Danilo Jankovic
Regional Nerve Blocks and Infiltration Therapy
Textbook and Color Atlas
3rd Edition, fully revised and expanded

Consultant on English Edition

William Harrop-Griffiths
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Consultant Anaesthetist
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I dedicate this book to my wife, Lydia, and my children Lara and Aleks. Their love, support, and encouragement have made the book possible.
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Just over 35 years ago, I became interested in the use of neural blockade for the relief of pain during and after surgery and became convinced that this was a superb treatment option for appropriately selected patients. Despite the wonderful advances in general anaesthesia and development of much improved systemic analgesia, I have not changed my view of the important role of neural blockade in the treatment of acute pain. Initiatives in the United States of America to make pain a "fifth vital sign" have focussed attention on the need for improved pain management, and the availability of as wide as possible a choice of options for patients. I have proposed that the relief of acute pain should be viewed as a "human right". In this context, there are a significant number of patients who will not obtain effective pain relief without access to potent neural blockade techniques. Such techniques are described in a very concise and beautifully illustrated manner in this text.

The management of cancer pain and chronic non-malignant pain represents a much more major challenge than the treatment of acute pain. However, here again the judicious use of neural blockade techniques can make the world of difference to the effective management of a substantial number of patients. It is a great pity that in some clinics there has been a disconnection between those providing non-invasive methods of management and those with the knowledge and technical skill to provide effective and safe neural blockade techniques. The effective and safe performance of neural blockade methods requires the requisite knowledge of anatomy, physiology and pharmacology followed by carefully supervised training with the assistance of clear and concise texts and reviews. Again, this textbook by Jankovic provides an excellent basis for those wishing to become skilled in this field. In parallel with the execution of such skill and knowledge, the other key ingredient is an appropriate collaboration with colleagues who can provide the other dimensions of patient care to ensure the best possible outcome in the treatment of cancer pain and chronic non-malignant pain. Such an approach is necessary in order to avoid at one end of the spectrum almost complete neglect of neural blockade techniques and at the other end of the spectrum an overuse with neglect of alternative methods.

The author of this text is a very highly skilled practitioner of regional nerve blocks and, like the author, this text is very practically orientated. The descriptions of anatomy are highly relevant to the regional blocks described and the illustrations are amongst the best that I have seen. I have no doubt that the readers will find this text extremely valuable in their clinical practice aimed at the relief of acute, chronic and cancer pain.

Professor Michael J. Cousins AM
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Professor & Director
Pain Management Research Institute
University of Sydney
The extremely gratifying response to the first and second editions of this book has encouraged me to meet the strong demand for further training in the technique of regional blocks by providing a substantially expanded, thoroughly checked and augmented edition. Thanks to the translations of the second edition into English, Italian and Spanish, I have received comments and suggestions on the book from all over the world, and I have taken these into account in the present edition. Just under four years since the publication of the second edition, I am therefore presenting this handbook in an expanded and revised form, including a much larger number of topics. As always, the focus has been on educational aspects.

The following groups of topics have been added:

Regional block techniques have been expanded and supplemented in accordance with the most recent findings in the field of regional anesthesia, particularly in the area of the brachial plexus and the lumbosacral plexus. The same applies to the section on neuraxial anesthesia.

The chapter on regional anesthesia in ophthalmology is completely new. Chapters on percutaneous epidural neuroplasty and intravenous regional anesthesia have also been newly added, as well as one on the ganglion impar.

As the important field of infiltration therapy techniques has been seriously and unjustly neglected in clinical practice, I have given it particular attention. After all, anesthetists and orthopedists, as well as physicians working in other specialties, all depend on this type of precise injection in everyday practice. The treatment of myofascial trigger points is also extremely important and requires specialized knowledge that is presented here. Quite specific injections into the most important trigger points are now presented in detail in this new edition, according to the regions of the body concerned (jaw, shoulder region, arm, gluteal region, etc.). The clinical signs and treatment of myofascial pain syndromes are also presented in precise detail. For example, intra-articular injections have been added, and the most important techniques involved are described.

I would like to express my thanks to colleagues and friends who have contributed to this edition: Prof. James Heavner, Prof. Gabor Racz, Prof. André van Zundert, and Prof. Battista Borghi. Thanks also go to my colleagues and friends, Prof. E. Freye and Prof. N. Körber, for advice, information, and ideas that have contributed to the success of this book.

I am grateful to Mr. H. Kreuzner, Dip. Eng., for his tremendous patience and expertise during our intensive collaboration and for the outstanding photographic work that resulted. Thanks also go of course to my son Aleks in this connection, who worked tirelessly and with tremendous commitment in producing and arranging the photographs. Last but not least, my thanks therefore also go to the members of my family, who have again supported me with all their strength and considerateness.

I would like to express my gratitude for the help with the English edition to my colleague and friend Professor William Harrop-Griffiths.

I am grateful to the staff at the publishers, particularly Matthias Franzke and Milena Schaeffer-Kurepka, for their constant support and expert assistance.

Danilo Jankovic
Cologne, August 2004
Preface to the first edition

This book presents a practical summary of the most important block techniques used in diagnostic and therapeutic and local anesthesia in the upper body. This work is based on my many years’ experience in clinical practice.

The book is aimed at the many specialist disciplines whose work involves pain therapy. This includes anesthetists, orthopedic surgeons, general surgeons, neurosurgeons, ENT surgeons, radiologists and fascia maxillary surgeons. The techniques presented here in the illustrations and text are an essential component of the modern multidisciplinary approach to pain therapy. Each individual block is discussed step by step and the way in which it is carried out is rendered easier to grasp through the use of specially developed record forms and checklists. At the same time, the physician concerned is informed about the relevant regulations that need to be observed. The focus is on the description and discussion of potential complications – how to recognize them quickly, how to prevent them and how to treat them in a timely fashion. I recommend those unfamiliar with this branch of pain therapy start by familiarizing themselves thoroughly with the anatomy of the region and the pharmacological properties of the most frequently used local anesthetics.

The underlying concept for this book was the idea of presenting, in a clear and practical fashion, ways of carrying out a block with optimal efficacy while at the same time ensuring the patient’s complete safety.

Special thanks go to my teacher, Prof. Hans Ulrich Gerbershagen. I would also like to thank the numerous colleagues and friends who have provided advice, information and ideas – particularly Dr. Günter Datz for his tremendous assistance, as well as my colleagues in my immediate area of work, particularly Ms. Gabriele Haarmann and Mr. Peter Kaufmann. Thanks also go to my family for their understanding, patience and support.

Last, but not least, I should like to express my gratitude to the publishers, Blackwell Science, for their helpful collaboration and for the excellent design and presentation of the book.

I shall welcome and gratefully take account of any suggestions, tips and constructive criticism from readers of this book.

Danilo Jankovic  
Cologne, December 1996
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Regional anesthesia means the interruption of impulse conduction in the nerves using specific, reversibly acting drugs (local anesthetics). This interruption of impulse conduction can be carried out in every region of the body in which the nerves are accessible for external injection.

The indications for regional anesthesia include:

1. Clinical anesthesia
   Particularly in the fields of traumatology, orthopedics, urology, and gynecology, as well as in large-scale abdominal surgery with continuous procedures for epidural or spinal anesthesia.
2. Obstetrics
3. Postoperative analgesia
   There is no postoperative analgesia procedure that is more appropriate than regional anesthesia. This field also includes the classic indications for a combination of local anesthetics with opioids or other substances.

Optimal patient care can only be achieved using a multimodal approach (effective pain therapy, early mobilization, early enteral nutrition, and emotional and psychological care). Effective pain therapy (e.g. with catheter analgesia procedures) plays a central role here, as it can substantially reduce the perioperative stress response (Table 1.1).

4. Pain therapy
   In 1979, a commission set up by the International Association for the Study of Pain (IASP) defined pain as “… an unpleasant sensory and emotional experience, linked to actual or potential tissue damage”.
   Acute pain is caused by stimulation of pain receptors. This stimulation is transient, and sets in motion biologically useful protective mechanisms. Ideally, pain can be relieved by treating the cause. Chronic pain is regarded as a pathological response on the part of the body.

### Table 1.1 Importance of effective pain therapy as part of a multimodal approach to treatment

<table>
<thead>
<tr>
<th>Effective pain therapy</th>
<th>Economic benefit</th>
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<td>Optimization of pain therapy: (e.g. with regional anesthetic procedures)</td>
<td>Optimizing hospital costs: DRG, optimized use of case discounts due to reduced hospital stays</td>
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<td>Blocking of the stress reaction</td>
<td>Avoiding risk of chronic conditions developing: Untreated persistent pain almost always leads to the pain becoming chronic</td>
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<td>Enteral nutrition, early mobilization</td>
<td>General economic costs: Preventing chronic pain from developing, with the resulting costs</td>
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<td>Optimization of convalescence: Reduced intensive care treatment times (e.g. abdominal and thoracic procedures by 1.5 days) Earlier discharge from hospital (e.g. serial rib fractures by 33 days) Shorter rehabilitation times (e.g. knee total replacement by 12 days)</td>
<td></td>
</tr>
</tbody>
</table>
body. It arises due to constant stimulation of nociceptive afferents, or can develop as neuropathic pain after injury or damage to the peripheral nociceptive system [5, 6, 17]. Chronic pain can often lead to alterations in patients' living habits, physical abilities, and personality, and requires a coordinated interdisciplinary approach. This in turn presupposes a clear diagnosis, based on a full general history and pain history, physical examination and functional assessment of the patient's musculature, locomotor apparatus, autonomic nervous system, and neurological and angiological situation.

In addition to medical treatment for pain, nerve blocks have a firmly established place in pain therapy – alongside physical and manual procedures, neurological and neurosurgical methods, physiotherapy and the psychosocial management of patients. In quantitative terms, regional anesthesia procedures play only a minor part in the management of chronic pain, but qualitatively they can produce very good results when used with the correct indications.

The application of the anesthesiological methods described in the subsequent chapters of this book for temporary interruption of stimulus conduction in a nerve or nerve plexus requires the use of strictly established indications and the implementation of a coordinated therapeutic approach. In principle, these blocks can be administered for surgery, diagnosis, prognosis, and therapy [3].
**Surgical blocks** are administered with high-dose local anesthetics for targeted isolation of a specific body region in order to carry out an operation.

**Diagnostic blocks** using low-dose local anesthetics are appropriate for the differential diagnosis of pain syndromes. They allow the affected conduction pathways to be recognized and provide evidence regarding the causes of the pain. Diagnostic blocks can also be used to clarify the question of whether the source of the pain is peripheral or central.

**Prognostic blocks** allow predictions to be made regarding the potential efficacy of a longer-term nerve block, neurolysis or surgical sympathectomy. They should also be used to prepare the patient for the effects of a permanent block.

**Therapeutic blocks** are used in the treatment of a wide variety of pain conditions. Typical examples of these are post-traumatic and postoperative pain, complex regional pain syndrome (CRPS) types I and II (reflex sympathetic dystrophy and causalgia), joint mobilization, post-herpetic neuralgia and tumor pain.

**Nerve blocks and chronic pain** [11]

A **multimodal treatment approach** to chronic pain is essential for successful treatment. The use of nerve blocks as part of this approach presupposes that the following steps have been taken:

- careful analysis of the pain;
- correct diagnosis and establishment of the indication;
- assessment of the pain chronicity stage;
- well-selected patient groups.

**Important preconditions for the application of nerve blocks in chronic pain include:**

- a good knowledge of anatomy;
- attention to and control of potential side effects and complications;
- choice of the correct block techniques;
- manual skill and good training on the part of the therapist.

The most important tasks facing us include conducting more double-blind, randomized and well-controlled studies on the use of nerve blocks in chronic pain conditions, and developing a consistent standard for carrying out nerve blocks. The answers to two questions need to be found:

- selection criteria to identify which patients are suitable for nerve blocks;
- the number of nerve blocks to be used in the treatment of chronic pain.

**Technical requirements**

Carrying out temporary nerve blocks and regional anesthetic procedures in surgery and pain therapy requires the appropriate basic technical equipment and experience in the use of all of the instruments concerned.

The conditions for patient positioning, the aseptic conditions required, and the syringes, needle types and other supplies needed are discussed alongside the individual block techniques described in this book.

Complete and properly functioning equipment must be available both for primary care and in case of adverse events and complications, as well as treatment monitoring.

**Accessories for primary care**

**Emergency equipment** (Figs. 1.1 and 1.2)

- intubation and ventilation facilities;
- oxygen source (breathing apparatus);
- ventilation bag with two masks (large, medium);
- Guedel tubes nos. 3, 4, 5;
- Wendel tubes nos. 26–32;
- endotracheal tubes nos. 28–36;
- tube clamp, blocker syringe (10 mL);
- laryngoscope with batteries (replacement batteries and replacement bulbs), spatula;
- Magill forceps, mouth wedge, 1 tube 2% lidocaine gel;
- suction device;
- infusion equipment;
- two sets of infusion instruments;
- five plastic indwelling catheters
- syringes (2 mL, 5 mL, 10 mL), plaster, gauze bandages.

![Fig. 1.1 Emergency equipment](image)
Chapter 1

**Emergency drugs**

- **Infusion solutions**
  - 1 bottle each of Ringer’s solution, plasma expander, 8.4% sodium bicarbonate (100 mL)

- **Defibrillator** (Fig. 1.3)

- **Drugs for emergency treatment**

  When blocks are being administered, a sedative (Valium®), a vasopressor (ephedrine) and a vagolytic (atropine) should be available for immediate injection. All other emergency medications should also be on hand:
  - 5 ampoules of atropine
  - 2 ampoules of Alupent® (oriprenaline)
  - 2 ampoules of Akrinor® (cafedrine–theodrenaline hydrochloride)
  - 3 ampoules 0.1% Suprarenin® (epinephrine) (1 : 1000)
  - 2 prepared syringes of Suprarenin® (1 : 10 000, 10 mL)
  - 2 ampoules of dopamine
  - 1 ampoule 10% calcium gluconate
  - 1 ampoule dimetinden maleate (Fenistil®)
  - prednisolone (Solu-Decorin®) (50 mg, 250 mg, 1000 mg)
  - 5 ampoules 0.9% sodium chloride
  - 2 ampoules 2% lidocaine
  - 3 ampoules diazepam (Valium®) (10 mg)
  - 2 ampoules midazolam (Dormicum®) (5 mg)
  - 1 ampoule clonazepam (Rivotril®) (1 mg)
  - 1 injection bottle thiopental sodium
  - 2 ampoules etomidate (Hypnomidate®)
  - 2 ampoules propofol (Disoprivan®)
  - 2 ampoules succinylcholine (suxamethonium chloride)

**Anesthetic machine**

For neuraxial anesthesia, ganglion blocks, intravenous regional anesthesia and plexus anesthesia, an anesthetic trolley with facilities for intubation is also required (Fig. 1.4).

**Monitoring**

- Electrocardiogram (ECG)
- Pulse oximeter (Fig. 1.5)
- Electrostimulator (e.g., HNS 11, B. Braun Melsungen, Germany; Fig. 1.6). Peripheral nerve stimulation is a valuable aid in clinical practice and has considerable advantages in combination with an atraumatic catheter technique.
- Temperature sensor, touch-free miniature infrared skin thermometer (e.g., M.U.S.S. Medical, Hamburg, Germany) (Fig. 1.7)
Local anesthetics in regional anesthesia and pain therapy

Local anesthetics produce reversible blockage of sodium channels in the nerve-cell membrane, thereby interrupting stimulus conduction.

Chemical structure and physicochemical properties [17]

All local anesthetics in common clinical use have three characteristic molecular sections in their chemical structure:

An aromatic residue, which basically determines the lipophilic properties of the agent. Substitutions in the aromatic group allow the pKa and lipid solubility of the substance to be influenced.

An intermediate chain, which in local anesthetics of the ester type (Table 1.3) contains a relatively unstable ester bond (CO–O) that can be broken down hydrolytically by pseudocholinesterases. Local anesthetics of the amide type (Table 1.4) are much more stable, since the amide bond (NH–CO) in their intermediate chain cannot be broken down in plasma. The length of the chain between the aromatic residue and the substituted amino group has an influence on the intensity of effect of the local anesthetic. The agent's protein-binding capacity and lipid solubility can be altered by substitution in the intermediate chain.

A substituted amino group, the protonization of which determines the ratio of the cationic to the basic form. Only the free base is capable of penetrating lipoprotein membranes. However, to be able to affect the nerve membrane, the local anesthetic must be available as a cation. The type of amino group substitution affects the distribution coefficient, the plasma protein binding and the intensity and duration of the drug's action.

Clinical significance of the physicochemical properties

Local anesthetics differ with regard to their molecular weight, their lipid and water solubility, pKa and protein-binding characteristics. These factors in turn have a substantial influence on the potency of the drug's local anesthetic effect on the onset of the effect and on its duration (Tables 1.5a, 1.5b).

Local anesthetic potency [4]

The combined effect of factors such as protein binding, stereoisomeric structure and lipophilia determine the potency of a local anesthetic agent. To achieve a blocking effect, the local anesthetic has to diffuse across the
cell membrane into the interior of the cell (importance of lipophilia for membrane diffusion) so that, from the cytosol (appropriate hydrophilic properties), it can occupy the sodium channel in its then protonated form (Table 1.6). A high degree of lipophilia is associated with good membrane permeation, and a high degree of hydrophilia is associated with good solubility in the cytosol. Local anesthetics therefore have to have both of these properties in a favorable ratio.

However, the clinical distinction that is made in local anesthetics between those of mild potency (procaine), medium potency (lidocaine, prilocaine, mepivacaine), and high potency (ropivacaine, bupivacaine, levobupivacaine, etidocaine) does not conform to these correlations in all respects.

**The onset of effect** in the isolated nerve, at physiological pH, depends on the pKa value of the local anesthetic. The lower this value is, the more local anesthetic base can diffuse toward the membrane receptors, and the shorter the time will be to the onset of the nerve block. Higher concentrations of local anesthetic accelerate onset.

**The duration of effect** depends on the dosage and concentration of the local anesthetic, its binding to the membrane receptors (protein-binding capacity), and its reabsorption from the tissue into the blood.
Table 1.5a Physicochemical and pharmacological parameters

<table>
<thead>
<tr>
<th>Agent</th>
<th>Molecular weight</th>
<th>pKa (25°C)</th>
<th>Distribution coefficient (lipid/water)</th>
<th>Protein binding (%)</th>
<th>Potency in vitro (isolated nerve)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procaine</td>
<td>236</td>
<td>8.9</td>
<td>0.02</td>
<td>5.8</td>
<td>1</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>220</td>
<td>7.7</td>
<td>2.9</td>
<td>64-70</td>
<td>4</td>
</tr>
<tr>
<td>Mepivacaine</td>
<td>234</td>
<td>7.7</td>
<td>0.9</td>
<td>77-80</td>
<td>3-4</td>
</tr>
<tr>
<td>Prilocaine</td>
<td>246</td>
<td>7.6</td>
<td>0.8</td>
<td>95</td>
<td>3-4</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>288</td>
<td>8.1</td>
<td>27.5</td>
<td>95</td>
<td>16</td>
</tr>
<tr>
<td>Etidocaine</td>
<td>276</td>
<td>7.7</td>
<td>141</td>
<td>95</td>
<td>16</td>
</tr>
<tr>
<td>Ropivacaine</td>
<td>274</td>
<td>8.1</td>
<td>9</td>
<td>95</td>
<td>16</td>
</tr>
<tr>
<td>Levobupivacaine</td>
<td>288</td>
<td>8.09</td>
<td>27.5</td>
<td>97</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 1.5b Local anesthetic potency and duration of effect

**Equipotent concentrations**
Medium-duration local anesthetics have more or less the same clinical potency (except perhaps for lidocaine – due to stronger vasodilation, this local anesthetic is resorbed more readily from the site of action, and this can affect the duration and intensity of the block).

Equipotent concentrations of long-acting local anesthetics cannot be demonstrated in the same way, since the three local anesthetics mentioned have completely different block profiles: etidocaine (highest lipophilic capacity) produces a mainly motor block, ropivacaine has a mainly sensory effect, and bupivacaine has both motor and sensory effects. Anesthetic concentrations of bupivacaine and ropivacaine are equipotent (one to one).

**Block profile** (Table 1.7)
The block profile shows the relation between sensory and motor block. Physicochemical properties determine the block profile. At high anesthetic concentrations – so far as these are toxicologically permissible – the excess quantity of the agent can also block fibers not primarily affected (motor or sensory fibers). On the other hand, the block profile is not altered by low concentrations. A reduced motor block is obtained at the cost of reduced analgesic quality, and this is why opioid supplementation is usually necessary with dilute concentrations of local anesthetic.

**Incompatibility**
Local anesthetics can precipitate after dilution with alkaline solutions, and should therefore not be diluted with or injected simultaneously with sodium bicarbonate.

**Side effects and systemic effects**
(Tables 1.8 and 1.9)
When assessing the safety and tolerability of a local anesthetic, account needs to be taken not only of its
Table 1.6 Chemical requirements of a local anesthetic. Local anesthetics must combine lipophilic and hydrophilic properties in a favorable ratio with each other. Hydrophilia = soluble in cytosol, lipophilia = overcoming the cell membrane.

Table 1.7 Relative block profile of long-acting local anesthetics

<table>
<thead>
<tr>
<th>Local anesthetic</th>
<th>Central nervous system</th>
<th>Heart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ropivacaine</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Levobupivacaine</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>++</td>
<td>++++</td>
</tr>
<tr>
<td>Etidocaine</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

Systemic effects
Adverse systemic effects of local anesthetics can occur when their plasma concentration is high enough to affect organs with membranes that can be irritated. Toxic plasma levels can be reached as a result of:
- Inadvertent intravascular or intrathecal/epidural injection;
- Overdosing, particularly in areas with good perfusion and correspondingly high resorption;
- Failure to adjust the dosages (mg/kg body weight), particularly in patients with hepatic or renal disease.

The severity of intoxication depends on the absolute plasma level, as well as on the strength of the local anesthetic's effect. While anesthetic dosages of short-acting local anesthetics (prilocaine, mepivacaine, lidocaine) can trigger clear CNS symptoms in a range extending to generalized cramp, cardiotoxic reactions are also possible with long-acting local anesthetics. In particular, cases of cardiac arrest have been reported with...
bupivacaine with comparatively small intravascular injections (50 mg; not treatable in half of the cases). Cardiac symptoms and cardiac arrest can also occur with ropivacaine after inadvertent intravascular injections. However, these can be treated effectively and only occur at higher dosages. The following sequence of increasing systemic toxicity applies to the most frequently used local anesthetics: procaine < prilocaine < mepivacaine < lidocaine < ropivacaine < levobupivacaine < bupivacaine.

**CNS toxicity:** Central reactions predominate in terms of frequency and clinical significance. The symptoms of these are listed in Table 1.9 in order of severity and toxicity. For speedy and appropriate treatment, it is important to observe and react immediately when even the preconvulsive signs of CNS intoxication are seen – particularly numbness of the tongue and perioral region. Since the symptoms of CNS toxicity occur either immediately after injection of the local anesthetic (intravascular injection) or within the first half hour (overdose), constant verbal contact must be maintained with the patient during this period.

**Cardiovascular toxicity:** toxic effects on the cardiovascular system usually occur after the administration of very high doses. They are seen in the form of conduction disturbances in the autonomic cardiac and vascular nerve fibers, depression of cardiac function, and peripheral vasodilation (Tables 1.8 and 1.9).

**Substance-specific side effects** [17]

One specific side effect of prilocaine is the increased methemoglobin level caused by the metabolite o-tolidine. Clinically, cyanosis, headache, cardiac palpitation and vertigo can be expected at methemoglobin levels of 10–20%, and loss of consciousness, shock and death when the level is 60% or more. This does not call into question the beneficial toxicological properties of prilocaine, since clinically relevant methemoglobinemia can only occur at dosages of more than 600 mg, which is much more than clinically used doses of mepivacaine or lidocaine. A clinically harmful methemoglobin level can be treated within a few minutes by the intravenous administration of 2–4 mg/kg toluidine blue (or alternatively, 1–2 mg/kg methylene blue). Because of this specific side effect, prilocaine is not indicated in patients with congenital or acquired methemoglobinemia, in patients who are anemic or have a history of heart disease, in obstetrics (e.g., for pudendal nerve or paracervical block), or in children under the age of 6 months.

**Allergic potential**

There are no reliable data regarding the frequency of allergic reactions after the administration of local anesthetics. There is no doubt that these are extremely rare, although the symptoms can range from allergic dermatitis to anaphylactic shock. Occasional cases of allergic reactions to ester local anesthetics have been reported, and the preservative substances which the various preparations contain (e.g., parabens) and the antioxidant sodium bisulfide in epinephrine-containing solutions are also under discussion as potential causes. In patients with suspected intolerance of local anesthetics...
Chapter 1

Table 1.10 Functional distinctions between nerve fibers

<table>
<thead>
<tr>
<th>Fiber type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aα</td>
<td>Motor, touch, pressure, depth sensation</td>
</tr>
<tr>
<td>Aβ</td>
<td>Motor, touch, pressure, depth sensation</td>
</tr>
<tr>
<td>Aγ</td>
<td>Regulation of muscle tone</td>
</tr>
<tr>
<td>Aδ</td>
<td>Pain, temperature, touch</td>
</tr>
<tr>
<td>B</td>
<td>Preganglionic sympathetic function</td>
</tr>
<tr>
<td>C</td>
<td>Pain, temperature, touch, postganglionic sympathetic function</td>
</tr>
</tbody>
</table>

Table 1.11 Overview of drugs

<table>
<thead>
<tr>
<th>Drug</th>
<th>Potency</th>
<th>Duration of effect</th>
<th>Toxicity</th>
<th>Half-life</th>
<th>Vdiss of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidocaine</td>
<td>1 (Ref.)</td>
<td>2 h</td>
<td>1 (Ref.)</td>
<td>96'</td>
<td>91</td>
</tr>
<tr>
<td>Mepivacaine</td>
<td>1</td>
<td>2–3 h</td>
<td>1.2</td>
<td>114'</td>
<td>84</td>
</tr>
<tr>
<td>Prilocaine</td>
<td>1</td>
<td>2–3 h</td>
<td>0.5</td>
<td>93'</td>
<td>261</td>
</tr>
</tbody>
</table>

Recommended maximum doses without epinephrine, according to specialist information:

- Lidocaine: 200 mg
- Mepivacaine: 300 mg
- Prilocaine: 400 mg

Selection of suitable substances for regional block

When surgical interventions are being carried out under regional anesthesia, priority must go to shutting off both sensory and motor systems, and knowledge of the expected length of the operation is vital to the choice of anesthetic. The onset of effect and the toxicity of the drug used play important parts, but not decisive ones. In the context of pain therapy, in which the fast-conducting A delta fibers and the slow-conducting C fibers (Table 1.10) are the target of the block, toxicity is much more important than the duration of the effect.

In diagnostic and therapeutic blocks, in which there is a risk of intravascular injection — e.g., in a stellate ganglion block or superior cervical ganglion block — prilocaine should be selected, as it is the medium-duration local anesthetic with the lowest toxicity (mepivacaine or lidocaine are alternatives) (Table 1.11).

Bupivacaine has an important role in regional blocks, being a longer-duration local anesthetic that provides high-quality analgesia and an easily controlled motor block. Its anesthetic potency is about four times that of local anesthetics with medium-duration effects (such as prilocaine). When the lower dosage required in pain therapy than in regional anesthesia is taken into account, bupivacaine can be used for practically all pain therapy procedures in spite of its relatively high toxicity.

Ropivacaine is the most recently introduced long-duration local anesthetic in the amino-amide series. The differential block is even more marked than with bupivacaine, and the drug is associated with much lower CNS toxicity and cardiac toxicity. These characteristics make it particularly suitable for regional anesthesia procedures in which higher dosages or concentrations are required. Ropivacaine provides good quality analgesia while largely maintaining motor activity (up to 80% of patients have no measurable motor block on the Bromage scale). At a dosage of 2 mg/mL, the drug is therefore the local anesthetic of choice for epidural obstetric analgesia and for postoperative analgesia (Table 1.7). With its pharmacological profile, ropivacaine is the first local anesthetic with primarily analgesic effects, and it is therefore particularly suitable for pain therapy indications.

Every anesthetist and pain therapy physician who uses anesthetic methods for temporary interruption of stimulus conduction in a ganglion, nerve or neural plexus should be familiar with the properties and potential applications of the following agents.

Short-acting local anesthetics

**Procaine (Novocaine®)**

Class of drug: Local anesthetic of the ester type.

Single threshold dose: 500 mg without epinephrine in adults.

LD50 (mouse): 52.2–60.0 mg/kg body weight i.v.

Plasma half-life: < 0.14 h.

Latency: Medium.

Duration of effect: 0.5–1 h, depending on the area of application and the concentration used.

Metabolism: Procaine is broken down in plasma by pseudocholinesterase into p-aminobenzoic acid — a naturally occurring component of folic acid synthesis — and into diethylaminoethanol. The metabolites are excreted in the urine or broken down in the liver.

Tolerability and control: Procaine is one of the local anesthetics that have the lowest toxicity. Due to its short half-life, procaine is easily controlled.
Clinical uses: It is not so much its local anesthetic potency that predominates in procaine, but rather its muscle-relaxing properties and vasodilatory effect—which are of primary importance in infiltration therapy and trigger-point treatment. In the therapeutic field, very good results can be obtained with superior cervical ganglion block. However, procaine’s high allergenic potency in comparison with amide local anesthetics argues against its use.

Dosage: Procaine is administered at concentrations of 0.5–2%. Precise dosages are described in the relevant sections of this book.

2-Chloroprocaine

2-Chloroprocaine, an ester local anesthetic, is a chlorinated derivative of procaine and is most rapidly metabolized local anesthetic currently used. Although the potency of chloroprocaine is relatively low, it can be used for epidural anesthesia in large volumes in a 3% solution because of its low systemic toxicity. The duration of action is between 30 and 60 minutes. This agent enjoyed its greatest popularity for epidural analgesia and anesthesia in obstetrics because of the rapid onset and low systemic toxicity in both mother and fetus. However, frequent injections are needed to provide adequate pain relief in labor and it is more usual to establish analgesia with chloroprocaine and then change to a longer acting agent such as ropivacaine or bupivacaine.

The use of chloroprocaine declined because of reports of prolonged neurological deficit following accidental subarachnoid injection. This toxicity was ascribed to the sodium meta-bisulfite used in the past as preservative. However there are no reports of neurotoxicity with newer preparations of chloroprocaine which contain disodium ethylenediaminetetraacetic acid (EDTA) as the preservative. Nevertheless these preparations are not recommended for intrathecal administration. However, since then, a number of reports of back pain have appeared. The incidence of back pain appears to be related to the large volume (greater than 40 ml) of drug injected. Chloroprocaine has also proved of value for peripheral nerve blocks and epidural anesthesia when the duration of surgery is not expected to exceed 30 to 60 minutes.

Tetracaine

Tetracaine is a long-acting amino ester. It is significantly more potent and has a longer duration of action than procaine or 2-chloroprocaine. Tetracaine remains a very popular drug for spinal anesthesia in the United States. This drug possesses excellent topical anesthetic properties, and solutions of this agent were commonly used for endotracheal surface anesthesia. Because of its slow onset and high toxicity, tetracaine is rarely used in peripheral nerve blocks.

Medium-term local anesthetics

Lidocaine (Xylocaine®, lignocaine)

Class of drug: Lidocaine is a medium-duration local anesthetic of the amide type.

Single threshold dose: 200 mg without epinephrine in adults/70 kg body weight. After injection of a maximum dose, subsequent injections should not be given for 90 min. The second dose must not exceed a maximum of half of the first dose.

LDS₀ (mouse): 31.2–62.2 mg/kg body weight i.v.

Plasma half-life: ca. 1.6 h.

Latency: Fast.

Duration of effect: 1–2 h, depending on the area of application and the concentration used.

Metabolism: Lidocaine is metabolized in hepatic microsomes. Only about 3% of the drug is excreted unchanged via the kidney.

Tolerability and control: Lidocaine is one of the local anesthetics with moderate relative toxicity. It is characterized by a medium-term duration of effect and good distribution characteristics. Lidocaine causes vasodilation, which may be less than that of procaine. When the medium-duration local anesthetics are compared, the strengths of the associated vasodilatory effects show the following sequence: lidocaine > mepivacaine > prilocaine. Lidocaine is therefore often used with epinephrine.

Clinical uses: Lidocaine is widely used in clinical practice, particularly in neural and segmental therapy. It is
also suitable for infiltration anesthesia, for peripheral nerve block, for epidural anesthesia, and for mucosal surface anesthesia (2% gel, Emla®). Dosage: Lidocaine is mainly administered as a 0.5–1% (1.5)% solution. Specific doses are given in the relevant chapters of this book.

Emla® cream
Emla® (a mixture of 2.5% lidocaine and 2.5% prilocaine) is a topical local anesthetic that penetrates intact skin and reaches an anesthetic depth of up to 5 mm. The onset of effect is approximately 1 h. When the effect takes place, the vessels in the skin show vasoconstriction initially, followed by vasodilation when higher concentrations are reached. This form of administration of this local anesthetic mixture has proved particularly useful in pediatric anesthesia before intravenous access placement, and for minor surgical procedures on the skin surface.

Lidocaine plaster
Lidocaine, administered in various forms (i.v., i.m. or transdermally) relieves pain associated with post-herpetic neuralgia (PHN) [1, 12, 13]. The analgesia is based on the blockade of neuronal sodium channels. However, intravenous administration of lidocaine can lead to plasma concentrations associated with antiarrhythmic effects. Topical application of lidocaine in the form of a gel or plaster avoids high plasma concentrations. This type of lidocaine plaster was developed in the USA, where it has been licensed since 1999 for pain treatment in post-herpetic neuralgia (Lidoderma®, Endo Pharmaceuticals Ltd., Chadds Ford, PA). The plaster consists of a soft, stretchable polyester base connected to an adhesive layer that contains 5% lidocaine. The plaster is 10 × 14 cm in size.

The systemic absorption of lidocaine has been shown in preclinical and clinical studies to be minimal (3%) in both volunteers and patients with PHN. Treatment with lidocaine plaster has been investigated in comparison with a placebo in three randomized, double-blind clinical studies including a total of 217 patients with PHN [7, 14, 15]. A significant reduction in pain intensity and allodynia was observed. Lidocaine plaster therefore represents a treatment option with a relatively low risk of adverse systemic events or drug interactions [8].

In Europe, clinical testing of the plaster for use in post-herpetic neuralgia is currently taking place, and its licensing for this indication can be expected within the next two or three years.

Mepivacaine (Scandicaine®, Meaverine®)
(Tables 1.5a, 1.8, 1.11)
Class of drug: Mepivacaine is a medium-duration local anesthetic of the amide type.
Single threshold dose without epinephrine in adults (70 kg body weight): 200 mg in the ENT field, 300 mg in other applications.
LD₅₀ (mouse): 40.3 ± 3.2 mg/kg body weight i.v.
Plasma half-life: ca. 1.9 h.
Latency: Fast.
Duration of effect: 1–3 h, depending on the area of application and the concentration used.
Metabolism: Mepivacaine is metabolized in the hepatic microsomes.
After intravenous administration, up to 16% of the agent is excreted unchanged via the kidney. Degradation in the liver mainly produces m-hydroxymepivacaine and p-hydroxymepivacaine. These metabolites are conjugated with glucuronic acid and excreted in the urine. Another metabolite, pipecolylxylidide, collects in bile and passes through the enterohepatic circulation with its degradation products. No 2,6-xyline is produced when mepivacaine is metabolized, and there is no evidence that either the agent or its metabolites have mutagenic or carcinogenic properties.

Tolerability and control: Mepivacaine is another of the local anesthetics with moderate relative toxicity. It is characterized by a medium-term duration of effect, with good distribution properties and some vasodilatory effect.
Clinical uses: Mepivacaine is the local anesthetic of choice when a medium-duration effect is required for diagnostic and therapeutic blocks in pain therapy – particularly in outpatients. It is suitable for infiltration anesthesia, intravenous regional anesthesia, peripheral nerve block and ganglion block, and for epidural anesthesia. Mepivacaine cannot be recommended in the obstetrics due to its long elimination half-life in the neonate.

Dosage: Mepivacaine is mainly used as a 1% (1.5%) or 0.5% solution. Specific doses are given in the relevant chapters of this book.

Prilocaine (Xylonest®)
(Tables 1.5a, 1.8, 1.11)
Class of drug: Prilocaine is a medium-duration local anesthetic of the amide type.
Single threshold dose: 600 mg (with or without vasopressor) in adults/70 kg body weight.
LD₅₀ (mouse): 62 mg/kg b.w. i.v.
Plasma half-life: ca. 1.5 h.
Latency: Fast.
Duration of effect: 2–3 h, depending on the area of application and the concentration used.
Metabolism: Prilocaine is mainly metabolized in hepatic microsomes, but also in the kidney and lungs. During degradation, the metabolite ortho-toluidine is produced. At doses higher than 600 mg, the body's reduction systems may become exhausted. At doses higher than 800 mg, noticeable methemoglobinemia can be expected (see the section on substance-specific side effects). Fast elimination from the blood leads to low systemic toxicity.

Tolerability and control: Among the amide local anesthetics, prilocaine shows the best ratio between anesthetic potency and toxicity. Due to its high distribution volume and marked absorption in the lungs, plasma levels are significantly lower than those of mepivacaine and lidocaine (by a factor of 2–3). It has a medium-term duration of effect.

Clinical uses: Due to its comparatively low toxicity, prilocaine is particularly suitable for regional anesthesia techniques that require a single injection of a large volume or a high anesthetic dosage. The increasing use of prilocaine (2% isobaric solution) for spinal anesthesia is relatively new. Comparative studies in recent years have shown good tolerability, while transient neurological symptoms (TNS; see Chapter 37) were observed more often with lidocaine and mepivacaine. Prilocaine – like other medium-duration agents – is not suitable for continuous blocks. Due to the possibility of raised methemoglobin levels, prilocaine should not be used in anemic patients, children under the age of 6 months, or in obstetrics.

Dosage: Depending on the area of application, a 0.5–2% solution is used. Specific doses are given in the relevant chapters of this book.

Long-acting local anesthetics

Ropivacaine (Naropin®)
(Tables 1.5a, 1.7, 1.11)

Class of drug: Local anesthetic of the amide type, pure S-enantioomer.

Single threshold dose:
Anesthesia:
Epidural: 0.5–1%, 200 mg;
Plexus blocks: 0.75%, 300 mg;
Conduction and infiltration anesthesia: 0.5–0.75%, 225 mg;
Injection at myofascial trigger points: 0.2% (1–2 mL per trigger point).

Continuous procedures: 0.2%, up to 14 mL/h. Increased doses may be required during the early postoperative period – up to 0.375%, 10 mL/h (maximum 37.5 mg/h). When it is administered over several days, the resulting concentrations are well below potentially toxic plasma levels.

A dosage of 300 mg should be regarded as a guideline value, as this dosage has been confirmed as tolerable by various pharmacological studies.

LD₅₀ (mouse): ca. 11.0–12.0 mg/kg b.w. i.v.

Plasma half-life: ca. 1.8 h.

Duration of effect: Epidural anesthesia ca. 7 h (analgesia); ca. 4 h (motor block), 10 mg/mL.
Plexus anesthesia (brachial plexus, lumbosacral plexus): 9–17 h, 7.5 mg/mL.
Infiltation anesthesia: postoperative analgesia after inguinal herniorrhaphy > 7 h (5–23 h), 7.5 mg/mL.
Peripheral nerve blocks in pain therapy: 2–6 h (0.2–0.375 mg/mL).

Latency: Medium (decreasing latency at increasing concentrations).

Metabolism: Ropivacaine is metabolized in the liver, mainly through aromatic hydroxylation. Only about 1% of the drug is excreted unchanged in the urine. The main metabolite is 3-hydroxyropivacaine.

Tolerability: Ropivacaine provides relatively low toxicity for a long-term local anesthetic. Compared with bupivacaine, it has a lower arrhythmogenic potential, and the margin between convulsive and lethal doses is wider. Ropivacaine has more favorable receptor kinetics ("fast in – medium out") in cardiac sodium channels, and in comparison with bupivacaine has only slight depressant effects on the energy metabolism of the mitochondria in cardiac muscle cells.

Clinical uses: The first clinical tests were carried out in 1988. Ropivacaine (Naropin®) has been in use since 1996. It is the first local anesthetic with a primary analgetic effect and is therefore of particular interest in pain therapy (postoperative and obstetric, as well as therapeutic blocks). In comparison with bupivacaine, it has fewer toxic side effects (CNS and, in particular, cardiac toxicity). High doses are needed before toxic effects develop. CNS symptoms appear well before cardiac symptoms, which in the clinical situation provides time for the local anesthetic injection to be stopped and for early treatment steps to be taken. In an animal model, the chances of successful resuscitation were also found to be better than with bupivacaine (90% vs. 50%) [9]. In addition, ropivacaine shows marked differential blocking in epidural analgesia and peripheral blocks. With a good quality of analgesia, up to 80% of patients have no measurable motor block on the Bromage scale. Epidural combinations (e.g., with sufentanil, dosage range 0.5–1 µg/mL) are possible. In view of the increased use of peripheral blocks and infiltrations at painful trigger points, evidence of higher muscular tissue tolerance is not available [19].

The relatively low toxicity of ropivacaine means that high concentrations can be given (e.g., 10 mg/mL so-
levobupivacaine in clinical practice. The numbers of published controlled clinical studies are also comparatively small. Available in-vitro, in-vivo, and controlled patient studies comparing levobupivacaine and bupivacaine have shown similar potency for neural blocks. After epidural administration of levobupivacaine, the same quality of sensory and motor block as with bupivacaine was seen. However, a significant differential block, as provided by ropivacaine, cannot be expected, as the drug has the same degree of lipophilia as bupivacaine.

**Levobupivacaine (Chirocaine®)**

(Tables 1.5a, 1.7, 1.8)

**Class of drug:** Local anesthetic of the amide type. A pure S-enantiomer of bupivacaine.

**Single threshold dose without epinephrine in adults:** 150 mg.

**LD₅₀ (mouse):** 10.6 mg/kg b.w.

**Plasma half-life:** 80 ± 22 min. Plasma protein binding of levobupivacaine in humans has been assessed in vitro, and was more than 97% at concentrations of 0.1–1.0 μg/mL.

**Latency:** Medium (between ropivacaine and bupivacaine).

**Duration of effect:** 8–24 h, depending on the area of application and the concentration used.

**Metabolism:** Levobupivacaine is extensively metabolized, and unaltered levobupivacaine is not found in the urine or feces. 3-Hydroxylevobupivacaine, one of the principal metabolites of levobupivacaine, is excreted via the urine as a glucuronic acid and sulfate ester conjugate. In-vitro studies have shown that levobupivacaine is metabolized via CYP3A4 isoforms and CYP1A2 isoforms into desbutyl-levobupivacaine or 3-hydroxylevobupivacaine. The studies showed that the degradation of levobupivacaine and bupivacaine is similar. After intravenous administration of levobupivacaine, the recovery rate within 48 h averaged ca. 95%, quantitatively measurable in urine (71%) and feces (24%).

**Tolerability and control:** Experimental animal studies have demonstrated a lower risk of CNS and cardiovascular toxicity with levobupivacaine than with bupivacaine. In volunteers, fewer negative inotropic effects were observed after intravenous administration of more than 75 mg levobupivacaine in comparison with bupivacaine. QT interval changes only occurred in a very few cases.

**Clinical uses:** There is little experience as yet with levobupivacaine in clinical practice. The numbers of published controlled clinical studies are also comparatively small. Available in-vitro, in-vivo, and controlled patient studies comparing levobupivacaine and bupivacaine have shown similar potency for neural blocks. After epidural administration of levobupivacaine, the same quality of sensory and motor block as with bupivacaine was seen. However, a significant differential block, as provided by ropivacaine, cannot be expected, as the drug has the same degree of lipophilia as bupivacaine.

**Bupivacaine (Carbostesin®, Marcaine®)**

(Tables 1.5a, 1.7, 1.8)

**Class of drug:** Local anesthetic of the amide type.

**Single threshold dose:** 150 mg without epinephrine in adults.

**LD₅₀ (mouse):** 7.8 ± 0.4 mg/kg b.w. i.v.

**Plasma half-life:** ca. 2.7 h.

**Latency:** Medium.

**Duration of effect:** 2.5–20 h, depending on the area of application and the concentration used. A mean duration of effect of 3–6 h can be assumed.

**Metabolism:** Bupivacaine is broken down in hepatic microsomes at a high rate. The predominant metabolism involves dealkylation to piperonyl xylidide (desbutyl-bupivacaine). There is no evidence that either the agent or its metabolites have mutagenic or carcinogenic properties.

**Tolerability and control:** Bupivacaine is one of the local anesthetics that has a high relative toxicity. Its anesthetic potency is about four times greater than that of mepivacaine. It is characterized by a slower onset of effect and by a long duration of effect.

**Clinical uses:** Bupivacaine is indicated as a long-duration local anesthetic, particularly for regional anesthesia in the surgical field, in postoperative analgesia, and in therapy for various pain conditions. It is suitable for infiltration anesthesia, peripheral nerve block, ganglion block and plexus block, as well as all forms of neuraxial anesthesia. The marked cardiac toxicity of bupivacaine has been known since publications dating from the late 1970s, and severe and fatal adverse effects are still reported. Strict observation of safety standards is therefore of fundamental importance for the safe use of this drug at high doses.

**Dosage:** Depending on the indication, bupivacaine is administered as a 0.125–0.5% solution. A 0.75% solution is still being marketed. Higher concentrations are not required in pain therapy. Specific doses are given in the following chapters.
Examination and patient preparation

Before regional anesthesia, the same type of examination of the patient should be carried out as for general anesthesia. Contraindications must be excluded, as well as neurological abnormalities, and when there are relative contraindications – e.g., hemorrhagic diathesis, stable systemic neurological disease or local nerve damage – a careful assessment of the risk–benefit ratio needs to be made.

Particular attention needs to be given to anatomical relationships, palpation of the landmarks and precise localization and marking of the needle insertion point. To ensure cooperation, the patient should be given detailed information about the aim of the block, its technical performance and possible or probable paresthesias and their significance. The patient should also be informed about potential adverse effects and complications of the block, and outpatients in particular should be familiarized with guidelines on behavior after anesthesia. The patient information session should be documented using a consent form signed by the patient.

In general, premedication and the administration of sedatives or analgesics should be avoided, particularly in outpatient pain therapy. Constant verbal contact should be maintained with the patient during the block, so that potential side effects or complications can be recognized immediately. In addition, any sedation that is not adjusted individually can lead to respiratory and circulatory complications, which may be mistaken for the early symptoms of local anesthetic toxicity.

Documentation of treatment

The patient history, including investigations at other centers, and diagnostic results should be documented just as carefully as the preparation, implementation, and success of the block. The checklists and record forms used in our own pain center have been adapted for each individual block technique, and are included in the following chapters.
Head and neck region
The pioneering work of Koller (1884) on the anesthetic effect of cocaine in the context of ophthalmic surgery was the historical starting-point for local and regional anesthesia [8].

Anatomy of the eye [2, 5, 10, 12]

The eyeball or bulbus oculi is embedded in the orbit, and is covered by the eyelids (Fig. 2.2). The length of the orbit varies substantially (42–54 mm). The eyeball makes up approximately one-quarter (7 mL) of the total volume of the orbit. The remainder of the orbit is filled with fatty tissue, vessels, the lacrimal gland, nerves, connective tissue, and the extraocular muscles. The orbit is form by two compartments, an extraconal space and an intraconal space, surrounded by the four rectus muscles. Injected local anesthetics are easily able to pass the barrier between the two compartments by diffusion.

The superior eyelid, the palpebra superior, and the inferior eyelid, the palpebra inferior, form the boundaries of the palpebral fissure, the rima palpebrarum. This ends at the medial angle of the eye, the angulus oculi medialis, with a bulge that encloses the lacrimal caruncle or caruncula lacrimalis.

The inner wall of the eyelids is covered by the conjunctiva (tunica conjunctiva) (Fig. 2.1). Closure of the eyelids is carried out by the orbicularis oculi muscle (facial nerve), and raising of the upper lid is carried out by the levator palpebrae superioris muscle (oculomotor nerve; Figs. 2.2 and 2.3). The lacrimal gland lies above the lateral angle of the eye (Fig. 2.2), and is divided into an orbital part and a palpebral part by the tendon of the levator palpebrae superioris muscle. The orbit, covered with periosteum (periortibita), is filled with a fatty tissue body, the retrobulbar fat, in which the eyeball, optic nerve and eye muscles are embedded (Fig. 2.2).

The movements of the eyeball are made possible by six muscles – four straight ones and two oblique ones: the superior rectus muscle, inferior rectus muscle, medial rectus muscle (oculomotor nerve), lateral rectus muscle (abducents nerve), superior oblique muscle (trochlear nerve), and inferior oblique muscle (oculomotor nerve; Fig. 2.3).

On the anterior surface of the eyeball, the bulbus oculi, lies the transparent cornea. Underneath this is the crystalline lens of the eye, which is located in front of the iris, with its central opening, the pupil. The optic nerve exits on the posterior surface of the eyeball, slightly medial to the optic axis (Fig. 2.5). A distinction is made between three different spaces in the eye: the anterior chamber of the eyeball, bounded by the cornea, the iris and the lens; the posterior chamber of the eyeball, which encircles the lens in a ring-like shape; and the postremal chamber of the eyeball, which contains the vitreous body (corpus vitreum; Fig. 2.5).

The eye has two different vascular systems: the ciliary arteries and the central retinal artery. All of the vessels originate from the ophthalmic artery (Fig. 2.4). The vascular system in the posterior ciliary arteries not only serves to supply blood, but is also important for maintaining intraocular pressure and tension in the eyeball. The large vessels (ophthalmic artery and vein) and the nerve fascicles are concentrated in the area of the posterior pole of the eye. The highest risk of injury is therefore during puncture of the posterior third of

Fig. 2.1 Eyelids and lacrimal apparatus, (1) Cornea, (2) conjunctiva, (3) medial angle of the eye, (4) lacrimal caruncle, (5) lacrimal papilla, (6) inferior eyelid, (7) pupil, (8) lateral angle of the eye, (9) superior eyelid
Fig. 2.2 Anatomy of the eye. (1) Eyeball, (2) lacrimal gland, (3) levator palpebrae superioris muscle, (4) superior rectus muscle, (5) lateral rectus muscle, (6) inferior rectus muscle, (7) medial rectus muscle, (8) superior oblique muscle, (9) optic nerve, (10) ciliary ganglion, (11) nasociliary nerve, (12) trigeminal ganglion, (13) frontal nerve, (14) ophthalmic nerve, (15) trochlear nerve, (16) abducent nerve, (17) oculomotor nerve, (18) internal carotid artery, (19) retrobulbar fat, (20) supraorbital nerve

The ciliary ganglion, a tiny collection of nerve cells, lies in the posterior part of the orbit between the optic nerve and the lateral rectus muscle (Fig. 2.2). The sensory and sympathetic roots of the ciliary ganglion are provided by the nasociliary nerve and the neural network around the internal carotid artery, but do not always connect to the ciliary ganglion. Their fibers can reach the eye directly via the ciliary nerves. The sympathetic fibers, which are already postganglionic after they have switched to the cervical sympathetic trunk ganglia, can accompany the ophthalmic artery and its branches on the way to their destination. Stimuli from the cornea, iris, choroid and intraocular muscles are conducted in the sensory fibers.

Anatomy relevant to injections

The average distance between the orbital margin and the ciliary ganglion is approximately 38 mm (ranging between 32 and 44 mm). In cadaver studies, Karampatiakis et al. [7] found that when a retrobulbar block was carried out with a needle 40 mm long, the needle tip would reach the posterior optic nerve in 100% of cases; even with needles 35 mm long, the covering of the optic nerve would be touched in 18% of cases.

To protect the posterior pole of the eye and the ciliary ganglion, the block needle should be no more than 32 mm in length.

The eyeball has an average longitudinal diameter of 23.5 mm (over 25 mm in severely myopic patients, increasing the risk of injury). The greatest risk of injury when carrying out a block is when the needle is introduced superior to or superomedial to the orbit. By contrast, when the direction of the gaze is straight ahead, the needle can be introduced with little risk at the inferolateral orbital margin and advanced parallel to the orbital floor up to the level of the posterior eyeball.

Physiology

The physiological pressure in the interior of the eye is between 10 and 20 mmHg. It is higher in patients with a large-diameter eyeball and in the recumbent position; it is higher in the morning than in the evening, and increases during coughing, physical exertion, and vomiting. An increased $P_{CO_2}$ or a reduced $P_{O_2}$ increases the pressure inside the eye. Inhalation anesthetics, as well as barbiturates, neuroleptic agents, opioids, and propofol, among other substances, lead to a reduction in intraocular pressure, while laryngoscopy and intubation...
Regional anesthesia in ophthalmology

- as well as drugs such as ketamine and muscle relaxants – have the opposite effect. The anterior and posterior chambers of the eye contain 250 µL of an aqueous liquid (rate of synthesis ca. 2.5 µL/min).

Anesthesia in eye surgery

Indications
Regional anesthesia for **intraocular procedures** (e.g., cataract operations, vitrectomies, etc.):
- Anesthesia of the eyeball, eyelid, conjunctiva
- Retrobulbar (intraconal) or peribulbar (extraconal) anesthesia
- Sub-Tenon anesthesia
- Surface anesthesia

**Extraocular procedures** (e.g. in strabismus) are usually carried out with the patient under general anesthesia.

Preoperative examination
Ophthalmological procedures are usually carried out in older people, and are associated with few risks. The great majority of diagnostic and surgical procedures in the eye can be safely carried out on an outpatient basis and usually with regional anesthesia. Independently of the type of anesthesia selected, a preoperative visit should be made. An information discussion with the patient is an absolute necessity.

Analgesia and sedation [4, 14]
It is recommended that one of the following drugs is given immediately before carrying out regional anesthesia:

- Midazolam 1 mg (+ remifentanil 0.33 µg/kg)
- Propofol 0.5 mg/kg

Deep sedation should not accompany regional anesthesia; the patient should be capable of cooperating.

Preparations
Place the patient in a comfortable position. Nasal oxygen administration should be carried out routinely. Continuous monitoring (pulse oximetry, ECG monitoring, blood-pressure monitoring) and intravenous access are necessary. An intravenous infusion is not obligatory. Before the procedure, the effect of the regional anesthesia administered should be checked (motility testing).

Characteristics of an ideal eye block
The block should be carried out with the smallest possible volume of the local anesthetic. Analgesia and akinesia of the eyeball (the latter is not always necessary).
No pain during the operation.
No significant complications.

**Techniques of conduction and infiltration anesthesia**

**Retrobulbar block (intraconal anesthesia)**

*Indications*
Intraocular procedures (e.g., cataract surgery, vitrectomies).

*Preparations*
See above.

*Materials* (Fig. 2.6)
Atkinson (23 G, 11/4") 0.60 x 32 mm needle, retrobulbar/peribulbar. Syringe 5 mL, swab, compresses, disinfectant, sterile precautions, local anesthetic (or alternatively: curved or bent needle – e.g., Strauss needle).

Sharp versus blunt needle tip: blunt needles are better in patients with high-grade myopia, with a longitudinal diameter of the eyeball of more than 25 mm. However, sharp tips provide a better feel when advancing the needle.

*Patient positioning*
The best position for the patient is semi-recumbent (45°).

*Injection technique*
Depending on the anesthetist’s preferences, two puncture methods are possible: usually transcutaneous, through the lower eyelid (Fig. 2.8a) or, more rarely, transconjunctival (Fig. 2.8b). The block needle is introduced in the 7 o’clock position on the right or the 5 o’clock position on the left. The eye should be gazing upward and to the contralateral side, and the eyeball can be delicately pushed in a medial and cranial direction using a free finger. The needle is directed initially at a slight angle toward the orbital floor (2–3°) under the eyeball. The needle is introduced along the bony floor of the orbit toward the back in the direction of the root of the nose and at an angle of less than 45° to the skin. Moving the eyeball inward and upward results in tensing of the inferior oblique muscle, which is thereby pulled out of the injection area.

At the end of the injection, the needle exits between the inferior rectus muscle and the lateral rectus muscle into the space lying temporal to the optic nerve, in which the ciliary ganglion is located.
The needle must not be advanced against hard resistance.

The injection of the local anesthetic should be carried out slowly, in incremental doses, after prior aspiration.

After the injection, an oculopressor should be placed for ca. 5–10 min, at a pressure of ca. 20–30 mmHg (Fig. 2.7). This allows better distribution of the local anesthetic as well as providing prophylaxis against hematoma.

Mobility testing of the eye must be carried out before the procedure (Fig. 2.12).

Dosage [6]

Oxybuprocaine HCl 0.4% for surface anesthesia if the transconjunctival access route is chosen.

3–5 mL local anesthetic (e.g., 0.75% ropivacaine, 0.5% bupivacaine, 2% prilocaine, 2% mepivacaine, 2% lidocaine) or combinations of these.

Possible adjuncts to the local anesthetic:

- Epinephrine (5 µg/mL or 1 : 200 000; see Chapter 50, Adjuncts to local anesthesia)
- Hyaluronidase (150 IU; Hylase®, Pharma Dessau, Germany) [6]

The addition of hyaluronidase to local anesthetics leads to improved diffusion and thus to a faster onset. This provides very good conditions for surgical procedures in the eye.

Side effects and complications [16]

Hemorrhage in the very well vascularized orbit, with a frequency of 0.7–1.7% (known as “compartment syndrome”), can lead to blindness.

Conjunctival hemorrhage (20–100%).

Retinal detachment and vitreous hemorrhage after perforation of the eyeball can lead to loss of vision.

Subperiosteal hemorrhage due to contact between the needle and the orbital floor.

Chemosis (25–40%) due to fast injection of larger volumes of a local anesthetic.

Perforation of the eyeball and intraocular injections can occur, particularly in severely myopic patients. To avoid these, patients should gaze straight ahead throughout the block procedure.

Injury to the optic nerve or intraneural injection (immediate blindness).

Subarachnoid injection is a severe complication (see Chapter 37, p. 285).

Intravascular injection, with serious CNS intoxication (see Chapter 1, p. 9 and Chapter 6, p. 65).

Oculocardiac reflex: bradycardia due to the vasovagal reflex is observed in younger and frail patients and may be seen both during the block procedure and also intraoperatively.

Injury to the extraocular muscles (usually the inferior oblique muscle or inferior rectus muscle) can lead to muscle necrosis, contractions, or disturbances of healing.

Peribulbar block (extraconal anesthesia) [1, 10]

If there is a fear of complications due to retrobulbar injection in certain patients (e.g., severely myopic patients with a long eyeball), extensive anesthesia and partial akinesia can also be achieved using a peribulbar block for procedures in the anterior part of the eye. In this case, the local anesthetic can be injected extraconally. Several technical variations of peribulbar, periocular and
extraconal anesthesia have been described. The method most often used today is a “two-injection technique.”

**Materials**
(See retrobulbar block.)
Peribulbar needle, 25 G, 0.50 x 30 mm.

**Injection technique**
The areas selected for puncture are those that are least well perfused with blood.
- Inferior, extraconal, or inferotemporal injection (injection depth up to a maximum of 25 mm). The superior orbital fissure serves as a landmark (Fig. 2.9a).
- Superior, extraconal injection (just medial to the medial angle of the eyelid). The anterior lower orbital margin serves as a landmark (Fig. 2.9b).

**Dosage**
Slow injection of 3–5 mL local anesthetic per puncture point (see retrobulbar anesthesia). After the injection, an oculopressor should be used for ca. 10 min (Fig. 2.7). This allows better extraconal–intraconal diffusion of the injected local anesthetic.

**Disadvantages**
- In peribulbar anesthesia, injuries to the trochlea or superior oblique muscle can occur. Some authors therefore recommend avoiding upper supranasal injection. However, this can lead to poorer results with the block.
- Larger amounts of local anesthetic are needed to achieve adequate extraconal–intraconal diffusion (increased intra-ocular pressure).
- Slower times to onset.
- There is a higher failure rate with peribulbar anesthesia in comparison to retrobulbar anesthesia (10–20%).

**Complications**
- Perforation of the eyeball (1 : 12 000–16 000 cases)
- Peribulbar hemorrhage
- Eyelid ecchymosis

**Sub-Tenon block**
In the sub-Tenon block, the sub-Tenon capsule is separated from the sclera and elevated. After opening and introduction of a special blunt sub-Tenon needle, the local anesthetic is injected into the sub-Tenon space. This method represents an alternative to the two methods described above, in which potential complications such as eyeball perforation can be avoided.

**Preparations**
See retrobulbar block.
Regional anesthesia in ophthalmology

Materials (Fig. 2.10)
An eyelid speculum (e.g., Barraquer’s), Moorfield forceps, blunt Westcott scissors, blunt sub-Tenon needle, 5-mL syringe, solution for surface anesthesia of the conjunctiva (oxybuprocaine 0.4%), local anesthetic, hyaluronidase (15–150 IU/mL), 5% aqueous iodine solution to clean the conjunctiva.

Procedure (Fig. 2.11)
The conjunctiva and the Tenon capsule adhering to it (between the medial rectus muscle and the inferior rectus muscle) are elevated with the forceps ca. 5–7 mm away from the corneal limbus (inferonasal point).
The conjunctiva and Tenon space are opened using Westcott scissors.
Blunt preparation of the channel to the posterior sub-Tenon space then follows. The sclera should be visible.
The blunt sub-Tenon needle is introduced into the posterior sub-Tenon space. Resistance is felt during this procedure (the posterior sub-Tenon capsule and the sclera are close together).
Slow injection of the local anesthetic is then carried out.
After the injection, an oculopressor is placed for ca. 5–10 min (Fig. 2.7).
Motility checking of the eye then follows.

Dosage
2–4 mL of local anesthetic (e.g., 0.75% ropivacaine, 0.5% bupivacaine, 2% prilocaine, 2% mepivacaine, 2% lidocaine).
Combination with hyaluronidase (15–150 IU/mL) is recommended in order to improve the diffusion of the local anesthetic.

Potential complications
This method is associated with few potential complications, which include:
Subconjunctival injection (chemosis). Prophylaxis: addition of hyaluronidase and use of an oculopressor after the block.
Perforation of the sclera.
Subconjunctival hemorrhage.
Adverse cardiovascular events.

Advantages
Complications occur extremely rarely.

Disadvantages
Eyelid akinesia is variable and depends on the volume of local anesthetic injected.
About 10% of patients require supplementation with an additional block of the facial nerve (4%), surface anesthesia (2.6%) or retrobulbar block (0.8%).
Pain during injection.

Anticoagulation and ocular block
In patients who are taking anticoagulant medication, coagulation parameters (INR) should be checked before the procedure. Long needles with sharp tips increase the risk of hemorrhage. Smaller needles and single-shot injections appear to be safer, and the sub-Tenon technique is apparently safer still [9].

Fig. 2.11 Carrying out a sub-Tenon block.
a) The conjunctiva and Tenon capsule are opened with Westcott scissors.
b) The sub-Tenon needle is introduced into the posterior sub-Tenon space.
Facial nerve block

In the majority of intraocular procedures, it is necessary to prevent eyelid movement (orbicularis oculi muscle). This can be achieved by a distal infiltration block of the nerve endings of the facial nerve that provide the motor supply to the orbit.

Anatomy (Fig. 2.14)

The seventh cranial nerve carries motor fibers for the muscles of facial expression, and – in the intermediate nerve, a nerve fascicle emerging separately from the brain stem – gustatory fibers and visceral efferent secretory (parasympathetic) fibers. Both sections of nerve pass through the internal acoustic meatus and emerge as a neural trunk in the facial canal. The geniculate ganglion is located at the bend in the nerves in the petrous bone. The facial canal then courses via the tympanic cavity and turns caudally toward the stylomastoid foramen, through which the nerve exits from the skull. In the parotid gland, it divides into its end branches (parotid plexus). Before entering the parotid gland, the facial nerve gives off the posterior auricular nerve and

Additional blocks for eyelid akinesia

Fig. 2.12 Checking the motility of the eye

Fig. 2.13 Surface anesthesia

Local or surface anesthesia

Local anesthetic solutions in droplet form (known as non-akinetic methods of ocular anesthesia) can be applied externally if the surgeon requires only small incisions for procedures in the anterior part of the eye. Drip anesthesia is used in more extensive procedures as an additional method of infiltration and block anesthesia. Resorption of the local anesthetic through the mucosa is extremely fast. The introduction of oxybuprocaine represented a substantial advance in ocular anesthesia. This agent causes only a mild burning sensation, and has neither hyperemic nor vasoconstrictive effects. In addition, it has no effect on the pupil and only causes mild loosening of the corneal epithelium. With the patient gazing upward and with the head tilted backward, the drops are introduced into the conjunctival sac (Fig. 2.13).

This procedure cannot be generally recommended and is reserved for highly motivated and non-anxious patients. It is not suitable for deaf patients or patients with or speech difficulties.

Fig. 2.14 Anatomy of the facial nerve. (1) Facial nerve, (2) auriculotemporal nerve, (3) superficial temporal branches, (4) parotid plexus, (5) temporal branches, (6) zygomatictemporal branch of zygomatic nerve, (7) zygomaticofacial branch of zygomatic nerve, (8) buccal branches of facial nerve.
Fig. 2.15 Block for eyelid anesthesia. Van Lint method

Fig. 2.16 Block for eyelid anesthesia. O’Brien method

Fig. 2.17 Block for eyelid anesthesia. Atkinson method

Fig. 2.18 Block for eyelid anesthesia. Nadbath–Rehmann method
branches to the posterior belly of the digastric muscle and to the stylohyoid muscle. From the parotid plexus emerge the temporal branches, zygomatic branches, buccal branches, and marginal mandibular branch, and the cervical branch to the platysma. These branches supply the muscles of facial expression.

**Block techniques**

The facial nerve can be blocked using various techniques along its course to the orbit.

**Van Lint method** (Fig. 2.15)

The injection is carried out temporally from the exterior margin of the eyelid, or classically just below it temporally. A 23-G needle 30–40 mm long is initially introduced until bone contact is made. After careful aspiration, the injection is carried out medially and downward, and then medially and upward. Fan-shaped injection is carried out as the needle is advanced (dosage: 1.5–2 mL local anesthetic).

**O'Brien method** (Fig. 2.16)

The facial nerve trunk is blocked just above the condylar process of the mandible. It is helpful for the patient to open and close the mouth. After palpation of the condylar process of the mandible, a 25-G needle 30–40 mm long is introduced until bone contact is made, and 1 mL local anesthetic is injected. The needle is then withdrawn, followed by injections first in the caudal direction and then in the cranial direction (dosage: 2–3 mL local anesthetic).

**Atkinson method** (Fig. 2.17)

A 23-G needle 30–40 mm long is introduced below the exterior angle of the eye at the level of the zygomatic arch and is moved upward and outward (dosage: 3 mL local anesthetic).

**Nadbath-Rehmann method** (Fig. 2.18)

The blocking of the main trunk of the facial nerve is carried out directly underneath the mastoid process. A 25-G needle 30 mm long is introduced vertically to a depth of 1.5–2 cm (dosage: 2–3 mL local anesthetic).

**Block of peripheral branches of the trigeminal nerve**

See Chapter 4.
## Conduction anesthesia for intraocular procedures

**Block**

- **Right**  
- **Left**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
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<tbody>
<tr>
<td>Diagnosis:</td>
<td></td>
</tr>
<tr>
<td>Premedication:</td>
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### Purpose of block:

- **Surgery**

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<th>Needle:</th>
<th><strong>0</strong> G</th>
<th><strong>Sharp</strong></th>
<th><strong>Blunt</strong></th>
</tr>
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<tbody>
<tr>
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<th>i. v. access:</th>
<th><strong>Yes</strong></th>
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### Ventilation facilities:

- **ECG**  
- **Pulse oximetry**  

### Emergency equipment (drugs):

- **Checked**

<table>
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<th>Patient:</th>
<th><strong>Informed</strong></th>
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</table>

### Position:

- **Supine**  
- **Sitting**  
- **Semi-sitting**

### Approach:

- **Retrobulbar**  
- **Peribulbar**  
- **Sub-Tenon**

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<th><strong>Surface anesthesia</strong></th>
<th><strong>Other (facial nerve, trigeminal nerve)</strong></th>
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</thead>
</table>

### Sedoanalgesia before block:

- **Midazolam**  
- **Propofol**  

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<th><strong>Remifentanil</strong></th>
<th><strong>mg/kg</strong></th>
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</table>

### Local anesthetic:

- **mL**  
- **%**

### Addition to injection solution:

- **No**  
- **Yes**

### Patient’s remarks during injection:

- **None**  
- **Pain**  
- **Paresthesias**  
- **Warmth**

### Objective block effect after 15 min:

- **Akinesia**  
- **Mydriasis**  
- **Exophthalmos**  
- **Incomplete block**

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<th>Monitoring after block:</th>
<th><strong>&lt; 1 h</strong></th>
<th><strong>&gt; 1 h</strong></th>
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### Time of discharge:

#### Complications:

- **None**  
- **Yes (hematoma, intravascular injection, other)**

### VISUAL ANALOG SCALE

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### Special notes:

© Copyright ABW Wissenschaftsverlag 2004, Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
3 Occipital nerves
Greater occipital nerve
Lesser occipital nerve

Anatomy

After exiting from the lower edge of the obliquus capitis inferior muscle, the second cervical spinal nerve divides into anterior and posterior branches. The anterior branches of the first four cervical spinal nerves form the cervical plexus, which is covered by the sternocleidomastoid muscle. The superficial branches of the cervical plexus, which penetrate the cervical fascia and pass to the skin, include the sensory lesser occipital nerve (anterior branch from C2 and C3). This emerges at the posterior edge of the sternocleidomastoid muscle, above its midpoint. It ascends steeply along the splenius capitis muscle and divides into several branches (Fig. 3.1). The areas it supplies include the skin on the upper exterior side of the neck, the upper part of the auricle and the adjoining skin of the scalp.

The posterior branch of the second cervical spinal nerve passes in a dorsal direction around the obliquus capitis inferior muscle and runs between the occipitovertebral muscles and the semispinalis capitis muscle. Here it divides into three branches: an ascending branch, which supplies the longissimus capitis muscle; a descending branch, which anastomoses with the posterior branch of C3 (the third occipital nerve); and the medial greater occipital nerve (posterior branch of C2).

The sensory greater occipital nerve passes in a cranial direction, goes through the semispinalis capitis muscle and trapezius muscle and reaches the skin about 2–3 cm away from the midline in the area of the superior nuchal line. It gives off several branches toward the top of the head and extends laterally as far as the ear. The course of its branches follows the branches of the occipital artery.

Blocks of the greater and lesser occipital nerves

Indications

Blocks of the greater and lesser occipital nerves are carried out for prognostic, diagnostic and therapeutic
purposes in patients with painful conditions in the region of the back of the head.

**Diagnostic**
Differential diagnosis of pain at the back of the head – e.g., in suspected tumors of the posterior cranial fossa.

**Therapeutic**
Occipital neuralgia characterized by pain in the suboccipital area and back of the head [5].

Neuralgia of the occipital nerves caused by compression is anatomically almost impossible. The origin of the neuralgia must under all circumstances be identified. The cause is often degenerative change – e.g., in the vertebral column, or muscle tension with irritation of the nerve roots. There may also be articular disease or tumors in the second and third cervical dorsal roots. In whiplash injuries, consideration can be given to activation of the numerous myofascial trigger points – e.g., in the area of the cervical musculature, masticatory muscles and sternocleidomastoid, trapezius, occipitofrontal and suboccipital muscles – and simultaneous treatment of these is possible [6].

**Specific contraindications**
None.

**Procedure**

**Preparations**
Check that the emergency equipment is complete and in working order. Sterile precautions, skin prep.

**Materials**
Syringes (2 mL), fine 26-G needles (2.5 cm), disinfectant, swabs for compression (Fig. 3.2).

**Patient positioning**
Sitting, with head tilted forward slightly.

**Landmarks**
Occipital artery, inferior nuchal line: one-third of the distance between the external occipital protuberance and the foramen magnum.
tact is also sought at a slightly cranial angle and the needle is withdrawn a little, followed by aspiration and injection.

**Spread of the blocks**
The areas supplied are illustrated in Figure 3.5.

There are close anatomical connections both with the trigeminal nerve and with the third occipital nerve. The third occipital nerve in particular is often anesthetized as well.

**Dosage**

*Diagnostic*
0.5–1 mL local anesthetic – e.g. 0.5–1% prilocaine, mepivacaine, or lidocaine.

*Therapeutic*
1–1.5 mL local anesthetic – e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), often with 1–2 mg dexamethasone added.

Higher doses should be avoided due to the high vascular perfusion and resultant rapid absorption.

**Injection techniques**

*Greater occipital nerve*
The needle is inserted about 2.5 cm from the midline, directly medial to the easily palpable occipital artery. It is advanced at a slightly cranial angle (Fig. 3.3) between the insertions of the trapezius and semispinalis muscles until bone contact is made. After minimal withdrawal and aspiration, the local anesthetic is injected.

*Lesser occipital nerve*
The injection is carried out about 2.5 cm lateral to the puncture point described above (Fig. 3.4). Bone contact is also sought at a slightly cranial angle and the needle is withdrawn a little, followed by aspiration and injection.

**Block series**
When there is evidence of improvement in the symptoms, 8–12 blocks are indicated.

**Complications**
Inadvertent intra-arterial injection may occur, extremely rarely.

*Treatment measures*
See Chapter 6, p. 66.
The trigeminal nerve, the largest of the cranial nerves, exits from the pons with a small motor root (the portio minor) and a large sensory root (portio major).
In the semilunar cavity of the dura mater, the sensory root expands to become the trigeminal ganglion (semilunar ganglion). The motor root runs along the medial side of the ganglion to the mandibular nerve.

The trigeminal ganglion lies on the dorsal surface of the petrous bone. The three main branches originate from its anterior margin (Fig. 4.1): the ophthalmic nerve, maxillary nerve and mandibular nerve.

Ophthalmic nerve
The optic branch is purely sensory and passes lateral to the cavernous sinus and abducent nerve to the superior orbital fissure. It draws sympathetic fibers from the internal carotid plexus and in turn gives off sensory fibers to the oculomotor nerve, trochlear nerve and abducent nerve. Before entering the fissure, the ophthalmic nerve branches into the lacrimal nerve, nasociliary nerve and frontal nerve.

The frontal nerve runs along the levator palpebrae superioris muscle to behind the center of the orbital cavity. There it divides into the supraorbital nerve, which passes to the supraorbital notch, and the supratrochlear nerve, which runs in a medial direction toward the trochlea.

The branches of the supratrochlear nerve supply the upper eyelid, the root of the nose and the adjoining skin of the forehead (upper end branch), as well as the skin and conjunctiva of the medial canthus (lower end branch).
Maxillary nerve

The second branch of the trigeminal nerve is also purely sensory. It emerges from the skull through the round foramen and enters the pterygopalatine fossa. From here, it gives off the zygomatic nerve to the orbit and the pterygopalatine nerves – two very short nerves that connect with the pterygopalatine (sphenopalatine) ganglion (Fig. 4.11).

As a continuation of its trunk, the infraorbital nerve penetrates through the inferior orbital fissure to the base of the orbit, to the infraorbital groove and infraorbital canal. After passing through the infraorbital foramen, it reaches the facial surface of the maxilla. Here it divides into three groups of branches, which supply the side of the nose, the lower eyelid and the upper lip.

Mandibular nerve

As the largest branch of the trigeminal nerve, the mandibular nerve contains the sensory parts of the trigeminal ganglion and takes up the motor root of the trigeminal nerve.

After passing through the oval foramen, the mandibular nerve forms a short, thick nerve trunk, on the medial side of which lies the otic ganglion. In its later course, the mandibular nerve divides into an anterior trunk with mainly motor fibers and a posterior trunk with nerve branches and end fibers mainly consisting of sensory fibers. The most important nerves and areas of supply in the posterior trunk are:

- Mental nerve (skin and mucosa of the lower lip and chin)
- Inferior alveolar nerve (molar and premolar teeth of the mandible)
- Lingual nerve (floor of the mouth, mucosa of the anterior two-thirds of the tongue)
- Auriculotemporal nerve (ear, skin and fascia of the temple)

The sensory branch of the anterior trunk, the buccal nerve, supplies the skin and mucosa in the area of the buccinator muscle.

Fig. 4.2 (1) Supraorbital and supratrochlear nerves, (2) infraorbital nerve, (3) mental nerve
Blocks of the supraorbital and supratrochlear nerves

The end branches of these two nerves provide the sensory supply for the skin of the forehead, top of the nose and the skin and conjunctiva of the medial canthus (Fig. 4.2).

Indications

Diagnostic
Differential diagnosis of hyperalgesic zones – e.g. the frontal part of the occipitofrontalis muscle

Therapeutic
Trigeminal neuralgia of the first branch and post-herpetic neuralgia
Postoperative and post-traumatic pain
Minor surgical interventions (note higher doses) along the surface of the innervated area – e.g. removal of cysts and atheromas, wound care

Specific contraindications
None.

Procedure

Preparations
Check that the emergency equipment is complete and in working order. Sterile precautions.

Materials
2-mL syringes, fine 26-G needles (25 mm), disinfectant, swabs for compression (Fig. 4.3).

Skin prep
For all blocks.

Patient positioning
Supine.

Landmarks
Supraorbital foramen, upper angle of the orbit.
Supraorbital nerve: palpation of the supraorbital foramen at the orbital margin.
Supratrochlear nerve: palpation of the upper angle of the orbit on the medial side of the root of the nose.

Injection techniques
Supraorbital nerve
After palpation of the supraorbital foramen, a swab is laid on the eyelid to prevent uncontrolled spread of the local anesthetic. The needle is introduced as far as the supraorbital foramen (bone contact), slightly with-
drawn, and after aspiration the injection is carried out slowly (Fig. 4.5).

Supratrochlear nerve
After palpation of the upper angle of the orbit, a swab is laid on the eyelid to prevent uncontrolled spread of the local anesthetic. The needle is introduced at the upper internal angle of the orbit (Fig. 4.6) and minimally withdrawn after bone contact. Slow injection of the local anesthetic follows after careful aspiration.
Chapter 4

Fig. 4.5 Anesthetizing the supraorbital nerve

Fig. 4.6 Anesthetizing the supratrochlear nerve

Therapeutic
0.5–1 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.25–0.5% bupivacaine.

Surgical
Up to 5 mL local anesthetic.
Shorter procedures: e.g. 1% prilocaine or 1% mepivacaine.
Longer procedures: 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine).

Side effects
Possible hematoma formation (prophylactic compression).

After the injection, carry out thorough compression (massaging in) to prevent hematoma formation and to encourage the local anesthetic to spread.

Complications
Risk of blood vessel and nerve damage with injections into the foramina and bone channels.

No injections should be made into the supraorbital foramen due to the risk of nerve injury.

Blocks of the infraorbital nerve

The infraorbital nerve, the end branch of the maxillary nerve, emerges about 1 cm below the middle of the lower orbital margin through the infraorbital foramen (Figs. 4.2, 4.35).

Indications
Diagnostic
Differential diagnosis of trigger zones

Therapeutic
Trigeminal neuralgia in the second branch and post-herpetic pain
Facial pain in the innervation area of the infraorbital nerve, post-traumatic pain and pain after dental extraction
Minor surgical procedures on the surface of the area of distribution (note higher dosages)

Specific contraindications
None.

Dosage
Diagnostic
0.5–1 mL local anesthetic – e.g. 0.5–1% prilocaine, mepivacaine, lidocaine.

It is not necessary to elicit paresthesias. Look for bone contact, withdraw the needle slightly, aspirate and inject.
Procedure

Preparation and materials (Fig. 4.3)

Skin prep
For all blocks.

Patient positioning
Supine.

Landmarks
Infraorbital foramen, orbital margin (Figs. 4.2 and 4.4).

Extraoral injection
Palpation of the infraorbital foramen, about 1 cm below the middle of the lower orbital margin.

Intraoral injection
Palpation of the lower orbital margin.

Injection techniques

Extraoral injection
After palpating the infraorbital foramen, the needle is introduced cranially just below the palpation point until bone contact is made (Fig. 4.7) and then withdrawn slightly.

Intraoral injection
The center of the lower orbital margin is palpated and marked with the middle finger. The upper lip is raised with a spatula or with the thumb and index finger. The needle is introduced above the second premolar tooth toward the infraorbital foramen, until bone contact is made, and then withdrawn slightly (Fig. 4.8).

Dosages

Diagnostic
0.5–1 mL local anesthetic – e.g. 0.5–1% prilocaine, mepivacaine, lidocaine.

Therapeutic (extraoral technique)
0.5–1 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine).

For both of these techniques, it is important that slow injection of the local anesthetic should only be carried out after careful aspiration. Afterwards, thorough compression should be carried out to prevent hematoma formation and to obtain better distribution of the local anesthetic.

No injections should be made into the infraorbital canal due to the risk of nerve injury.
Complications
Injection into the bone canal carries a risk of nerve damage.

Blocks of the mental nerve
The mental nerve, the sensory end branch of the mandibular nerve, emerges from the mental foramen at the level of the second premolar (Fig. 4.2). It provides the sensory supply of the skin and mucosa of the lower lip and chin (Fig. 4.37).

Indications
Diagnostic
- Differential diagnosis of trigger points and hyperalgesic zones

Therapeutic
- Trigeminal neuralgia of the third branch
- Post-traumatic pain and pain in the innervation area of the mental nerve
- Dental treatment of canine tooth, first premolars and incisors of the lower jaw
- Post-dental extraction pain (intraoral technique)
- Surgical procedures on the surface of the lower lip (note higher dosages)

Specific contraindications
None.

Procedure
Preparation and materials (Fig. 4.3)
Skin prep
In all blocks.

Patient positioning
Supine.

Landmarks
Mental foramen (Figs. 4.2 and 4.4).

Extraoral and intraoral injection
Palpation of the mental foramen at the level of the second premolar.

Injection techniques
Extraoral injection
After palpation of the mental foramen, the needle is inserted about 2.5 cm lateral to the midline (Fig. 4.9) until bone contact is made.
Intraoral injection
After palpation of the mental foramen, the lower lip is pressed downward using a spatula. The needle is inserted between the first and second premolars, into the lower reflection of the oral vestibule, in the direction of the neurovascular bundle (Fig. 4.10).

Dosage
Diagnostic
0.5–1 mL local anesthetic – e.g. 0.5–1% prilocaine, mepivacaine, lidocaine.

Therapeutic (extraoral technique)
0.5–1 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine).

Surgical
Up to 5 mL local anesthetic extraorally.
Shorter procedures: 1% prilocaine or 1% mepivacaine.
Longer procedures: 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine).
Intraorally: 2–3 mL local anesthetic.

Side effects
Potential hematoma formation (prophylactic compression).

Complications
Injection into the bone canal carries a risk of nerve damage.

Blocks of the maxillary nerve and pterygopalatine ganglion
The maxillary nerve emerges from the skull through the round foramen. It connects with the pterygopalatine (sphenopalatine) ganglion in the pterygopalatine fossa (Fig. 4.11). The nerve and ganglion are responsible for sensory and autonomic supply to the central area of the face and head.

Fig. 4.11 (1) Trigeminal ganglion (Gasserian ganglion) and (2) pterygopalatine fossa with the maxillary nerve, (3) pterygopalatine ganglion and (4) maxillary artery

For both of these techniques, it is important that slow injection should only be carried out after careful aspiration. Afterward, thorough compression should be carried out to prevent hematoma formation and to obtain better distribution of the local anesthetic.

Injections should never be made into the mental canal, due to the risk of nerve injury.
Indications
Diagnostic
Differential diagnosis of facial pain

Therapeutic
Trigeminal neuralgia in the second branch, postherpetic neuralgia
Cluster headache [6], histamine headache, Sluder's neuralgia [19]
Facial pain in the area of supply
Pain in the eye region (iritis, keratitis, corneal ulcer), root of the nose, upper jaw and gums
Postoperative pain in the area of the maxillary sinus and teeth
Pain after dental extraction

Neural therapy
- Hay fever, vasomotor rhinitis
- Diseases of the oral mucosa
- Localized paresthesias

Specific contraindications
Bleeding diathesis, anticoagulation treatment.

Procedure
These blocks should only be carried out only with appropriate experience. It is absolutely necessary to have a detailed discussion with the patient before the procedure.

Preparations
Check that the emergency equipment is complete and in working order. Sterile precautions. Intravenous access.

Fig. 4.12 Nerves and ganglia in the vicinity:
(1) otic ganglion, (2) pterygopalatine ganglion
Materials
2-mL syringe, 22-G needle (40 mm) for the intraoral technique, 5-mL and 10-mL syringe, 23-G needle (60 mm) for the extraoral technique. Disinfectant, spatula for the intraoral technique, compresses, cooling element available, emergency drugs (Fig. 4.13).

Skin prep
In all blocks.

Intraoral technique

Patient positioning
The patient should be sitting, leaning back slightly and with the head tilted back.

Landmarks
Posterior edge of the upper seventh tooth (second maxillary molar) (Fig. 4.14).

Injection technique
Using a 22-G needle (40 mm), the puncture is made medial to the posterior edge of the upper seventh tooth (second maxillary molar) through the greater palatine foramen. The needle is introduced at an angle of about 60°. The vicinity of the ganglion is reached at a depth of 3.5–4 cm. The greater palatine canal is about 3.4 cm long in adults. After careful aspiration at various levels, the local anesthetic is injected (Fig. 4.15).

Dosage
Therapeutic
Intraorally: 1–2 mL local anesthetic – e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine).

Extraoral technique

Above the zygomatic arch (suprazygomatic technique)

Intraoral access is associated with fewer complications.

Patient positioning
Sitting, with face to the side and with the mouth slightly opened. Alternative: supine.

Landmarks
Center of the upper margin of the zygomatic arch.
**Injection technique**

A skin injection is made directly above the middle of the zygomatic arch. A 6-cm long needle is introduced at an angle of ca. 45° in the direction of the pterygopalatine fossa (contralateral molar teeth) (Fig. 4.16). After paresthesias have been elicited in the area of the nostril, the upper lip and the cheek, the needle is withdrawn slightly and aspirated carefully at various levels, and the local anesthetic is administered slowly in several small doses. Repeated aspiration at various levels must be carried out during this procedure.

Separate blocking of the maxillary nerve and pterygopalatine region is rarely possible with this method.

**Below the zygomatic arch**

**(infrazygomatic technique)**

**Patient positioning**

Supine or sitting, face to the side with the mouth slightly open.

**Landmarks**

Mandibular fossa.

**Injection technique**

The most important requirement for carrying out this block successfully is accurate location of the mandibular fossa between the condylar and coronoid processes of the mandible. It is helpful for the patient to open and close the mouth. After skin infiltration, a 6-cm needle is introduced at an angle of 45° in the direction of the back of the eyeball (Fig. 4.17). After ca. 4-4.5 cm, the lateral part of the pterygoid process is reached and the needle is withdrawn slightly and lowered into the pterygopalatine fossa (about 0.5 cm medial to the pterygoid). After the paresthesias described above have been elicited and after careful aspiration at various levels, the local anesthetic is carefully injected in several small doses. If pain occurs in the region of the orbit, the procedure should be stopped.

**Dosage**

*Diagnostic*

Up to 5 mL local anesthetic – e.g. 0.5% prilocaine, mepivacaine, lidocaine.

*Therapeutic*

Extraorally: 5-10 mL local anesthetic – e.g. 0.5% ropivacaine, 0.25% bupivacaine (0.25% levobupivacaine). In acute conditions, with 1-2 mg dexamethasone added.

*Surgical*

Extraorally: 5-10 mL local anesthetic – e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

**Block series**

A sequence of six to eight blocks is recommended for the extraoral technique.
Side effects

Transient visual weakness (extremely rare). Horner’s syndrome, extremely rare and usually with high doses. There are connections with the superior cervical ganglion via the pterygoid canal, deep petrosal nerve and greater superficial petrosal nerve.

Hematoma in the cheek or orbital cavity due to blood vessel puncture (Figs. 4.18 and 4.19). Immediate outpatient treatment: alternating ice-pack and heparin ointment, depending on the spread of the hematoma, for ca. 1 h. This can be continued at home, with the patient also taking coated Reparil® tablets (sodium aescinate) if appropriate. Resorption of the hematoma, which is harmless but visually uncomfortable for the patient, occurs within 2 weeks at the most.

Complications

Intravascular injection (maxillary artery and maxillary vein; Fig. 4.27).
Epidural or subarachnoid injection (Fig. 4.28).

Both of these complications are extremely rare. Immediate treatment: see Chapter 6, p. 66f.

The maxillary artery and vein lie in the immediate vicinity.
Chapter 4

Record and checklist

Maxillary nerve and pterygopalatine ganglion

Block no. □ Right □ Left

Name: __________________ Date: __________________

Diagnosis: __________________

Premedication: □ No □ Yes

Purpose of block: □ Diagnostic □ Therapeutic

Needle: □ 22 G □ 40 mm long □ 60 mm long

i.v. access: □ Yes □ No

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

Position: □ Supine □ Sitting

Approach: □ Above the zygomatic arch □ Intraoral
□ Below the zygomatic arch (mandibular fossa)

Local anesthetic: □ ml □ %

Test dose: □ ml

Addition to injection solution: □ No □ Yes

Patient’s remarks during injection: □ None □ Pain □ Paresthesias □ Warmth

Nerve region

Objective block effect after 15 min:
□ Cold test □ Temperature measurement right ___°C left ___°C
□ Numbness (V1)

Monitoring after block: □ < 1 h □ > 1 h

Time of discharge

Complications: □ None □ Yes (hematoma, intravascular, injection, other)

Subjective effects of the block: □ None □ Increased pain □ Reduced pain □ Relief of pain

VISUAL ANALOG SCALE

Duration:

0 10 20 30 40 50 60 70 80 90 100

Special notes:

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
The pterygopalatine (sphenopalatine) ganglion, which lies in the pterygopalatine fossa (sphenomaxillary fossa), is triangular in shape; extending to ca. 5 mm, it is the largest neuronal conglomerate outside of the brain. The ganglion has three types of nerve fiber and is connected to the trigeminal nerve via sensory fibers. It is linked to the facial nerve, internal carotid plexus and superior cervical ganglion via sympathetic fibers; the motor fibers have parasympathetic (visceromotor) connections. There is also direct contact between the anterior horn of the spinal cord and the neurohumoral axis (adenohypophysis) [15, 21].

**Indications**

Greenfield Sluder [19] drew attention to the significance of this ganglion as long ago as 1903. In 1918, he described a number of symptoms capable of being treated by injection or topical application of a local anesthetic or cocaine, with the associated anesthesia of the pterygopalatine ganglion: headache; pain in the eyes, mouth, or ears; lumbosacral pain, arthritis, glaucoma and hypertension. Similar observations were reported by Ruskin [17], Byrd and Byrd [5] and Amster [1].

More recent studies [3, 8, 14, 16] have shown that nasal local anesthesia of the ganglion can be used with good success rates in the treatment of:

- Acute migraine
- Acute or chronic cluster headache
- Various types of facial neuralgia
- Tumor pain in the nasal and pharyngeal area

**Specific contraindications**

None.

**Procedure**

**Materials** (Fig. 4.20)

- 2-mL syringe, plastic part of a plastic indwelling catheter (for self-administration in tumor pain), nasal speculum, applicators (cotton buds).

**Patient positioning**

Supine or sitting, with head tilted back.

**Application**

An applicator soaked in local anesthetic – e.g. 2% lidocaine gel or a 4% aqueous lidocaine solution – preferably a cotton bud – is carefully advanced along the inferior nasal concha as far as the posterior wall of the nasopharynx (Fig. 4.21) and left in place for 20–30 min (Fig. 4.22). In patients with cancer pain, the plastic part of a plastic indwelling catheter can be advanced as far as possible into the nasal cavity, and the local anesthetic – e.g. 0.5% bupivacaine – can be instilled with a 2-mL syringe. The block can be carried out bilaterally.

**Dosage**

Local anesthetics: 2% lidocaine gel, 1.5–2 mL 4% lidocaine (aqueous solution) or 1.5–2 mL bupivacaine. Disadvantage: the onset of effect is slightly slower.

**Fig. 4.20 Materials**

**Fig. 4.21 Nasal application**
Chapter 4

Block of the mandibular nerve and otic ganglion

After passing through the oval foramen, the mandibular nerve forms a short, thick nerve trunk, with the otic ganglion lying on the medial side of it. Its most important branches (Fig. 4.23) are the buccal nerve, lingual nerve, inferior alveolar nerve, mental nerve and auriculotemporal nerve.

Indications
Diagnostic
Differential diagnosis of trigeminal neuralgia (anterior two-thirds of the tongue) and glossopharyngeal neuralgia (posterior third of the tongue)

Therapeutic
Tinnitus (the otic ganglion has connections with the chorda tympani, the nerves of the pterygoid canal and the medial pterygoid nerve)
Trigeminal neuralgia in the third branch
Trismus after dental extraction
Dental surgery and maxillary surgery (higher dosages required)
Temporomandibular joint dysfunction syndrome (in collaboration with an orthodontist), if infiltration of the trigger points of the temporalis muscle, lateral pterygoid muscle and masseter muscle is unsuccessful

Specific contraindications
Bleeding diathesis, anticoagulation treatment.

Procedure
This block should only be carried out only with appropriate experience. It is absolutely necessary to have a detailed discussion with the patient before the procedure.

Preparation and materials (Fig. 4.13)

Skin prep
In all blocks.

Patient positioning
Supine, with face to the side.

Landmarks
Mandibular fossa, zygomatic arch, tragus (the needle insertion point lies ca. 2 cm laterally, Fig. 4.24).

Injection technique
After skin infiltration, a 60-mm needle is introduced into the skin perpendicularly (Fig. 4.25).

Fig. 4.22 The anesthetic should be allowed 20–30 min to take effect

10% cocaine: at a dosage of 0.2–0.4 mL, there is no reason to fear adverse CNS effects [3]. Advantage: very fast onset of effect.
If the recommended doses are used, there is no difference between these substances with regard to effectiveness and resorption.

Block series
In acute pain, one or two applications are recommended. In chronic conditions, one to three applications can be given over a period of up to 3 weeks. In cancer pain, applications may be indicated three times per day over a longer period.

Side effects
The method is not very invasive and has minimal side effects. Effects that may occur include: a sense of pressure in the nose, sneezing, short-term lacrimation due to irritation of branches of the lacrimal gland, a bitter taste and slight numbness in the oral and pharyngeal cavity.

Complications
Very occasionally, toxic effects may occur as a result of absorption of the local anesthetic into very well vascularized tumor tissue. In long-term treatments, erosions may sometimes lead to spinal absorption of the local anesthetic. To prevent this, periodic rinsing with a physiological saline solution can be carried out.
Fig. 4.23 Distribution areas of: (1) mandibular nerve; (2) buccal nerve; (3) lingual nerve; (4) inferior alveolar nerve; (5) mental nerve; (6) auriculotemporal nerve

Fig. 4.24 The most important requirement is that the mandibular fossa should be identified precisely. It lies between the condylar process and the coronoid process of the mandible and is easiest to localize when the patient opens and closes his or her mouth.

Paresthesias in the lower jaw region, lower lip and lower incisors occur when the needle reaches a depth of ca. 4–4.5 cm.

Fig. 4.25 Needle insertion technique: the needle is directed at an angle of 90°.

After paresthesias have clearly developed, the needle is withdrawn slightly, aspirated carefully at various levels and the local anesthetic is slowly injected in several
small doses. Aspiration should be repeated several times at different levels as this is done. There is a delayed onset of the desired effect in the area of the auriculotemporal nerve.

If contact is made with the pterygoid process when the needle is being introduced, withdraw the needle 0.5–1 cm and redirect dorsally.

### Distribution of the block
The area supplied by the mandibular nerve is shown in Figure 4.32. The otic ganglion (Fig. 4.26), which lies directly under the oval foramen, is always anesthetized along with the nerve.

### Dosage

**Diagnostic**
Up to 5 mL local anesthetic – e.g. 5% prilocaine, mepivacaine, lidocaine.

**Therapeutic**
5–10 mL local anesthetic – e.g. 0.5% ropivacaine, 0.25% bupivacaine (0.25% levobupivacaine).
In acute conditions, with 1–2 mg dexamethasone added.

**Surgical**
10 mL local anesthetic – e.g. 0.75% ropivacaine, 0.5 bupivacaine, 1% prilocaine, 1% mepivacaine.

### Block series
A series of six to eight blocks is recommended. When there is evidence of symptomatic improvement, further blocks can also be carried out.

### Side effects

Transient facial paralysis caused by injecting too superficially.
Hematoma in the cheek due to vascular puncture. These harmless hematomas can take up to two weeks to resolve.
Immediate treatment: see the section on blocks of the maxillary nerve and pterygopalatine ganglion, Figs. 4.18 and 4.19.

### Complications

Intravascular injection (middle meningeal artery and maxillary artery, Fig. 4.27).
Epidural or subarachnoid injection (Fig. 4.28). Immediate treatment: see Chapter 6, p. 67.
Mandibular nerve and otic ganglion

Block no. □ Right □ Left

Name: ___________________ Date: ___________________
Diagnosis: ___________________
Premedication: □ No □ Yes

Purpose of block: □ Diagnostic □ Therapeutic
Needle: □ 22 G □ 50 mm long □ 60 mm long
i.v. access: □ Yes □ No
Monitoring: □ ECG □ Pulse oxymetry
Ventilation facilities: □ Yes (equipment checked)
Emergency equipment (drugs): □ Checked
Patient: □ Informed

Position: □ Supine □ Sitting
Approach: □ Mandibular fossa

Local anesthetic: ______ ml ______ %
Testdose: ______ ml

Addition to injection solution: □ No □ Yes

Patient's remarks during injection:
□ None □ Pain □ Paresthesias □ Warmth

Nerve region: ___________________

Objective block effect after 15 min:
□ Cold test □ Temperature measurement right _____°C left _____°C
□ Numbness (V,)

Monitoring after block: □ < 1 h □ > 1 h

Time of discharge: ___________________

Complications: □ None □ Yes (hematoma, intravascular injection, other)

Subjective effects of the block: Duration: ___________________
□ None □ Increased pain
□ Reduced pain □ Relief of pain

VISUAL ANALOG SCALE

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|----------------|

Special notes: ___________________

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Chapter 4

Gasserian ganglion block

The trigeminal ganglion (semilunar ganglion, Gasserian ganglion) lies on the dorsal surface of the petrous bone. The intracranial Gasserian ganglion lies medially in the middle cranial fossa, lateral to the cavernous sinus, internal carotid artery and cranial nerves III-VI, and posterior and superior to the oval foramen, through which the mandibular nerve exits from the intracranial cavity (Fig. 4.29). All of these structures can be injured when the ganglion is blocked. The average size of the ganglion is ca. 1–2 cm.

Part of the ganglion (the posterior two-thirds) is located within the trigeminal cave (Meckel cavity), a duplication of the dura that encloses the ganglion. The oval foramen is a channel ca. 5 mm long and its largest diameter is ca. 8 mm.

Indications

Local anesthetics

Diagnostic, before neurodestructive procedures.

Neurodestructive procedures

Neurodestructive methods – particularly radiofrequency lesions of the ganglion, and more rarely glycerol rhizolysis, alcohol injection, corticosteroid injection, or balloon compression of the ganglion – are used in pain conditions that are unbearable and cannot be influenced using other conservative measures:

- Cancer pain
- Trigeminal neuralgia
- Cluster headache
- Pain in the eye region
- Post-herpetic neuralgia

Specific contraindications

Local infection, sepsis, hemorrhagic diathesis, anticoagulation treatment, significantly increased intracranial pressure.

Procedure

This block should only be carried out by highly experienced specialists. A very good knowledge of anatomy, manual skill, radiographic guidance when conducting the procedure, and strictly aseptic conditions are required. It is necessary to have a detailed discussion with the patient before the procedure.

Premedication

This method is painful, and preoperative administration of 0.05 mg fentanyl is therefore recommended.

Preparations

The completeness and functioning of the emergency equipment should be checked. Sterile precautions. Intravenous access, ECG monitoring, ventilation facilities, pulse oximetry.

Materials

A fine 22-G spinal needle 80 mm long, 2-mL and 5-mL syringes, disinfectant, sterile compresses, emergency medication, intubation kit, and cooling element should be ready to hand.

Skin prep

In all blocks.

Patient positioning

Supine; the head is raised with a cushion.

Landmarks (Fig. 4.30)

- Medial edge of the masseter muscle, ca. 3 cm lateral from the angle of the mouth at the level of the second molar tooth.
- Ipsilateral pupil.

Fig. 4.29 The trigeminal ganglion and the neighboring cranial nerves and internal carotid artery. (1) Optic nerve. (2) internal carotid artery. (3) oculomotor nerve. (4) trochlear nerve. (5) trigeminal nerve. (6) abducent nerve.
Center of the zygomatic arch and articular tubercle (external acoustic meatus).

The following should be noted during puncture:
- The operator should stand on the side on which the block is being carried out.
- Radiographic guidance for the puncture is indispensable.
- An intraoral location should be excluded after introduction of the needle (risk of contamination).
- There is a risk of perforating the dural cuff (subarachnoid injection).
- Frequent aspiration and fractionated injection of the smallest possible fractions (blood, CSF?).

**Needle insertion technique**

Local anesthesia at the needle insertion site is carried out ca. 3 cm from the angle of the mouth (medial edge of the masseter muscle). The patient is asked to gaze straight ahead and focus on a marked point on the wall. The needle should be directed toward the forward-gazing pupil when seen from the front and toward the articular tubercle of the zygomatic arch or external acoustic meatus when viewed from the side (Fig. 4.30).

The needle is then introduced at the level of the second molar tooth, through the previous skin injection in the direction indicated. An intraoral location of the needle must be excluded (risk of contamination). After 4.5–6 cm, bone contact should be made (infratemporal surface of the large wing of the sphenoid bone, directly in front of the upper boundary of the oval foramen; Fig. 4.31). The needle is now withdrawn slightly, and the path to the oval foramen (ca. 1–1.5 cm away from the first bone contact; Fig. 4.31) is probed millimeter by millimeter by advancing and withdrawing.
the needle. If the tip of the needle is located in the oval foramen, the patient will report pain and paresthesias in the area of distribution of the mandibular nerve (mandible). The needle is now slowly advanced for a further 0.5–1 cm. A small test dose of 0.1–0.2 mL local anesthetic is carefully administered. The remaining dose of 1–1.5 mL is injected in small fractions with constant aspiration. Particular attention should be given to possible subarachnoid or intravascular positioning of the needle. The sensory distribution of the block is shown in Figure 4.32.

**Dosage**

1–2 mL local anesthetic – e.g. 1% lidocaine, 0.5–0.75% ropivacaine, or 0.5% bupivacaine.

**Complications**

*Subarachnoid injection (total spinal anesthesia)*

(Fig. 4.28)

Immediate measures: see Chapter 6, p. 67.

Important prophylactic measures:

- Very good knowledge of anatomy
- Precise execution of the procedure (radiographic guidance)
- Careful dosage

- Constant aspiration and injection in the tiniest fractions of 0.1 mL local anesthetic (several test doses)
- No time pressure

*Intravascular injection (Fig. 4.27)*

Intravascular injection (middle meningeal artery) is always possible (in this highly vascularized region).

*Hematoma in the cheek or orbit due to vascular puncture* (Figs. 4.18 and 4.19)

Immediate measures: see p. 43.

*Transient visual weakness or blindness*  
Optic nerve; extremely rare.

**Trigeminal nerve: comparison of analgesia zones**

Figures 4.33 to 4.37 provide schematic illustrations of the areas supplied by the individual nerves. During blocks, the anesthetic spread may overlap.
Trigeminal nerve

Fig. 4.34 Maxillary nerve
Fig. 4.35 Infracircular nerve
Fig. 4.36 Mandibular nerve
Fig. 4.37 Mental nerve
### Trigeminal ganglion (Gasserian ganglion)

<table>
<thead>
<tr>
<th>Block</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td>Date:</td>
<td></td>
</tr>
<tr>
<td>Diagnose:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Premedication:</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Purpose of block:</td>
<td>Diagnostic</td>
<td>Therapeutic</td>
</tr>
<tr>
<td>Needle:</td>
<td>22 G</td>
<td>80 mm long</td>
</tr>
<tr>
<td>i.v. access:</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Monitoring:</td>
<td>ECG</td>
<td>Pulse oximetry</td>
</tr>
<tr>
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<td>Subarachnoid injection</td>
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### VISUAL ANALOG SCALE

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Chapter 5: Infiltration of trigger points in the muscles of mastication

Temporomandibular joint pain-dysfunction syndrome

This chapter describes injection techniques in the three clinically most relevant muscles of the temporomandibular joint - the masseter muscle, temporalis muscle, and lateral pterygoid muscle.

It was dental specialists who carried out most of the research that led to the recognition of the muscular components of the general craniofacial pain syndrome. These syndromes are often associated with definite signs of temporomandibular joint dysfunction. In 1969, Laskin [1] presented the classic definition of the myofascial pain-dysfunction (MPD) syndrome. For this diagnosis, he required that only one of the following requirements should be met:

1. Unilateral pain, usually in the ear or in the preauricular area.
2. Pressure pain in the muscles of mastication.
3. A creaking or cracking noise in the temporomandibular joint.
4. Restricted opening of the mouth.

A lack of clinical or radiographic evidence of organic changes in the temporomandibular joint is characteristic. Targeted injections into identified trigger points (TrPs) have an important role as a supplementary measure in addition to other corrective dental measures, stretching exercises, sprays, etc.

Masseter muscle ("trismus muscle")

The anatomic insertions of the masseter muscle are located in the zygomatic arch and maxilla at the top and on the external surface of the ramus of the mandible and angle of the mandible at the bottom (Fig. 5.1).

Symptoms of active trigger points in this muscle (occluder) are marked restriction of mouth opening (trismus), dental pain (lower and upper molar teeth), and unilateral tinnitus (deeper muscle; Fig. 5.1).

Procedure

Materials

Sterile precautions, 25-G needle 25 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.

Injection technique

Superficial layer of the muscle

The trigger points in the middle and lower belly of the muscle are located using what is known as "pincer-grip palpation" with the mouth open and the jaw supported, so that they can be held between the fingers (Fig. 5.2). The needle is advanced until bone contact is made (mandible) and then withdrawn 1–2 mm (Fig. 5.3). The injection is carried out after aspiration.

Deeper layer of the muscle

This layer lies on the posterior part of the ramus of the mandible. The mouth is opened wide and the depression directly underneath the head of the mandible in front of the external auditory canal is palpated (Fig. 5.4).
Fig. 5.2 Masseter muscle. Palpation using what is known as the “pincer grip.” Searching for trigger points in the superficial part of the muscle.

Fig. 5.3 Masseter muscle. Injection into the superficial part of the muscle.

Fig. 5.4 Masseter muscle. Injection into the deeper part of the muscle.

Fig. 5.5 (1) Temporal muscle. Myofascial trigger points with referred pain (temporal headache and maxillary dental pain). (2) Coronoid process. Illustration adapted from Travell and Simons [3].
Infiltration of trigger points in the muscles of mastication

Dosage
0.5–1 mL local anesthetic per TrP – e.g. 0.2–0.5% ropivacaine, 0.5% procaine, 0.5% lidocaine.

Temporal muscle ("temporal headache and maxillary dental pain")

The anatomic insertions of the temporal muscle (occluder) are at the temporal bone at the top and on the fascia of the temporal fossa, and on the coronoid process of the mandible at the bottom. Four trigger points have been described (Fig. 5.5). The symptoms include temporal headache and dental pain in the maxillary teeth.

Procedure

Materials
Sterile precautions, 25-G needle 25 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.

Injection technique
The patient is asked to open the mouth slightly to relax the muscles. Pulsation in the temporal artery is palpated. One finger is kept constantly on the artery to avoid inadvertent injection, while the other finger palpates and fixes the TrP. The needle is introduced obliquely until bone contact is made, and then withdrawn by 1 mm. After aspiration, the local anesthetic is injected (Fig. 5.6).

After infiltration and massaging of the injected area, a cooling spray and passive stretching of the muscle are applied. This is followed by warm packing and then active jaw movements.

Dosage
0.5–1 mL local anesthetic per TrP – e.g. 0.2–0.5% ropivacaine, 0.5% procaine, 0.5% lidocaine.

Lateral pterygoid muscle ("pain radiating deep into the temporomandibular joint")

Anatomy
The upper part inserts anteriorly at the sphenoid bone and posteriorly at the articular disk and temporomandibular joint capsule. The lower part inserts anteriorly at the lateral pterygoid plate and posteriorly at the neck of the mandible (Fig. 5.7).

Symptoms
The lateral pterygoid muscle (jaw opening) transfers pain deep into the temporomandibular joint and to
Chapter 5

Fig. 5.8 Lateral pterygoid muscle. Injection into the upper part of the muscle

Fig. 5.9 Lateral pterygoid muscle. Injection into the lower part of the muscle

the **maxillary sinus region** (Fig. 5.7). The pain is always combined with functional disturbances of the joint. The muscle's trigger points are the most important myofascial cause of referred pain in the area of the temporomandibular joint (this myofascial syndrome is often confused with temporomandibular joint arthritis).

**Procedure**

**Materials**

Sterile precautions, 23-G needle 40 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.

**Extraoral injection technique**

A good knowledge of the anatomy is a prerequisite for carrying out this injection, as the full extent of the muscle cannot be palpated extraorally.

**Upper part**

A vertical puncture is made in an easily palpable depression just above the zygomatic arch and, after aspiration, infiltration is carried out up to a depth of 1.5–2 cm (Fig. 5.8).

**Lower part**

The patient is asked to open the mouth wide. The needle's path lies through the masseter muscle. The needle is introduced through the mandibular notch at an angle of ca. 45° in the direction of the upper molar teeth at a depth of ca. 3–4 cm (Fig. 5.9). After aspiration, the injection is carried out.

**Dosage**

1–2 mL local anesthetic per TrP – e.g. 0.2–0.5% ropivacaine, 0.5% procaine, 0.5% lidocaine.
There are two sympathetic trunks arranged paravertebrally that belong to the peripheral autonomic nervous system. In the area of the neck, these include four sympathetic trunk ganglia on each side, serving as cholinergic switchpoints: the superior and middle cervical ganglia, the vertebral ganglion and the cervicothoracic ganglion (Fig. 6.1).

The cervicothoracic ganglion (stellate ganglion) at the level of C7-T1 arises from the fusion of the lowest cervical ganglion (7th and 8th cervical ganglion) with the highest thoracic ganglion (1st and/or 2nd thoracic ganglion).

The immediate vicinity of the ganglion is dominated by the first rib, the pleura and the brachial plexus. The ganglion lies ventral to the vertebral artery, medial and dorsal to the common carotid artery and the jugular vein, and lateral to the esophagus and trachea. It is separated from the transverse processes of the 6th and 7th cervical vertebrae by the longus colli muscle (Fig. 6.2).

It receives afferent fibers from the white rami communicantes of the 1st and 2nd thoracic nerves and gives off gray rami communicantes to the 1st (and 2nd) thoracic nerves and the 8th (and 7th) cervical nerves.

The stellate ganglion is connected to the neighboring ganglia, the brachial plexus, the cranial intercostal nerves and the phrenic nerve, and to the vagus nerve and recurrent laryngeal nerve (Fig. 6.3). Fibers from the gray rami communicantes also supply the heart and great vessels (subclavian, carotid, vertebral, inferior thyroid and intercostal arteries), the esophagus and the trachea, as well as the thymus gland (Fig. 6.4).

The size and development of the stellate ganglion are subject to considerable variation. Average sizes of between 25 mm (15–50 mm) x 3–10 mm x 5 mm have been reported (Fig. 6.5) [17, 18, 25]. This corresponds to the size of the superior cervical ganglion and is much more voluminous than the middle cervical ganglion. On the other hand, the stellate ganglion is only developed in 80% of patients; some authors [17,18] have only been able to identify it in 38% of individuals studied.

Fig. 6.1 The cervical ganglion trunk: (1) superior cervical ganglion, (2) middle cervical ganglion and (3) cervicothoracic ganglion
Stellate ganglion block

Indications
Block of the stellate ganglion is a useful method of pain therapy in patients with perfusion disturbances in the areas of the head, neck, upper extremities and upper thoracic wall.

The following indications have been described in the literature:

- Vasospastic diseases in the areas of the face, shoulder and arm.
- Arterial dysfunctions: Raynaud–Burger syndrome, anterior scalene syndrome, Volkmann’s ischemic contracture.
- Venous dysfunctions: thrombophlebitis, postphlebitic edema.
- Combined dysfunctions – e.g. lymphedema after mastectomy.
- Head: intracranial vascular spasms, facial paralysis, vertigo, central post-stroke syndrome (contralateral block!).
- Eye: central vein thrombosis, occlusion of the central retinal artery.
- Nose: vasomotor rhinitis.
- Ear: Ménière’s disease [10, 11, 13, 24], sudden deafness [15], tinnitus.

Our own results in the treatment of tinnitus show that up to 8 weeks after the start of the disease, 80% of patients can be successfully treated using 2–10 blocks over a period of 1–6 weeks. Up to 12

---

Fig. 6.2 The immediate vicinity of the stellate ganglion: (1) pleura, (2) brachial plexus, (3) vagus nerve; (4) recurrent laryngeal nerve; (5) trachea

Fig. 6.3 Close anatomical connections in the ganglion trunk include those to (1) the phrenic nerve, (2) the recurrent laryngeal nerve, (3) the vagus nerve and (4) the brachial plexus
weeks after the start of the disease, the success rate with 10–16 blocks, spread over a period of 6 weeks, was only 35%. If the condition had been present for more than 6 months, block treatment was unsuccessful.

Traumatic cerebral edema [9].
Complex regional pain syndrome (CRPS) in the area of the face, neck and arm [35].
Phantom pain.
Hyperhidrosis.
Joint stiffness.
Positive effect on the immune system [21].
Acute herpes zoster and zoster neuralgia in the head and neck region.
A trigeminal and cervical localization is reported in ca. 25% of cases. Good to very good results are obtained with stellate ganglion block in acute zoster (with opioids added if necessary [8]).

In assessing the success rates reported in the literature, it should be noted whether a distinction has been made between acute and chronic herpes zoster. The 85% success rate reported by Colding [4] when treatment was initiated within 3 weeks of the start of disease confirms the results reported by other authors [5, 29, 32, 36]. Milligan and Nash [23] regard 1 year after the start of disease as being the limit for treatment with stellate ganglion block. The results of their block series – freedom from pain in 22% of patients – are therefore not comparable.

Our own results [15] in the treatment of zoster neuralgia: up to 12 weeks after the start of disease, the success rate with 7–19 blocks, spread over a period of 3–10 weeks, was 80%. If the disease had started 6 months or more previously, the results were varied and unsatisfactory.

**Specific contraindications**

Grade 2 atrioventricular (AV) block, contralateral pneumothorax, recent thrombolytic therapy after myocardial infarction or pulmonary embolism, anticoagulation treatment, severe asthma/emphysema (if appropriate, priority can be given to block of the superior cervical ganglion here; see Chapter 7), paralysis of the contralateral phrenic nerve or recurrent laryngeal nerve. In addition, blocks should never be carried out bilaterally at the same time.

![Fig. 6.4](image-url) Fibers from the gray rami communicantes supply the heart, esophagus, airways and thymus.

![Fig. 6.5](image-url) The immediate vicinity of the ganglion (transverse section). (1) First rib, (2) subclavian artery and scalenus anterior muscle, (3) jugular vein, (4) second rib, (5) cervicothoracic ganglion, (6) common carotid artery and thyroid gland, (7) T2 intervertebral artery and zygapophyseal joint, (8) T2 vertebral body, (9) spinal medulla. The average size of the cervicothoracic ganglion is 25 mm x 3–10 mm x 5 mm.
**Procedure**

The paratracheal anterior technique is the currently accepted standard. This block should only be carried out by experienced pain therapists. A detailed discussion should be held with the patient before the procedure.

**Preparations**

Check that the emergency equipment is complete and in working order. Sterile precautions, skin prep. Intravenous access, ECG monitoring, ventilation facilities, pulse oximetry. Avoid premedication. The patient must remain responsive at all times so that any possible side effects or complications will be apparent immediately.

**Materials**

Fine 26-G needles 2.5 cm long for local anesthesia, 5-mL syringe, 10-mL syringe, 22-G needle (3 cm or 5 cm long, depending on the patient’s anatomy) with injection tube (immobile needle), intubation kit, emergency drugs, cushions for positioning, disinfectant (Fig. 6.6).

**Skin prep**

In all blocks.

**Patient positioning**

Supine, with neck extended.

**Landmarks**

Sternocleidomastoid muscle, common carotid artery, jugular fossa, transverse processes of the 6th or 7th cervical vertebra.

1. The 6th cervical vertebra is palpated. For this purpose alone, the patient rotates the head toward the opposite side (Fig. 6.7).

2. For palpation of the site between the larynx and the sternocleidomastoid muscle, a cushion is placed under the shoulder blades and the head is tilted back. The patient must not swallow, speak, cough, or move, and is asked to breathe with the mouth slightly open in order to relax the neck muscles (Fig. 6.8).

3. The index and middle fingers are moved between the trachea and sternocleidomastoid muscle to locate the pulse in the common carotid artery. This is displaced laterally together with the medial margin of the sternocleidomastoid muscle (Fig. 6.9). The transverse process is now identified. Usually, the transverse process of C6 is easily palpated at the level of the cricoid, or the transverse process of C7 can be located using the two-finger method (Fig. 6.8).
Injection technique

The injection can be made at the level of C6 or C7. The transverse process of the sixth cervical vertebra is easier to palpate; the distance from the pleura is greater and there is less danger of puncturing the vertebral artery. Block at the level of C7 can extend as far as T3, with a reduced dose of local anesthetic. However, the likelihood of injuring the pleura or puncturing the vertebral artery is greater here.

After skin infiltration, the needle is introduced vertical to the skin at this point and advanced until bone contact is made with the transverse process (Figs. 6.9 and 6.10). The transverse process is reached at a depth of 2–4 cm, depending on the anatomy.

After bone contact has been made, the needle is withdrawn about 1 mm and with careful aspiration at various levels, an initial test dose of 1 ml. of the local anesthetic is injected.

If there is no bone contact, or if paresthesias in the brachial plexus are elicited, the needle must be withdrawn and corrected medially. If the transverse process is still not reached, the direction of the needle should be carefully corrected caudally or cranially.

After approximately 1 min, slow injection of the remaining dose can be carried out.

A single test dose by no means guarantees correct positioning of the needle. The remaining dose must never be injected quickly and carelessly. It must be administered slowly in small quantities (several test doses) with constant aspiration.

Effect of the block

Characteristic unilateral symptoms of a stellate ganglion block are: conjunctival injection, increased tear production, swelling of the nasal mucosa, reddening, hyperthermia and anhidrosis in the affected side of the face. At higher doses, hyperthermia and anhidrosis in the region of the shoulder and arm can occur.

Horner's syndrome is regarded as the clinical sign of a successfully conducted block. In 1869, the ophthalmologist Johann Friedrich Horner described the triad of
Chapter 6

Fig. 6.12 Course of the phrenic nerve

Fig. 6.13 Positions of (1) the recurrent laryngeal nerve and (2) the vagus nerve

ptosis, meiosis and enophthalmos as a sequel of paralysis of the sympathetically innervated ocular muscles (Fig. 6.11).

Horner's syndrome is not necessarily a sign of complete block of the stellate ganglion. Two effects of the block need to be distinguished:

- After ca. 1–2 min, Horner's syndrome develops as a result of cerebral (facial) spread. This can be achieved with a low dose of the local anesthetic.
- Complete block, including the shoulder and arm region, requires a higher dose and the local anesthetic needs to spread as far as T4.

This complete cervicothoracic sympathetic block is only obtained after ca. 15-20 min. Horner's syndrome occurs not only after stellate ganglion block, but is also characteristic of all blocks of the cervical sympathetic trunk.

Dosage

“Low dose” for indications in the head region (cerebrofacial effects) [3, 9, 15, 30]:
2–4 mL local anesthetic – e.g. 0.375–0.5% ropivacaine, 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine), or 1% prilocaine, 1% mepivacaine, 1% lidocaine.

“Medium high dose” for indications in the shoulder and arm region [3, 6, 12, 25, 30, 33, 35]:
10–15 mL local anesthetic – e.g. 0.2–0.375% ropivacaine, 0.25% bupivacaine (0.25% levobupivacaine), or 0.5% prilocaine, 0.5% mepivacaine, 0.5% lidocaine.

In acute pain, 1–3 mg morphine, 0.0125–0.025 mg fentanyl [8, 22, 34], or 0.03 mg buprenorphine with local anesthetic, or in a physiological saline solution.

Block series

If the clinical picture being treated does not show temporary improvement after the second block, there is no point in carrying out a series of treatments. Otherwise, for all the indications mentioned, a series of 6–10 blocks can be carried out. In difficult cases (e.g. herpes zoster ophthalmicus), further blocks can also be carried out when there is a visible trend toward improvement.

Side effects

Hematoma formation (harmless).
Persistent coughing [27].
Block of the following nerves:
Phrenic nerve (Fig. 6.12), main symptom: dyspnea with normal auscultation findings.
Vagus nerve (Fig. 6.13), main symptom: tachycardia, hypertension.
Recurrent laryngeal nerve (Fig. 6.13), main symptom: foreign-body sensation in the throat, hoarseness. It should be noted here that in ca. 43% of cases, anastomoses with the cervicothoracic ganglion are found [17, 18].
Brachial plexus: a partial brachial plexus block may occur if the local anesthetic spreads into the area of the roots of C6–T1.

When giving consent, the patient must be clearly informed about the possibility of these adverse effects – most of which do not require any treatment.

Complications
Intravascular injection
Intravascular injections are extremely rare when the correct technique is used. In particular, there is a risk of injection into the vertebral artery (the diameter of which is ca. 0.3 mm larger on the left side than on the right). More rarely, there is a risk of puncturing the carotid artery, the inferior thyroid artery, or the first intercostal artery (Fig. 6.14).

Fig. 6.14 Risk of intravascular injection into
(1) the vertebral artery,
(2) the inferior thyroid artery,
(3) the carotid artery and
(4) first intercostal artery
Chapter 6

Most complications arise when the local anesthetic is administered without prior bone contact.

Bilateral block of the stellate ganglion is contraindicated, since bilateral paresis of the recurrent laryngeal or phrenic nerves would be life-threatening.

**CNS intoxication**

Intravascular administration (Fig. 6.15), overdosage and/or rapid vascular uptake of the local anesthetic can quickly lead to toxic CNS reactions. Symptoms include:

- Sudden vertigo, pressure in both ears and in the head.
- Brief blackouts, not usually requiring treatment (Fig. 6.16).
- Reversible "locked-in syndrome" with brief apnea and inability to move or respond to external stimuli [7]. The patient remains conscious and is hemodynamically stable, and vertical eye movement is maintained.

**Treatment:** constant verbal contact, oxygen administration, support for breathing (with mask ventilation if necessary), cardiovascular monitoring, diazepam if necessary (0.05 mg/kg body weight, i.v.). Tonic-clonic seizure: a very serious complication (Fig. 6.17). Without immediate and correct treatment is given, this can lead to cerebral injury or even death.

**Treatment:** thiopental (1–2 mg/kg b.w. – routinely ca. 150 mg – i.v. carefully dosed), to prevent additional cardiovascular or CNS depression. Sedation with diazepam (10–20 mg). Oxygen administration (mask), support for breathing. The airways must be kept free, if necessary with succinylcholine (60–80 mg) to make intubation easier. Vasopressor administration to support the circulation. Leg elevation, fluid volume replacement. Cardiovascular monitoring; cardiopulmonary resuscitation if necessary.

**Preconvulsive signs** of toxic reactions are a numb sensation on the lips and tongue, vertigo, metallic taste, drowsiness, ringing in the ears, visual disturbances, slurred speech, muscle tremor, nystagmus.

**Effects on the cardiovascular system**

Toxic effects on the cardiovascular system only occur after very high doses of local anesthetic, manifesting as a drop in blood pressure, bradycardia, circulatory collapse and cardiac arrest.
Treatment: leg elevation, fluid volume replacement, oxygen administration, vasopressor administration if needed, cardiopulmonary resuscitation if needed.

**Epidural or subarachnoid injection** [31]

There is a risk of perforating the dural membrane if the needle is inserted too medially (Fig. 6.18). Cerebrospinal fluid (CSF) pressure is very low in the cervical area and it is almost impossible to aspirate CSF. High epidural anesthesia or high spinal anesthesia is extremely rare. It can lead to bradycardia, hypotension and possibly to respiratory arrest and loss of consciousness. The first signs are: heaviness in the limbs, sweating, dyspnea, apprehension and anxiety.

**Treatment:** immediate endotracheal intubation, ventilation with 100% oxygen, rapid volume infusion, atropine i.v. in bradycardia, vasopressor administration if needed.

After a stellate block has been carried out, the patient must be monitored for 60 min. In the outpatient department, medium-duration local anesthetics (e.g. prilocaine, mepivacaine, or lidocaine) are preferable.

**Pneumothorax**

The incidence of this complication is extremely low when the paratracheal technique is used. If it occurs at all, it usually produces a small pneumothorax that resolves spontaneously (Fig. 6.19). If there is a suspicion of a pneumothorax, a chest radiograph is required after 4–6 h.

**Esophageal perforation or tracheal perforation**

Extremely rare. Puncture of the esophagus (Fig. 6.19) causes a bitter taste during the injection. Careful follow-up is indicated if there is any suspicion.
## Record and checklist

### Cervicothoracic ganglion (stellate ganglion)

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- **Name:** 
- **Date:** 
- **Diagnosis:** 

#### Premedication
- □ No
- □ Yes

#### Purpose of block
- □ Diagnostic
- □ Therapeutic

#### Needle
- □ 22 G
- □ 40 mm long
- □ 50 mm long

#### i.v. access
- □ Yes

#### Monitoring
- □ ECG
- □ Pulse oximetry

#### Ventilation facilities
- □ Yes (equipment checked)

#### Emergency equipment (drugs)
- □ Checked

#### Patient
- □ Informed

#### Position
- □ Supine
- □ Neck extended

#### Approach
- □ Paratracheal
- □ C6
- □ C7
- □ Other

#### Local anesthetic
- \_

#### Test dose
- \_

#### Addition to injection solution
- □ No
- □ Yes

#### Patient’s remarks during injection
- □ None
- □ Pain
- □ Paresthesias
- □ Warmth

#### Nerve region

#### Objective block effect after 15 min
- □ Cold test
- □ Temperature measurement right \_ \_ °C left \_ \_ °C

#### Horner’s syndrome
- □ Yes
- □ No

#### Segment affected
- □ C2
- □ C3
- □ C4
- □ C5
- □ T

#### Monitoring after block
- □ < 1 h
- □ > 1 h

#### Time of discharge

#### Complications
- □ None
- □ Yes (intravascular, epidural, subarachnoid injection; other)

#### Side effects
- □ None
- □ Yes (recurrent laryngeal nerve, phrenic nerve, vagus)

#### Subjective effects of the block
- □ None
- □ Increased pain
- □ Reduced pain
- □ Relief of pain

#### Duration

#### VISUAL ANALOG SCALE

- [Scale with values from 0 to 100]

#### Special notes

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
The superior cervical ganglion arises from the fusion of three or four upper cervical ganglia. It lies medial to the vagus trunk, in front of the longus capitis muscle and behind the internal carotid artery, in the angle of the vertebrae and transverse processes of the second and third cervical vertebrae (Figs. 7.1 and 7.2). In the literature, its long, flat, or spindle-like extension is described as being 14-43 mm in length, 6-8 mm in breadth, and 3-5 mm in depth [8, 9] (Fig. 7.3). The superior cervical ganglion is thought to contain 760,000-1,000,000 nerve fibers in all, 5000-12,000 of which are preganglionic. Some 5000 of these fibers are myelinated [8, 9]. This underlines its importance as a switchpoint with numerous double or triple connections to neighboring ganglia, nerves, and vessels. The superior cervical ganglion takes its preganglionic fibers mainly from the spinal nerves coursing thoracically, with only a few being drawn from the neighboring cervical nerve roots. An unknown number of these preganglionic fibers pass through the ganglion toward the higher carotid ganglia, without switching. Rami communicantes connect the superior cervical ganglion with numerous organs, vessels, muscles, bones, joints, the last four cranial nerves, the vertebral plexus, and also with the phrenic nerve. It supplies the upper cervical spinal nerves with gray rami communicantes, and it sends off vascular fibers to the internal and external carotid arteries. Autonomic branches pass from the ganglion to the larynx, pharynx, heart, and – together with vascular plexuses – to the salivary and lacrimal glands, to the hypophysis, thyroid, and other glands. There are also contacts with the middle cervical ganglion and to the tympanic plexus. There are connections with the

Fig. 7.1 Topographic position of the superior cervical ganglion: (1) glossopharyngeal nerve, (2) superior cervical ganglion, (3) vagus nerve. The superior cervical ganglion has an average size of: 26.6 mm (14-43 mm) × 7.2 mm × 3.4 mm

Fig. 7.2 Arteries in the immediate vicinity of the ganglion: (1) vertebral artery and (2) internal carotid artery
Blocks of the superior cervical ganglion

Indications
The areas of application are partly identical to those for the stellate block, but due to its marked cerebrofacial effects, the superior cervical ganglion block is particularly suitable for the head and facial region – although controlled studies are still lacking here.

Therapeutic
- Migraine [5], cluster headache, headaches of cervical origin
- Complex regional pain syndrome (CRPS) in the head region
- Perfusion disturbances, vasospastic diseases
- Central post-stroke syndrome (contralateral block)
- Facial pain
- Vertigo (of vertebral origin)
- Peripheral facial paralysis
- Trigeminal neuralgia in the 1st and 2nd branches
- Post-herpetic neuralgias* (otic, ophthalmic)
- Sudden deafness,* tinnitus*
- Hyperhidrosis in the head region.

Neural therapy
- Asthma, urticaria, vasomotor rhinitis, etc.

Specific contraindications
Grade 2 atrioventricular (AV) block, recent antithrombotic therapy after myocardial infarction or pulmonary embolism, anticoagulation treatment, contralateral paresis of the phrenic nerve or recurrent laryngeal nerve.

Simultaneous bilateral block.

Procedure
Lateral extraoral technique

This block should only be carried out by an experienced anesthetist. The patient should have a full explanation of the procedure before it is carried out.

Preparations
Check that the emergency equipment is complete and in working order. Sterile precautions. Intravenous access, ECG monitoring, pulse oximetry, ventilation facilities.

* The explanations given in Chapter 6, p. 61, also apply here.
**Materials**

5-mL syringe, 23-G needle (60 mm), intubation kit, emergency drugs, disinfectant (Fig. 7.4).

**Skin prep**

In all blocks.

**Patient positioning**

Supine, with the head turned about 30–40° to the opposite side.

**Landmarks**

Mastoid process, angle of the mandible, medial margin of the sternocleidomastoid muscle (Fig. 7.5). The angle of the mandible and the mastoid are marked with the index and middle finger. From the anterior margin of the mastoid process, a vertical line is drawn downward; about 1 cm above the angle of the mandible, a horizontal mark is applied. The intersection of these two lines defines the injection point (Fig. 7.6).

**Injection technique**

After skin infiltration, a 6-cm long needle is introduced in the direction of the contralateral mastoid at a craniodorsal angle of about 20° (Fig. 7.7). In normal anatomy, bone contact is made at about 3.5–5 cm, and careful aspiration is carried out at various levels after the needle has been minimally withdrawn. Only then can a test dose of 0.5 mL of the local anesthetic be administered.

After about 1 min, slow injection of the remaining dose can be carried out. The patient's upper body is then raised.

A single test dose by no means guarantees correct positioning of the needle. The remaining dose must never be injected quickly or carelessly. It must be administered slowly in small quantities (several test doses) with repeated aspiration.
Chapter 7

Fig. 7.7 Craniodorsal puncture in the direction of the contra-lateral mastoid

Fig. 7.8 Characteristic directions of radiation during the injection

Fig. 7.9 Distribution of the block

**Effects of the block**

Characteristic signs of a successful block are radiation and a warm sensation in the area of the back of the head, ear, eyes and corner of the mouth and the ipsilateral half of the face (Figs. 7.8 and 7.9). Conjunctival injection, increased tear production and ipsilateral nasal congestion are equally characteristic, as is Horner's syndrome - which is by no means restricted to stellate block, but occurs in all blocks of the sympathetic cervical trunk.

**Dosage**

**Therapeutic**

5 mL local anesthetic – e.g. 0.5–1% procaine, 0.5–1% prilocaine, 0.5–1% lidocaine, 0.2% ropivacaine, 0.125% bupivacaine (0.125% levobupivacaine).

**Block series**

A series of 6–10 blocks is appropriate for all indications. In difficult cases (e.g. herpes zoster), additional blocks can also be carried out when there is evidence of improvement.

**Side effects**

Hematoma formation (harmless).

Block of the following nerves:

- Phrenic nerve, main symptom: dyspnea
- Recurrent laryngeal nerve, main symptoms: foreign-body sensation in the neck and hoarseness
- Vagus nerve, main symptoms: tachycardia, hypertension
Glossopharyngeal nerve, main symptoms: numbness in the posterior third of the tongue, paresis of the pharyngeal muscles
Partial anesthesia of the cervical plexus
Persistent coughing

Complications

Most complications arise when the local anesthetic is administered without prior bone contact.
Bilateral block of the superior cervical ganglion is contraindicated, since bilateral paralysis of the recurrent laryngeal nerve or phrenic nerve is life-threatening.
**Intravascular injection**

There is a particular risk of injection into the vertebral artery (Fig. 7.10), the diameter of which is about 0.3 mm wider on the left side than on the right. Intra-arterial administration of a local anesthetic can produce toxic reactions very quickly.

For the symptoms and treatment, see Chapter 6, p. 65.

**Epidural or subarachnoid injection**

There is a risk of perforating the dural membrane. Cerebrospinal fluid (CSF) pressure is very low in the cervical area, and it is almost impossible to aspirate CSF. The resultant high epidural anesthesia or high spinal anesthesia can lead to bradycardia, a drop in blood pressure, and possibly to respiratory arrest and loss of consciousness.

For treatment, see Chap.6, p.67.

---

Superior cervical ganglion blocks in pain therapy or as an option in depressive conditions

In my own clinical experience over many years with superior cervical ganglion block series (10–12 on average), there have been surprisingly good results in a large number of patients. These observations principally concern patients with pain-associated depression in chronic pain conditions (various types of headache, migraines, facial pain, post-nucleotomy pain, fibromyalgia, etc.). In the superior cervical ganglion block, the usual volume of 5 ml local anesthetic (e.g. 1% procaine) covers neighboring nerves such as the vagus nerve, for example. The superior cervical ganglion is often barely distinguishable from the vagus nerve. Left-sided vagus stimulation with an implantable electrode has been successfully used since 1938 to treat various neurological diseases such as epilepsy [1, 2], treatment-resistant depression [12–14], anxiety states [15], sleep disturbances [15], and other conditions. Dysfunction of the autonomic nervous system is almost always present as an accompanying symptom of depression [3]. The long-term analgetic effect of vagus stimulation was demonstrated in a study by Kirchner et al. [7]. Like the anti-epileptic and antidepressive action of vagus stimulation, this is probably due to neurobiochemical effects.

For example, patients receiving vagus stimulation of the cerebrospinal fluid show a significant increase in norepinephrine and serotonin levels and a significant decrease in proalgetic excitatory amino acids such as aspartate and glutamate. The same group of authors report marked symptomatic improvement during vagus stimulation in a patient with chronic tension headache. In this context, answers will have to be found in the future to the following questions: What role does the superior cervical ganglion play in this? Is the functioning of the superior cervical ganglion more important than that of the vagus nerve? It should not be forgotten that the superior cervical ganglion is the last station at which information from the body can be modulated before entering the CNS.
### Superior cervical ganglion

<table>
<thead>
<tr>
<th>Block no.</th>
<th>□ Right</th>
<th>□ Left</th>
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</table>

| Name: | | Date: |
| Diagnosis: | |
| Premedication: | □ No | □ Yes |

- **Purpose of block:** □ Diagnostic □ Therapeutic
- **Needle:** □ 23 G □ 50 mm □ 60 mm ______
- **i.v. access:** □ Yes
- **Monitoring:** □ ECG □ Pulse oximetry
- **Ventilation facilities:** □ Yes (equipment checked)
- **Emergency equipment (drugs):** □ Checked
- **Patient:** □ Informed

| Position: | □ Supine | □ Head to contralateral side |
| Approach: | □ Extraoral (direction of C2 vertebra) |

| Local anesthetic: | ____ mL ____ % |
| Test dose: | ____ mL |

- **Addition to injection solution:** □ No □ Yes

- **Patient's remarks during injection:** □ None □ Pain □ Paresthesias □ Warmth

| Nerve region | |

| Objective block effect after 15 min: |
| □ Cold test | □ Temperature measurement right ____°C left ____ °C |
| Horner's syndrome: | □ Yes □ No |
| Segments affected: | □ C2 □ C3 □ C4 □ C5 (numbness, warmth) |
| Monitoring after block: | □ < 1 h □ > 1 h |

- **Time of discharge:**

| Complications: |
| □ None | □ Yes (intravascular, epidural, subarachnoid injection; other) |

| Side effects: |
| □ None | □ Yes (recurrent laryngeal nerve, phrenic nerve, vagus nerve, glossopharyngeal nerve ...) |

| Subjective effects of the block: |
| □ None | □ Increased pain |
| □ Reduced pain | □ Relief of pain |

| VISUAL ANALOG SCALE |

<table>
<thead>
<tr>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
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<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
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</table>

| Special notes: |

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Anatomy

The anterior branches of the four upper cervical spinal nerves (C1 to C4) form the **cervical plexus** (Fig. 8.1), which is covered by the sternocleidomastoid muscle. The branches of the cervical plexus carry motor, sensory, proprioceptive, and autonomous fibers and divide into superficial cutaneous branches penetrating the cervical fascia and deeper muscular branches that mainly innervate the joints and muscles.

The **cutaneous branches** of the cervical plexus are the lesser occipital nerve, great auricular nerve, transverse cervical (colli) nerve, and the supraclavicular nerves (Fig. 8.2). The **lesser occipital nerve** (from C2 and C3) passes on the splenius capitis muscle to its insertion area, where it fans out into several branches and supplies the skin on the upper side of the neck and upper part of the auricle and the adjoining skin of the scalp. The largest plexus branch is usually the **great auricular nerve** (from C2 and C3), which passes upward behind
Deep (and superficial) cervical plexus

the external jugular vein and divides into a posterior and an anterior end branch. The posterior branch supplies the skin lying behind the ear and the medial and lateral surfaces of the lower part of the auricle. The anterior branch supplies the skin in the lower posterior part of the face and the concave surface of the auricle. The transverse cervical nerve (from C2 and C3) passes almost horizontally over the external surface of the sternocleidomastoid muscle in an anterior direction toward the hyoid bone, divides into superior and inferior branches and supplies the skin over the anterolateral side of the neck between the mandible and the sternum. The common trunk of the supraclavicular nerves (from C3 and C4) appears at the posterior margin of the sternocleidomastoid muscle, just below the transverse cervical nerve, passes downward and divides into anterior, medial and posterior supraclavicular nerve branches. The areas supplied by the supraclavicular nerves include the skin over the caudal part of the neck and the skin above the shoulders and the lateral upper chest, as well as the skin covering the anterior part of the deltoid muscle and occupying the acromial region.

The muscular branches of the cervical plexus include segmentally arranged nerve branches supplying the deeper anterior neck muscles (the rectus capitis anteri-
or and lateralis, longus colli, longus capitis and inter-
transverse, scalenus anterior and medius and levator
scapulae), as well as the inferior descending cervical
nerve, the trapezius branch and the phrenic nerve. The
inferior descending cervical nerve (from C2 and
C4) gives off several fibers to the carotid and jugular
nerve plexus and joins with the superior descending
cervical nerve to form the ansa cervicalis. The area sup-
plied includes the sternothyroid muscle, sternocleido-
mastoid muscle, thyrohyoid muscle, geniohyoid muscle
and omohyoid muscle.

The trapezius branch appears at the surface just
below the accessory nerve and passes to the trapezius
muscle. The phrenic nerve (from C4 and C3/5) is the
motor nerve for the diaphragm, but it also contains
sensory and sympathetic fibers that supply the fibrous
pericardium, mediastinal pleura and the central part of
the diaphragmatic pleura as the nerve courses through
the thorax. Connections have been described between
the phrenic nerve (left or right branch) or the phrenic
plexus and the following structures: inferior and mid-
dle cervical ganglion, subclavian plexus, pulmonary
plexus, inferior vena cava, esophagogastric junction,
cardiac end of the stomach, hepatic portal, suprarenal
cortex, etc.

### Block of the deep cervical plexus

#### Indications

**Diagnostic**
- Localization and differentiation of various types of
  neuralgia

**Therapeutic**
- Post-herpetic neuralgia
- Occipital and cervicogenic headache
- Torticollis

**Surgical**
- In combination with a block of the superficial cervical
  plexus:
  - Carotid endarterectomy [1, 2]
  - Excision of cervical lymph nodes
  - Plastic surgery in the area of innervation

**Specific contraindications**
- Grade 2 atrioventricular (AV) block, anticoagulant
treatment, contralateral paresis of the phrenic nerve or
recurrent laryngeal nerve.
- Simultaneous bilateral blocks.

#### Procedure

This block should only be carried out by experienced
anesthetists. It is absolutely necessary to have a detailed
discussion with the patient before the procedure.

#### Preparations

- Check that the emergency equipment is complete and
  in working order. Sterile precautions. Intravenous access,
  ECG monitoring, pulse oximetry, ventilation facilities.

**Materials**
- 5-mL syringes, 10-mL syringes, three fine 22-G needles
  (5 cm), intubation kit, emergency drugs, disinfectant
  (Fig. 8.3).

**Skin prep**
- in all blocks.

**Patient positioning**
- Supine, with the head tilted slightly backward and
  turned about 45° to the opposite side.

---

Fig. 8.3 Materials

Fig. 8.4 Landmarks: transverse processes of C2 to C4
Landmarks
Posterior edge of the sternocleidomastoid muscle, caudal part of the mastoid process, Chassaignac's tubercle (C6), transverse processes of C2, C3, C4 and C5 (Figs. 8.4 and 8.6).
The patient is asked to turn the head toward the opposite side and to lift it slightly, making the posterior edge of the sternocleidomastoid apparent.
The transverse process of C6 and the caudal tip of the mastoid process are located. A line is drawn from the mastoid process along the posterior edge of the sternocleidomastoid muscle to the level of C6 (Figs. 8.5 and 8.6). The transverse process of C2 is palpated and marked on the skin. This lies about 1.5 cm caudal to the mastoid process and about 0.5–1 cm dorsal to the marked line. The transverse processes of C3, C4 and C5 are also palpated and marked. The distances between them are each ca. 1.5 cm, and like C2 they lie about 0.5–1 cm dorsal to the marked line.

Injection technique
The aim is to block the anterior branches of the cervical plexus in the groove of the transverse process.
After thorough skin prep, skin infiltration is carried out at the marked areas of C2, C3 and C4 and the needles are introduced (Fig. 8.6). To do this, the anaesthetist stands at the patient's head. In the sequence C2 to C4, the needles are directed perpendicular to the skin and advanced slightly caudal (ca. 30°) to the transverse process. In normal anatomy, the distance from the transverse processes to the skin varies between 1.5 and 3.5 cm. After clear bone contact and minimal withdrawal of the needle, careful aspiration needs to be carried out at various levels.
Only then may the local anesthetic be injected in several small doses, with repeated aspiration (Fig. 8.7).

Effects of the block

If the local anesthetic spreads in the direction of the superior cervical ganglion and/or the cervicothoracic ganglion, Horner’s syndrome may develop (see Chapter 6, p. 63).

Block series

If there is improvement after two treatment sessions, a series of 8–12 therapeutic blocks is indicated.

Dosage

**Diagnostic**

2 mL local anesthetic per segment – e.g. 1% prilocaine, mepivacaine, lidocaine.

**Therapeutic**

3 mL local anesthetic per segment – e.g. 0.2–0.375% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

Surgical

30 mL local anesthetic:

0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine) mixed with 1% prilocaine or 1% mepivacaine.

Of this: 10 mL for fan-like injection into the superficial cervical plexus (center of the posterior edge of the sternocleidomastoid muscle, Figs. 8.2 and 8.8) and 20 mL for anesthesia of the deep cervical plexus.

Side effects

Simultaneous block of the following nerves:

- Phrenic nerve, main symptom: unilateral paralysis of diaphragmatic movement
- Recurrent laryngeal nerve, main symptoms: hoarseness and foreign-body sensation in the throat
- Glossopharyngeal nerve, main symptoms: numbness in the final third of the tongue, paralysis of the pharyngeal muscles
- Vagus nerve, main symptoms: tachycardia, hypertension
- Partial block of the upper part of the brachial plexus

Complications

**Intravascular injection**

There is always a risk of intravascular injection due to the rich vascular supply in this area. Particular attention should be given to avoiding puncture of the vertebral artery. Toxic reactions may occur after intravascular administration of local anesthetics, and the symptoms and treatment of these are outlined in Chapter 6, p. 65.

**Epidural or subarachnoid injection**

When the needle slides along the transverse process and enters an intervertebral foramen, there is a risk of dural puncture and subarachnoid injection of local anesthetic. This can lead to a high spinal or high epidural block. The clinical picture and management of this complication is covered in Chapter 6, p. 67.
Deep cervical plexus

<table>
<thead>
<tr>
<th>Block no.</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
</table>

Name: __________________________  Date: __________________________

Diagnosis: __________________________

Premedication: □ No  □ Yes

Neurological abnormalities: □ No  □ Yes

□ Yes (which?)

Purpose of block: □ Diagnostic  □ Therapeutic

Needle: □ 22 G  □ 40 mm  □ 50 mm  □ 60 mm

i.v. access: □ Yes  □ No

Monitoring: □ ECG  □ Pulse oxymetry  □ No

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

Position: □ Supine  □ Head to contralateral side

Needle technique: 3-needle technique (C2, C3, C4)

Local anesthetic: _______ ml  _______ % per segment

Addition to injection solution: □ No  □ Yes

Patient’s remarks during injection:

□ None  □ Pain  □ Paresthesias  □ Warmth

Nerve region: __________________________

Objective block effect after 15 min:

□ Cold test  □ Temperature measurement right _____ °C  □ left _____ °C

□ Horner’s syndrome  □ Yes  □ No

□ Sensory (C2, C3, C4, C5)  □ Motor

□ Segments affected: __________________________ (numbness, warmth)

Monitoring after block: □ < 1 h  □ ≥ 1 h

Time of discharge: __________________________

Complications:

□ None  □ Yes (intravascular, epidural, subarachnoid injection)

Side effects:

□ None  □ Yes (Horner’s syndrome, phrenic nerve, recurrent laryngeal nerve, brachial plexus…)

Subjective effects of the block:

Duration: __________________________

□ None  □ Increased pain  □ Relief of pain

□ Reduced pain

VISUAL ANALOG SCALE

0 10 20 30 40 50 60 70 80 90 100

Special notes: __________________________

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
The brachial plexus arises from the union of the spinal nerve roots of C5, C6, C7, C8 and T1 and it often also contains fine fibers from the fourth cervical nerve and second thoracic nerve. After they have left their intervertebral foramina, the roots of the plexus appear in the interscalene groove between the scalenus anterior and scalenus medius muscles and they join together there to form the primary cords or trunks (Fig. 9.1). The upper roots (C5, C6) form the superior trunk, the roots of C7 continue as the middle trunk and the inferior trunk arises from the roots of C8 and T1. After passing through the interscalene groove, the primary cords of the plexus, lying close together, move towards the first rib. The suprascapular nerve and subclavian nerve already branch off from the superior trunk here, in the posterior triangle of the neck above the clavicle. When crossing the first rib, the trunks of the plexus lie dorso-lateral to the subclavian artery and are enclosed along with the artery by a connective-tissue sheath. The plexus runs through under the middle of the clavicle, following the course of the subclavian artery, into the tip of the axilla. As it does so, each of the primary cords divides into the anterior (ventral) divisions and posterior (dorsal) divisions. These supply the ventral flexor muscles and the dorsal extensor muscles of the upper extremity. In the axilla itself, the nerve cords regroup and separate into the individual nerves (Fig. 9.2). The ventral branches of the superior and middle trunk combine to form the lateral cord (fasciculus lateralis, C5, C6, C7; Fig. 9.3). The following nerves emerge from this:

- Musculocutaneous nerve
- Median nerve (lateral root)
- Lateral pectoral nerve

All of the dorsal branches of the three trunks form the posterior cord (fasciculus posterior, C5–8, T1). The end branches of this (Fig. 9.3) are the:

- Radial nerve
- Axillary nerve
- Thoracodorsal nerve
- Inferior subscapular nerve
- Superior subscapular nerve

The ventral branches of the inferior trunk continue as the medial cord (fasciculus medialis, C8, T1). The following nerves (Fig. 9.3) emerge from this:

- Ulnar nerve
- Median nerve (medial root)
- Medial pectoral nerve
- Medial antebrachial cutaneous nerve
- Medial brachial cutaneous nerve

Introduction

The classical blocks of the brachial plexus using Hirschel’s [19] (axillary approach) and Kulenkampff’s [23] (supraclavicular block) anesthesia have been continuously developed and supplemented with additional access routes (Fig. 9.4). As representative techniques for a multitude of clinical procedures for plexus anesthesia, the axillary perivasular block [3, 18, 74], sub-
Brachial plexus

clavian perivascular block using the Winnie and Collins technique [73], Winnie’s interscalene block [70, 74] and Raj’s infraclavicular approach [41] may be mentioned. All of the blocks of the brachial plexus are based on the concept that the nerve plexus lies within a perivascular and perineural space in its course from the transverse processes to the axilla. Like the epidural space, this space limits the spread of the local anesthetic and conducts it to the various trunks and roots. Within the connective tissue sheath, the concentration and volume of the local anesthetic used determine the extent of the block’s spread.

Apart from technical aspects, the main differences between the various block procedures are that the injection is made into the interscalene space, the subclavian space, the infraclavicular space, or the axillary space — leading to different focuses for the block.

In this chapter, four techniques that are among the standard methods for plexus anesthesia will be described: the interscalene, subclavian perivascular, infraclavicular and axillary blocks of the brachial plexus.

All four procedures have well-known advantages in contrast with general anesthesia:

They can be used on an outpatient basis.

Use in patients with a full stomach, high-risk and emergency patients and patients who are anxious about general anesthesia.

Absence of side effects such as nausea and vomiting.

Absence of postoperative pulmonary complications.

Excellent postoperative pain control, particularly with the use of long-term local anesthetics (continuous procedures).

Sympathetic block with vasodilation, better perfusion and faster recovery of traumatized extremities.

Certain points should always be observed when preparing for this procedure:

Contraindications must be excluded.

The anatomic relationships in each patient must be precisely studied and studied again for repeated blocks.

Neurological abnormalities must be excluded.

The procedure must be explained to the patient in detail in order to ensure cooperation.

The patient must be placed in a comfortable position during the intervention.

All patients should be informed of possible side effects and complications; outpatients in particular must also be advised of what they should and should not do after anesthesia or pain treatment.

**Fig. 9.2** Regrouping of the nerve cords in the area of the axilla and their distal distribution. (1) Lateral cord, (2) musculocutaneous nerve, (3) posterior cord, (4) medial cord, (5) median nerve, (6) radial nerve, (7) ulnar nerve

**Interscalene block**

**Indications**

**Surgical**

Clavicle, shoulder, upper arm [1, 56] (the exception is the medial aspect):

As a “single-shot” administration or continuous regional anesthesia [17, 37, 61] or in combination with basic general anesthesia.
In combination with basic general anesthesia, the administration of 20–25 mL 0.75% ropivacaine or 20 mL 0.5% bupivacaine allows a marked reduction in the dosage of the general anesthetic and, in our own experience, leads to excellent postoperative pain control.

Reduction of shoulder dislocation.

Therapeutic

Shoulder and upper arm pain ("frozen shoulder"): humeroscapular periarthritis, muscles of the rotator cuff, post-stroke pain (ca. 70% of patients have severe shoulder pain). The aim of the block is to allow pain-free and successful physiotherapy.

Mobilization of the shoulder.

Shoulder arthritis.

Post-herpetic neuralgia in the innervation area.

Lymphedema after breast amputation.

Vascular diseases and injuries, with continuous block in the acute stage.

Complex regional pain syndrome (CRPS), type I (sympathetic reflex dystrophy) and type II (causalgia):

If abduction of the arm is possible, an axillary block is preferable here (see p. 106).

Postamputation pain – e.g. after disarticulation.

Tumor-related pain:

Continuous administration (e.g. in Pancoast tumor and neuropathic tumor pain [65]) is an alternative to repeated single applications here. The therapeutic effect of additional opioid administration has been evaluated in the literature [21, 64]. The period of treatment is limited. It can provide supplementation to oral opioid administration, but it cannot replace it.
Contraindications

Specific
Infection or malignant disease in the neck.
Infection of the skin in the puncture area.
Contralateral paresis of the phrenic or recurrent laryngeal nerves.
Anticoagulation treatment.
Distorted anatomy – e.g. due to prior surgical interventions or trauma to the neck.

Relative
The decision should be taken after carefully weighing up the risks and benefits:
Hemorrhagic diathesis.
Stable systemic neurological diseases.
Local nerve injury (as there may be doubt whether the cause is surgery or anesthesia).
Severe chronic obstructive pulmonary disease.

Procedure

Interscalene technique
(Winnie’s anterior route)

“Single-shot” technique
This block should only be carried out by experienced anesthetists or under their supervision. It is absolutely necessary to have a detailed discussion with the patient before the procedure.

Preparations
Check that the emergency equipment is present and in working order. Sterile precautions. Intravenous access, ECG monitoring, pulse oximetry, intubation kit, emergency medication, ventilation facilities.

Materials (Figs. 9.5 and 9.6)

Paresthesia technique
Plexufix® 25-mm (38–50-mm) long 24-G (45") needle with “immobile needle” injection lead (B. Braun Melsungen).

Electrostimulation
Stimuplex® HNS 11 nerve stimulator (B. Braun Melsungen).
Stimuplex® D® 50-mm 22-G (15°) needle with “immobile needle” injection lead (B. Braun Melsungen).

Continued technique

Anterior technique
Contiplux® D® set: 50-mm 22-G (15°) needle (B. Braun Melsungen) with Contiplux ® catheter
or
Contiplux®–Tuohy continuous set: 38(–52)-mm 18-G Tuohy needle with Contiplux ® catheter

If technical difficulties arise, the catheter and Tuohy puncture needle are always removed simultaneously. A catheter must never be withdrawn through a Tuohy puncture needle that remains in place (because of catheter shearing).
Chapter 9

Posterior technique

Contiplex D® set: 80(--110)-mm 18-G (15°) needle with Contiplex ® catheter
Contiplex®-Tuohy continuous set: 102-mm 18-G Tuohy needle with Contiplex ® catheter
Syringes: 2, 10 and 20 mL.
Local anesthetics, disinfectant, swabs, compresses, sterile gloves and drape.

Skin prep
In all blocks.

Patient positioning
Supine, with the head turned to the opposite side.

Landmarks
Sternocleidomastoid muscle, interscalene groove between the scalenus anterior and scalenus medius muscles (Fig. 9.7), transverse process (C6), external jugular vein.

Location of the puncture site
To locate the injection site, the patient’s arm is drawn in the direction of the knee (Fig. 9.8). The patient is asked to turn the head to the opposite side and to lift it slightly (ca. 20°), so that the posterior edge of the sternocleidomastoid muscle becomes evident (Fig. 9.9). The transverse process (C6) is palpated at the lateral edge of the sternocleidomastoid muscle. For confirmation (pleura) and guidance, the pulsation of the subclavian artery (at the lower end of the interscalene groove) and the upper

Fig. 9.7 The interscalene groove. Scalenus medius muscle (1) and scalenus anterior muscle (2). Injection of the local anesthetic into the proximal neurovascular sheath of the brachial plexus. The plexus is located in a kind of “sandwich” between the scalenus anterior muscle and scalenus medius muscle.
edge of the clavicle can also be palpated and their distance from the injection site can be estimated (Fig. 9.10).

Posterior to the sternocleidomastoid muscle, the scalenus anterior muscle is palpated. The interscalene groove between the scalenus anterior and scalenus medius muscles is felt with “rolling fingers” and located (Fig. 9.11). The injection site in the interscalene groove lies at the level of the cricoid, opposite the transverse process of C6 (Chassaignac’s tubercle). The external jugular vein often crosses the level of the cricoid cartilage here (Fig. 9.12). When there are anatomical difficulties, it is helpful for the patient to inhale deeply or to try and blow out the cheeks. The scalene muscles then tense up and the interscalene groove becomes more easily palpable.

**Injection technique**

The traditional technique first described by Winnie is a classic paresthesia technique. After disinfection of the puncture area, draping and skin infiltration, the injection site is isolated using the index and middle fingers. The injection needle is advanced between the fingers in the direction of the transverse process (C6). The direction of insertion runs medially and ca. 30–40° caudally, as well as slightly posteriorly (Fig. 9.13). The index and middle finger continue to palpate the interscalene groove.

When the needle is positioned superficially, paresthesias usually occur in the area of the elbow, index finger and thumb. Paresthesias in the shoulder region also frequently occur. These result from stimulation of the suprascapular nerve, which is often located in the connective tissue sheath [3].

When the anatomy is normal and no paresthesias are elicited after ca. 2–2.5 cm, the needle position needs to be corrected.

Once the paresthesias have been elicited, the correct positioning of the needle is checked by aspirating at various levels and quickly injecting an initial dose of the local anesthetic (2–3 mL). The patient will experience a brief pain (pressure paresthesia) due to expansion of the perivascular space. During further injection of the local anesthetic, aspiration has to be repeated after every 4–5 mL. Pressure from the index or middle finger allows the direction of spread of the local anesthetic to be guided during the injection. After successful injection, the entire area is massaged in order to ensure even distribution of the local anesthetic. This also provides hematoma prophylaxis.
Fig. 9.11 4. Palpating the interscalene groove with "rolling" fingers

Fig. 9.12 Position of the external jugular vein

Fig. 9.13 Injection in the direction of the transverse process of C6

The patient must be informed about the expected paresthesias and their significance.

**Electrostimulation**

Stimulation current of 1–2 mA and 2 Hz is selected for a stimulus duration of 0.1 ms.

The injection needle is advanced in the direction of the transverse process (C6). After the motor response from the relevant musculature (biceps brachii muscle – musculocutaneous nerve and/or deltoid muscle – axillary nerve [51, 62] or twitching of the distal arm muscles), the stimulant current is reduced to 0.2–0.3 mA. Slight twitching suggests that the stimulation needle is in the immediate vicinity of the nerve. After aspiration, injection of a local anesthetic is carried out in incremental doses. During the injection, the twitching slowly disappears.

**Dosage**

**Surgical**

"Single-shot" administration:

40 mL local anesthetic is sufficient for an adequate block of the brachial plexus and caudal part of the cervical plexus. In the literature [13, 25, 47, 61, 70], the doses administered vary from 30 mL to 50 mL. A mixture of 20 mL 0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine) with 20 mL 1% prilocaine (1% mepivacaine) has proved its value very well in practice (in our own experience). This leads to a fast onset and long duration.

25 mL local anesthetic – e.g. 1% prilocaine (1% mepivacaine), in combination with 5–10 mg diazepam i.v. for reducing a dislocated shoulder.

20–25 mL local anesthetic – e.g. 0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine), in combination with basic general anesthesia for surgical interventions in the area of the shoulder and clavicle. This leads to very good postoperative pain control.

20 mL local anesthetic is sufficient to block the lower part of the cervical plexus and the upper part of the brachial plexus. The brachial plexus is only incompletely anesthetized with this amount and block of the ulnar nerve territory is often deficient.

**Therapeutic**

"Single-shot" administration (block series):

10 mL local anesthetic – e.g. 0.2% ropivacaine or 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine) in shoulder and upper arm pain, shoulder arthritis, post-stroke pain, lymphedema after mastectomy.

10–20 mL local anesthetic – e.g. 0.2–0.375% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)
in post-herpetic neuralgia, vascular diseases and injuries, complex regional pain syndrome (CRPS) types I and II, post-amputation pain.

25 mL local anesthetic – e.g. 1% prilocaine or 1% mepivacaine in combination with 5–10 mL diazepam i. v. to mobilize the shoulder.

If there is evidence of symptomatic improvement, a series of 8–12 blocks can be carried out.

**Continuous interscalene block – anterior technique (adapted from Meier)**

**Skin prep**
In all blocks.

**Patient positioning**
(See the steps for locating the puncture site under “Interscalene block – ‘single-shot’ technique,” p. 87).

**Landmarks (Fig. 9.14a)**
- Superior thyroid notch
- Posterior edge of the sternocleidomastoid muscle
- Posterior scalene groove
- External jugular vein
- Transition from the middle to lateral third of the clavicle.

**Technique [31]**

After identification of the posterior edge of the sternocleidomastoid muscle at the level of the superior thyroid notch, the block needle (55-mm Contiplex® D or Contiplex®-Tuohy needle, 38 or 52 mm) is introduced at an angle of 30° caudally and slightly laterally, in the direction of the transition from the middle to the lateral third of the clavicle (Fig. 9.14b).

A stimulation current of 1–2 mA and 2 Hz is selected with a stimulus duration of 0.1 ms. After a motor response from the relevant musculature (twitching in the biceps brachii muscle – musculocutaneous nerve and/or deltoid muscle – axillary nerve is regarded to be as reliable as twitching of the distal muscles [51, 62]), the stimulation current is reduced to 0.2–0.3 mA. Slight twitching suggests that the stimulation needle is in the immediate vicinity of the nerve. The catheter is advanced approximately 3 cm beyond the end of the cannula or needle (Fig. 9.15).

After removal of the cannula or needle, fixation of the catheter and placement of a bacterial filter, and after careful aspiration and injection of a test dose, the bolus administration of the local anesthetic follows.
Chapter 9

Continuous interscalene block – posterior technique (Pippa technique)

The posterior cervical paravertebral block of the brachial plexus is an alternative to Winnie’s anterior route. This method was first described by Kappis in 1912, and was republished by Pippa in 1990 as a “loss of resistance” technique [33, 44, 65]. The availability of electrical nerve stimulation has made this access route to the brachial plexus more important.

Indications and contraindications
(See anterior interscalene block, p. 83.)

Procedure

This block should only be carried out by experienced anesthetists or under their supervision. An detailed discussion with the patient is an absolute necessity.

Preparation
(See anterior interscalene block, p. 85.)

Materials
(See anterior interscalene block, p. 85.)

Skin prep
In all blocks.

Patient positioning
Sitting, with the neck flexed (to relax the cervical muscles) and supported by an assistant (the lateral recumbent position can be used as an alternative).

Landmarks
Spinous processes of the sixth (C6) and seventh (C7 – vertebra prominens) cervical vertebrae (Fig. 9.16).

The mid-point between the spinous processes of C6 and C7 is marked. The puncture site is located approximately 3 cm lateral to this point (Fig. 9.17).

Level of the cricoid cartilage (target direction).

It is absolutely necessary to note the following points during this puncture procedure:
- Electrical nerve stimulation is the method of choice.
- After puncture, the needle should be passed towards the lateral edge of the cricoid cartilage.
Brachial plexus

Technique
Disinfection of the puncture area, draping and skin infiltration. After an incision with a stylet, the needle is introduced at the sagittal level and perpendicular to the skin, aiming approximately for the level of the ipsilateral cricoid cartilage (Fig. 9.18). The needle passes the major cervical muscles (trapezius, splenius cervicis and levator scapulae; Fig. 9.19) on the way to the transverse process (C7). It is absolutely necessary to avoid any deviation in a medial direction from the sagittal level. At a depth of ca. 3.5–6 cm, contact is made with the transverse process of C7. The needle is withdrawn slightly, the injection direction is corrected slightly cranially, and one advances past the transverse process a further 1.5–2 cm deeper. Stimulation current of 1–2 mA and 2 Hz is selected with a stimulus duration of 0.1 ms. After the motor response from the relevant musculature (biceps brachii muscle and/or deltoid, or muscles of the index finger and thumb), the current is reduced to 0.3–0.5 mA. The catheter is advanced approximately 3 cm beyond the end of the needle or cannula. After removal of the needle or cannula, fixation of the catheter and placement of a bacterial filter, and after careful aspiration and injection of a test dose, the bolus administration of the local anesthetic follows.

Dosage
40 mL local anesthetic (see above) is commonly used for the procedure. As a subsequent 24-hour infusion for postoperative analgesia:

- 0.2% ropivacaine, 6–14 mL/h (max. 37.5 mg/h)
- 0.25% bupivacaine [17] (0.25% levobupivacaine), 0.25 mg/kg b.w./h

Fig. 9.18 Interscalene block, posterior access route. Puncture technique: the needle is introduced at the sagittal level and perpendicular to the skin in the direction of the ipsilateral cricoid cartilage

Fig. 9.19 Interscalene block, posterior access route. Puncture technique: the needle passes the strong cervical muscles (trapezius muscle, splenius cervicis muscle, and levator scapulae muscle). (1) Sternocleidomastoid muscle, (2) scalenus anterior muscle, (3) scalenus medius and scalenus posterior muscles, (4) levator scapulae muscle, (5) spine of the sphenoid bone, (6) splenius capitis and splenius cervicis muscles, (7) trapezius muscle, (8) trachea, (9) esophagus, (10) internal jugular vein, (11) common carotid artery, (12) vagus nerve, (13) vertebral artery and vein
0.125% bupivacaine (0.25% levobupivacaine), 0.125 mg/kg b.w./h, combined with opioids if appropriate [37]

Individual adjustment of the dosage and period of treatment is necessary. The following information is therefore only intended to provide guidance.

Distribution of the blocks
The complete distribution of the anesthesia is shown in Fig. 9.20.

Interscalene block
Side effects
Simultaneous anesthesia of the following nerves and ganglia (Fig. 9.21):
- Vagus nerve, main symptoms: tachycardia, hyper tension.
- Recurrent laryngeal nerve, main symptoms: hoarseness and foreign-body sensation in the throat.
- Phrenic nerve, main symptoms: unilateral paralysis of diaphragmatic movement and simulation of pneumothorax, particularly with continuous blocks [13, 37]. An ipsilateral block of the phrenic nerve has been observed as a side effect after an interscalene block in nearly 100% of patients [63].
- Cervicothoracic (stellate) ganglion, with Horner’s syndrome.
- Bronchospasm [59].
- Contralateral anesthesia [14].
- Bilateral distribution of the local anesthetic [28].
- Reversible “locked-in” syndrome [1].

Complications
Nerve injuries
Traumatic nerve injuries are an extremely rare complication of this technique [2, 61].
Prophylaxis: Only needles with short-beveled tips should be used. Intraneural positioning should be excluded. Vasopressor additives should be avoided. This procedure should not be performed in adult patients under general anesthesia. For details, see p. 106 in the section on axillary blocks.

Intravascular injection [11]
There is a particular risk of intravascular injection into the vertebral artery (Fig. 9.21) or other cervical vessels. This can very quickly lead to toxic reactions. For the symptoms and treatment, see Chapter 6, p. 65.

Epidural or subarachnoid injection [24, 43, 57]
Epidural injection of the local anesthetic can lead to high epidural block, and subarachnoid administration can lead to a total spinal block. Both complications are
significant and life-threatening, and require immediate treatment (see Chapter 6, p. 67).
Prophylaxis: injection with short needles and introduction of the needle in a caudal direction.

**CNS toxicity**
Overdose and/or intravascular diffusion of the local anesthetic can, in extremely rare cases, lead to CNS toxicity (see Chapter 6, p. 66).

**Pneumothorax**
When the technique is carried out correctly, this complication is unlikely. The needle is advanced at a safe distance from the dome of the pleura.

**Pressure on the carotid artery**
Extremely rare and transient. Caused by the volume of the injection [50].
Chapter 9

Interscalene block of the brachial plexus

„Single-shot“-technique

<table>
<thead>
<tr>
<th>Right</th>
<th>Left</th>
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- Name: ____________________________ Date: ____________________________
- Diagnosis: ____________________________
- Premedication: □ No □ Yes
- Neurological abnormalities: □ No □ Yes (which?)
- Purpose of block: □ Surgical □ Diagnostic □ Therapeutic
- i. v. access: □ Yes □ No
- Monitoring: □ ECG □ Pulse oxymetry
- Ventilation facilities: □ Yes (equipment checked) □ No
- Emergency equipment (drugs): □ Checked □ Not checked
- Patient: □ Informed □ Not informed
- Position: □ Supine □ Head to contralateral side
- Needle type: □ Plexufix® □ 25 mm □ 50 mm □ Stimuplex® D □ Other
- Puncture technique: □ Interscalene groove located □ Level C6
- Nerve region: ____________________________
- Local anesthetic: ________ ml ________ % (in incremental doses)
- Addition: □ Yes ________ μg/mg □ No
- Patient’s remarks during injection: □ None □ Paresthesia □ Warmth
- □ Pain triggered (intraneuronal location?)
- Nerve region: ____________________________
- Objective block effect after 15 min:
  □ Cold test □ Temperature measurement right ________ °C left ________ °C
  □ Sensory □ Motor
- Monitoring after block: □ < 1 h □ > 1 h
- Time of discharge: ____________________________
- Complications:
  □ None □ Intravascular □ Epidural/subarachnoid □ Pneumothorax
- Side effects:
  □ None □ Hematoma □ Phrenic nerve □ Recurrent laryngeal nerve
  □ Horner’s syndrome
- Subjective effects of the block:
  □ None □ Increased pain □ Reduced pain □ Relief of pain
- Duration: ____________________________

VISUAL ANALOG SCALE

Special notes:

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Interscalene block of the brachial plexus

Continuous technique

Purpose of block:  □ Surgical  □ Therapeutic

i. v. access:  □ Yes

Monitoring:  □ ECG  □ Pulse oxymetry

Ventilation facilities:  □ Yes (equipment checked)

Emergency equipment (drugs):  □ Checked

Patient:  □ Informed

Position:  □ Supine  □ Other

Puncture technique:  □ Electrostimulation

Access route:  □ Anterior  □ Posterior

Needle type:  □ Contiplex® D    mm    G    □ Tuohy   mm    G    □ Other

Puncture technique:  □ Interscalene groove located    □ Level C6

Catheter:  □ Advanced    cm

Aspiration test:  □ Carried out

Bacterial filter:  □ Placed

Bolus administration:    ml    %

Addition to injection solution:  □ No  □ Yes

Patient’s remarks during injection:  □ None  □ Paresthesias  □ Warmth

Pain triggered (intraneural location?):

Nerve region

Objective block effect after 15 min:

□ Cold test  □ Temperature measurement: right    °C left    °C

□ Sensory  □ Motor

□ Continuous monitoring

□ Infusion for postoperative analgesia

Local anesthetic:   %   ml/h

□ Additon to LA:   mg   µg

Patient-controlled anesthetic PCA

Local anesthetic:   %

Addition

□ Baseline rate   ml/h

□ Bolus administration   ml

□ Lockout interval   min

Complications:

□ None  □ Intravascular  □ Epidural/subarachnoid  □ Pneumothorax

Side effects:

□ None  □ Hematoma  □ Phrenic nerve

□ Recurrent laryngeal nerve  □ Horner’s syndrome

Subjective effects of the block:

Duration:

□ None  □ Increased pain  □ Reduced pain  □ Relief of pain

VISUAL ANALOG SCALE

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Supraclavicular perivascular (subclavian perivascular) block

Definition
Injection of a local anesthetic into the area of the brachial plexus trunks in the caudal part of the interscalene groove, in its most compact part above the clavicle. This technique was first described by Winnie and Collins [73].

Indications
Surgical
Operations in the upper arm, forearm and hand.

Therapeutic
None.

Contraindications
Specific
Infections or malignant diseases in the area of the throat and neck.
Infection of the skin in the injection area.
Contralateral paresis of the phrenic nerve or recurrent laryngeal nerve.
Anticoagulant treatment.
Distorted anatomy – e.g. due to prior surgical interventions or trauma in the area of the throat and neck.
Severe chronic obstructive pulmonary disease.
Contralateral pneumothorax.

Relative
The decision should be taken after carefully weighing up the risks and benefits:
Hemorrhagic diathesis.
Stable systemic neurological diseases.
Local nerve injury (as there may be doubt whether the cause is surgery or anesthesia).

Procedure
This block should only be carried out by experienced anesthetists or under their supervision. Patients should receive full information before the procedure.

Preparations and materials
(See the section on the interscalene block, Figs. 9.5 and 9.6.)

Technique
Locating the injection site
The most important landmarks are:
The interscalene groove, with its caudal part in the supraclavicular fossa (see the section on the interscalene block, steps for location, Figs. 9.8–9.12). The process of locating the site is often difficult when the caudal part of the interscalene groove is covered by the omohyoid muscle. During the injection, particular attention should be given to the course of the scalenus medius muscle (Fig. 9.22).
The subclavian artery, which is located in the immediate vicinity of the plexus trunks. The arterial pulse is the most important mark for the injection.
The midpoint of the clavicle. The injection point is located ca. 1.5–2 cm lateral to the clavicular head of the sternocleidomastoid muscle and 2 cm above the clavicle.
The course of the external jugular vein as far as the supraclavicular fossa.

Injection technique
After clear palpation of the subclavian artery, the tip of the left index finger is placed directly over the pulsation.
The hub of an injection needle with a short-beveled tip is fixed between the index finger and the thumb of the right hand (Fig. 9.24).
The needle is introduced in a caudal direction along the long axis of the body, near the scalenus medius muscle. The needle hub almost touches the skin of the throat, with the shaft lying parallel to the skin.

Perforation of the fascia is confirmed by a “fascial click,” and it is accompanied by paresthesias. The patient is asked to say “now” when paresthesias are experienced and to describe their location precisely. Paresthesias elicited below the shoulder, particularly in the innervation area of the median nerve, are important here. Paresthesias in the shoulder area indicate stimulation of the suprascapular nerve and are less important, since this nerve often lies outside the neurovascular sheath.
After paresthesias have been elicited, correct positioning of the needle is checked by aspiration at various levels and an initial dose of local anesthetic (2–3 mL) is quickly injected. The increased pressure within the perivascular space causes pain for the patient (known as pressure paresthesia). During the injection of local anesthetic, aspiration must be repeated after each 4–5 mL. The index finger of the left hand should apply pressure above the needle in order to prevent the local anesthetic from spreading cranially (Figs. 9.25, 9.26).

After successful injection, the entire area is massaged to ensure even distribution of local anesthetic. This also serves for hematoma prophylaxis.
Electrostimulation
A stimulation current of 1–2 mA and 2 Hz is selected with a stimulus duration of 0.1 ms, and the needle is advanced in the direction of the brachial plexus trunks (Fig. 9.25). After the motor response from the relevant musculature, the current is reduced to 0.2–0.3 mA (Fig. 9.26). Slight twitching suggests that the stimulation needle is in the immediate vicinity of the nerve. After aspiration, injection of a local anesthetic is carried out in incremental doses. During the injection, the twitching slowly disappears.

Problem situations
If the needle is positioned too far anteriorly in the vicinity of the scalenus anterior muscle, the subclavian artery may be punctured. This is definite evidence that the needle is located in the perivascular space.

The needle is withdrawn to lie subcutaneously and then introduced dorsolaterally, in the vicinity of the scalenus medius muscle, until paresthesias are elicited.

If no paresthesias are elicited, then the needle has missed all three trunks of the brachial plexus lying and it will come into contact with the first rib (protective function, preventing pleural puncture).

The needle is withdrawn to a subcutaneous position and its direction is corrected by about 1 cm dorsally, closer to the scalenus medius muscle.

When a tourniquet is applied, an additional block of the intercostobrachial nerve (T2) and medial brachial cutaneous nerve is sometimes required. For this purpose, the arm is abducted about 90° and 5 mL of local anesthetic is injected directly above the pulsations of the axillary artery.

Dosage
Surgical
40 mL local anesthetic
0.75% ropivacaine
0.5% bupivacaine (0.5% levobupivacaine)
1% prilocaine
1% mepivacaine

Distribution of the block
The complete distribution of the anesthesia is shown in Fig. 9.27.

Side effects
Concomitant block of the following nerves and ganglia:

The patient must be informed about the expected paresthesias and their significance. If severe pain occurs during the injection (intraneural location), the injection should be stopped immediately and the position of the needle should be changed.
Vagus nerve, recurrent laryngeal nerve, phrenic nerve.
Stellate ganglion (see section on interscalene block, p. 92).

Complications
Pneumothorax (0.5–6%; Fig. 9.28).
Neural injury (see section on axillary block, p. 111).
Intravascular injection (see Chapter 6, section on stellate ganglion, p. 65).
CNS intoxication (see section on axillary block of the brachial plexus, p. 112).

Vertical infraclavicular block
(Kilka, Geiger and Mehrkens technique)

With the traditional infraclavicular block of the brachial plexus [41], an alternative access route was sought that would provide a more effective alternative to the axillary route [52, 67]. The aim of this technique was to achieve a more complete distribution of the anesthesia and a faster onset, allowing better tolerance of the tourniquet and dispensing with the need for special positioning of the arm, while facilitating catheter techniques [22, 30].

Indications and contraindications
(See axillary block, p. 106.)

Additional contraindications
Chest deformities.
Distorted anatomy (e.g. a dislocated and healed clavicular fracture, prior surgical procedures, or trauma in the puncture area).
Foreign bodies in the puncture area (subclavian central venous line, cardiac pacemaker, etc.).

Procedure
This block should only be carried out by experienced anesthetists or under their supervision. Full prior explanation for the patient is mandatory.

Preparations
(See interscalene block, p. 85.)

Materials (Fig. 9.6)
Stimuplex® neurostimulator HNS 11 (B. Braun Melsungen).
“Single-shot” technique
Stimuplex D® 40(−55)-mm 22-G (15°) needle (B. Braun Melsungen), or Tuohy 38(−52)-mm 18-G needle (B. Braun Melsungen).
Continuous technique
Contiplex D® set: 55-mm 18-G (15°) needle (B. Braun Melsungen) with Contiplex® catheter.
Contiplex®-Tuohy continuous set: 38(−52)-mm 18-G Tuohy needle with Contiplex® catheter.
Syringes: 2, 10, 20 mL.
Local anesthetics, disinfectant, swabs, compresses, sterile gloves and drape.
Chapter 9

Fig. 9.29 Vertical infraclavicular block. Landmarks: (1) middle of the jugular fossa, (2) ventral process of the acromion, (3) puncture site

Fig. 9.30 Vertical infraclavicular block. The precise location of the ventral acromion (1) is very important. The immobile acromion can be distinguished from the mobile humeral head by passive movement of the ipsilateral upper arm. (2) Coracoid process, (3) humerus, (4) scapula

**Landmarks**
- Center of the suprasternal notch.
- Anterior acromion.
- Infraclavicular fossa.

The course of the brachial plexus should be studied again (see interscalene block, steps for locating the puncture site, Figs. 9.8–9.12).

**Locating the puncture site**
The line between the suprasternal notch and the anterior acromion is halved (Fig. 9.29). Precise location of the anterior acromion is very important (the immobile acromion can be distinguished from the mobile humeral head by passive movement of the upper arm; Fig. 9.30). The plexus lies at a depth of ca. 3 cm lateral to the axillary artery and vein. The first rib provides some protection against puncture of the pleura.

**Skin prep**
In all blocks.

**Patient positioning**
Supine, with the hand on the side being blocked lying relaxed on the abdomen.

The following points must be observed during the puncture procedure:
- Electrical nerve stimulation is the method of choice.
- The anesthetist should stand at the patient’s head (this provides better control of any needle deviation, particularly in the medial direction).
- Caution should be exercised if a depth of 3 cm is reached without any motor response from the relevant musculature (risk of pneumothorax!).
- The needle should never be directed medially (possible injury to the subclavian artery and vein).
- Peripheral muscle contractions (flexion or tension of the first to third fingers – radial and median nerves) are regarded as a promising response to the stimulation.
- Aspiration of blood means that the puncture is too far medial.
- If severe pain occurs during the injection (intraneural location), the injection should be stopped immediately and the position of the needle should be corrected.
- Before and during the injection (after each 4–5 mL), aspiration should be performed.
Technique

“Single-shot” technique

After disinfection of the puncture area and draping, skin infiltration should be carried out **directly below the clavicle** (Fig. 9.31). A skin incision is made with a stylet at the puncture site so that the needle can be introduced easily. The electrostimulation needle is advanced **strictly perpendicular to the surface the patient is resting on** (Figs. 9.32 and 9.33). A stimulation current of 1–2 mA and 2 Hz is selected with a stimulus duration of 0.1 ms. After the motor response from the relevant musculature, the stimulation current is reduced to 0.3–0.5 mA. The plexus is located at a depth of ca. 3–4 cm. Slight twitching suggests that the stimulation needle is in the immediate vicinity of the plexus. After aspiration, injection of a local anesthetic is carried out in incremental doses. During the injection, the twitching slowly disappears.

**Dosage**

**Surgical**

40–50 mL local anesthetic – e.g. 0.5–0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine). A combination of 0.5–0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine) with 1% prilocaine or 1% mepivacaine has proved very successful in practice.
Therapeutic
15–20 mL local anesthetic – e.g. 0.2–0.375% ropivacaine or 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

Distribution of the block
The complete distribution of the anesthesia is shown in Fig. 9.34.

Continuous technique
The Tuohy or Contiplex plastic indwelling catheter should be advanced as slowly as possible. A stimulation current of 1–2 mA and 2 Hz is selected with a stimulus duration of 0.1 ms. After the motor response from the relevant musculature is seen, the stimulation current is reduced to 0.2–0.3 mA. Slight twitching suggests that the stimulation needle is in the immediate vicinity of the nerve. The opening of the Tuohy needle should be directed toward the course of the neurovascular sheath of the plexus (Fig. 9.4). The catheter is advanced approximately 3 cm beyond the end of the needle or cannula (Fig. 9.35). As the needle’s angle of puncture is not parallel to the neurovascular sheath, some springy resistance can often be expected when advancing the catheter. Initial administration of 5–10 mL 0.9% saline is recommended. After removal of the needle or cannula, fixation of the catheter and placement of a bacterial filter, and after careful aspiration and injection of a test dose, the bolus administration of the local anesthetic follows.
**Dosage**

**Test dose and bolus administration**

Test dose: 3–5 mL local anesthetic – e.g. 0.5–0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine).

Bolus administration: 20–40 mL local anesthetic – e.g. 0.5–0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine).

**Maintenance dose**

Individual adjustment of the dose and period of treatment is absolutely necessary. The following information is therefore only intended to provide guidance.

**Continuous infusion**

Infusion of the local anesthetic via the plexus catheter should be started approximately 1 h after the bolus administration. Administering a test dose is obligatory. The following dosages have proved their value in practice:

- **6–15 mL/h** 0.2% ropivacaine (max. 37.5 mg/h).
- **8–18 mL/h (usually 10–14 mL/h)** 0.125% bupivacaine (0.125% levobupivacaine).
- **6–16 mL/h (usually 8–10 mL/h)** 0.25% bupivacaine (0.25% levobupivacaine).

If necessary, the infusion can be supplemented with bolus doses of 5–10 mL 0.5–0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine).

**Patient-controlled analgesia (PCA)**

- **Baseline rate** of 4 mL/h 0.2% ropivacaine or 0.125% bupivacaine (0.125% levobupivacaine).
- **Bolus administration** of 3–4 mL 0.2% ropivacaine or 0.125% bupivacaine (0.125% levobupivacaine).
- **Lockout interval** of 15–20 min.

**Side effects**

- Hematoma formation.
- Horner’s syndrome (rare).

**Complications**

- Pneumothorax (Fig. 9.36) [35].
- Prophylaxis: not directing the needle medially.
- Intravascular injection (see axillary block, p. 112)
- CNS toxicity (see axillary block, p. 112)
- Nerve injury (see axillary block, p. 111)

Fig. 9.36 Vertical infraclavicular block. Risk of pneumothorax.
### Infraclavicular block of the brachial plexus

#### „Single-shot“-technique

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<thead>
<tr>
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<tbody>
<tr>
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### Intraclavicular block of the brachial plexus

#### Continuous technique

<table>
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<tr>
<th>Technique</th>
<th>☐ Right</th>
<th>☐ Left</th>
</tr>
</thead>
</table>

#### Purpose of block:

| ☐ Surgical | ☐ Therapeutic |

#### i. v. access:

| ☐ Yes |

#### Monitoring:

| ☐ ECG | ☐ Pulse oximetry |

#### Ventilation facilities:

| ☐ Yes (equipment checked) |

#### Emergency equipment (drugs):

| ☐ Checked |

#### Patient:

| ☐ Informed |

#### Technique:

- ☐ Vertical infraclavicular
- ☐ Other

#### Position:

| ☐ Supine |

#### Puncture technique:

| ☐ Electrostimulation |

#### Needle type:

| ☐ Contiplex® D mm G | ☐ Tuohy mm G | ☐ Other |

#### Catheter:

| ☐ Advanced cm |

#### Aspiration test:

| ☐ Carried out |

#### Bacterial filter:

| ☐ |

#### Test dose:

- ☐ ml %

#### Bolus administration:

- ☐ ml %

(in incremental doses)

#### Addition to injection solution:

- ☐ No
- ☐ Yes µg/mg

#### Patient's remarks during injection:

- ☐ None
- ☐ Paresthesias
- ☐ Warmth
- ☐ Pain triggered (intraneural location?)

#### Nerve region:

| ☐ |

#### Objective block effect after 15 min:

| ☐ Cold test | ☐ Temperature measurement: right °C left °C |
| ☐ Sensory | ☐ Motor |
| ☐ Continuous monitoring |

#### Infusion for postoperative analgesia

Local anesthetic: % ml/h

Addition to LA: mg µg

Patient-controlled anesthesia (PCA)

Local anesthetic: % ml/h

Addition: %

- ☐ Baseline rate ml/h
- ☐ Bolus administration ml
- ☐ Lockout interval min

#### Complications:

- ☐ None
- ☐ Signs of intoxication
- ☐ Pneumothorax
- ☐ Hematoma
- ☐ Neurological injury (median nerve, ulnar nerve, radial nerve)

#### Subjective effects of the block:

| ☐ None | ☐ Increased pain | ☐ Reduced pain | ☐ Relief of pain |

#### VISUAL ANALOG SCALE

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Axillary block

Single-shot techniques and block series

Indications

Surgical
As a single-shot or continuous block [7, 26, 33, 45, 46, 55]. This is the method of choice for all general, vascular, neurosurgical or orthopedic procedures and manipulations in the arm below the elbow and in the hand region.

Diagnostic
Postamputation pain.
Complex regional pain syndrome (CRPS) types I and II.
Checking (confirmation) of surgical sympathectomy.
Differential diagnosis of peripheral and central pain.

Prophylactic
As an alternative to cervicothoracic ganglion block, when a stellate block is contraindicated or cannot be carried out for technical reasons.

Therapeutic
Following peripheral nerve injury, with causalgia development (see case 3, p. 121).

Following surgical neurolysis, to improve postoperative reinnervation.
Severe arterial spasm – e.g. after accidental intraarterial injection of thiopental (or as a continuous block).
Complex regional pain syndrome (CRPS) types I and II (see cases 1 and 2, pp. 120f).
Rheumatic diseases.
Wrist arthritis.
Neuropathies – e.g. due to diabetes.
Post-herpetic neuralgia.
Post-amputation pain (block series in chronic pain conditions).
Postoperative pain (in most cases, a preoperative block with a long-duration local anesthetic is sufficient).

Contraindications

Specific
Infections (e.g. lymphangitis) or malignant disease in the arm.
Anticoagulation treatment.
Upper arm fractures or other conditions preventing abduction of the arm.
Patient refusal.

Fig. 9.37 Distal (axillary) neurovascular sheath.
(1) Musculocutaneous nerve, (2) median nerve, (3) axillary artery, (4) ulnar nerve, (5) lateral cord
The decision should be taken after carefully weighing up the risks and benefits:
- Hemorrhagic diathesis.
- Stable systemic neural diseases.
- Local nerve injury (as there may be doubt whether the cause is surgery or anesthesia).

**Procedure**

This block should only be carried out by experienced anesthetists or under their supervision. The patient should be fully informed about the procedure.

**Preparations and materials**

(See section on interscalene block, p. 85; see Figs. 9.5 and 9.6).

**Skin prep**

in all blocks.

**Patient positioning**

Supine, with the upper arm abducted (90–100°) and the forearm flexed (90°) and rotated outward (Fig. 9.38).

Hyperabduction must be avoided. It obliterates the arterial pulsation, making palpation of the artery difficult and adversely affecting the distribution of the local anesthetic.

**Landmarks**

Axillary artery, deltoid muscle, pectoralis major muscle, biceps muscle, coracobrachialis muscle. The axillary fossa is delimited by the deltoid muscle and pectoralis major muscle above and by the biceps and coracobrachialis muscles below (Fig. 9.39). The axillary artery lies together with the ulnar nerve, median nerve and radial nerve, as well as the brachial and medial antebrachial cutaneous nerves in the neurovascular sheath. The sheath normally encloses the axillary vein as well, but not always.

**Location of the injection site**

The axillary artery is palpated as proximally as possible under the lateral edge of the pectoralis major muscle and is fixed with the index and middle fingers (Fig. 9.39).

The high proximal palpation and fixing of the axillary artery increases the likelihood of including the musculocutaneous in the block. This nerve leaves the axillary fossa together with the axillary nerve at the level of the coracoid process.

**Injection technique**

After disinfection of the entire axilla and draping, the skin is infiltrated immediately above the fixed artery. The skin at the injection site is incised with a stylet to
make introduction of the needle easier. Winnie [69] recommends the use of an “immobile needle.” This is slowly advanced proximally at an angle of ca. 15–30° in the direction of the neurovascular sheath (Fig. 9.40a, b).

**Needle position**
Before the injection, it must be confirmed that the neurovascular sheath has been reached and that the needle is securely positioned in the fascial compartment. The following techniques are suitable for this:

**"Fascial clicks"**
Enter the needle into the neurovascular sheath is confirmed by what are termed “fascial clicks.” When needles with short-beveled tips are used, puncture of the connective tissue is easily felt and is often also audible.

**Pulse-synchronous movement of the needle**
Positioning of the needle tip in the immediate vicinity of the artery can be confirmed by pulse-synchronous movement of the needle, although this does not guarantee secure positioning in the neurovascular sheath and does not provide reliable evidence on its own.

**Electrical nerve stimulation** (Fig. 9.41)
Twitching of the relevant musculature to neural stimulation, this allows individual nerves to be targeted and located with ease, and nerve lesions are rarely produced. Patient cooperation is not required.

**Technique**
A stimulation current of 1–2 mA and 2 Hz is selected with a stimulus duration of 0.1 ms. After the motor response from the relevant musculature, the stimulation current is reduced to 0.2–0.3 mA. Slight twitching suggests that the stimulation needle is located in the immediate vicinity of the nerve. After aspiration, injection of a local anesthetic is carried out in incremental doses. During the injection, the muscle twitching slowly disappears.

Fig. 9.40a, b Puncturing the neurovascular sheath

Fig. 9.41 Electrical nerve stimulation
Paresthesias
It is not obligatory to produce paresthesias with this block technique. Due to the potential risk of nerve injury – Selander [47, 49] reports post-block neuropathies in 2.8% of cases, while other authors [66, 68] only report occasional complications – paresthesias should be avoided if possible. On the other hand, it should be emphasized that in ca. 40% of cases, paresthesias are produced inadvertently [47, 49, 53], and these are a definite sign of correct needle positioning. The patient must be informed about these and must be able to report the occurrence of paresthesias immediately and describe their spread.

Arterial puncture technique
Aspiration of blood indicates that the needle is located in the axillary artery and therefore within the neurovascular sheath.

Injection
When the needle is securely located in the neurovascular sheath, repeated aspiration is carried out and the local anesthetic is injected slowly. A certain amount of pressure is needed for this, since the fascial cover creates resistance to the injection. Aspiration must be repeated after each injection of 4–5 mL, no matter which technique is used.

Perivascular technique
In the perivascular technique [3, 18], all of the local anesthetic is distributed in the neurovascular sheath around the artery (perivascular).

Transarterial injection
This technique is being increasingly used due to its high success rate (89–99%) [6, 53, 72] and low complication rate, and its value has been particularly demonstrated with obese patients. After targeted puncture of the artery and blood aspiration (Fig. 9.42), the needle is withdrawn until no more blood can be aspirated. Without creating paresthesias, 20 mL of local anesthetic is injected initially. The needle is then advanced to the opposite side of the artery and, after careful aspiration, the remaining volume (20 mL) is administered [61]. The following are variants of this procedure:

Single injection into a single compartment [6]
The entire dose of the local anesthetic is deposited behind the artery (posterior).

Multiple injections into multiple compartments [53]
Half of the dose is injected behind the artery (posterior) and the other half is distributed according to the area to be operated on: in the ulnar and median nerve region (in front of the artery), radial nerve region (behind the artery) (Fig. 9.37). Potential disadvantages of the transarterial technique are that persistent bleeding may reduce the quality of the anesthesia by diluting the local anesthetic, or that a hematoma may compress neighboring nerves and prevent access of the local anesthetic. As with all procedures, intravascular injection – into the axillary vein as well – is theoretically possible with this technique [15].

Distribution of the local anesthetic
To ensure optimal distribution of the local anesthetic, the neurovascular sheath is compressed with the fingers distal to the needle during the injection. Applying a tourniquet distal to the injection site is ineffective, since the muscle mass is little affected by this [71, 74]. After removal of the needle, compressing the axilla (3–5 min) (Fig. 9.43) and simultaneous massaging encourages improved distribution of the local anesthetic. It also serves for hematoma prophylaxis.
**Dosage**

**Surgical**

40–50 mL local anesthetic – e.g. 0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine). A combination of 0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine) with 1% prilocaine or 1% mepivacaine has proved its value in practice (in our own experience). According to De Jong [8, 9, 10], 42 mL local anesthetic is required to reach the musculocutaneous and axillary nerves. Other authors report the use of 30–50 mL. Opinions vary with regard to the addition of opioids [12, 21].

**Diagnostic**

20 mL local anesthetic – e.g. 0.2% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine), 0.5% prilocaine, 0.5% mepivacaine.

**Prophylactic**

10–20 mL local anesthetic – e.g. 0.2–0.375% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

**Therapeutic**

10 mL local anesthetic – e.g. 0.2–0.375% ropivacaine or 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine), in diabetic and other neuropathies and in rheumatic diseases.

10–15 mL local anesthetic – e.g. 0.2% ropivacaine or 0.125% bupivacaine (0.125% levobupivacaine), in wrist arthritis.

10–20 mL local anesthetic – e.g. 0.375% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine), in post-amputation pain, after surgical neurolysis and in post-herpetic neuralgia.

20 mL local anesthetic – e.g. 0.2–0.375% ropivacaine or 0.25–0.375% bupivacaine (0.25–0.375% bupivacaine), in complex regional pain syndrome (CRPS) types I and II.

20 mL local anesthetic – e.g. 0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine), in severe arterial spasm – e.g. after accidental intra-arterial injection of thiopental.

**Distribution of the block**

After onset of the full effect – the latency period can be up to 30 min in the axillary block – the anesthesia completely covers the arm and hand from the elbow downwards, as well as much of the upper arm (Fig. 9.44).
Patients must be given the relevant information, especially in outpatient procedures.

From the anesthesiological point of view, the following points should be taken into account:

**Prophylaxis**

Only needles with short-beveled tips should be used. During the injection, the needle should be introduced parallel to the nerve fascicle with the beveled angle in the longitudinal direction of the course of the nerve.

Intraneural positioning of the needle should be excluded. If the patient reports severe pain during the injection, the injection should be stopped at once and the needle should be withdrawn.

Vasopressor additives should be avoided. They are rarely indicated — and are even contraindicated in pain therapy — and may cause prolonged ischemia. They are also contraindicated in hypertonia, hyperthyroidism and arrhythmia [48, 49].

In particular, reactions to epinephrine (restlessness, tachycardia, arrhythmia) may be confused with signs of overdose of local anesthetic.

Avoid supplementation. An incomplete plexus block should not be supplemented with other additional peripheral nerve blocks, since this would mean paresthesias would not be available as warning signals [53, 72].

Blocks should not be carried out in adult patients under general anesthesia.

Careful documentation

The following should be documented in every nerve block:

- Approach.
- Needle type.
- Local anesthetic used and additives, if any.
- Description of the paresthesias elicited.
- Any vascular puncture or injection pain.
- Hematoma formation.
- Any supplementation.
- Tourniquet duration.

**Diagnosis and treatment**

When there is the slightest suspicion of neurological injury, a detailed examination should be carried out and the diagnosis should be made by a neurologist. In the axillary plexus block, the median and ulnar nerves are the ones most often affected. The prognosis is generally very good. With neurological treatment and physiotherapy, restoration of function takes a few days, up to a maximum of a year ("tincture of time") [47, 53, 61, 66, 68].
**Intravascular injection**

There is a particular risk of injection into the axillary artery or axillary vein [15]. For symptoms and treatment, see Chapter 6, p. 65.

Prophylaxis: During slow injection, aspiration should be repeated after each 4–5 mL.

**CNS toxicity**

In very rare cases, overdose of local anesthetic, fast absorption of local anesthetic at the injection site, or inadvertent intravascular injection can lead to toxic reactions. These develop in the course of ca. 20 min after the injection, or much more quickly with intravascular administration.

Early symptoms include a numb sensation in the lips and tongue, a metallic taste, sleepiness, vertigo, ringing in the ears, auditory disturbances, visual disturbances, slurred speech, muscular trembling and nystagmus.

Generalized tonic-clonic seizures are the most dangerous cerebral complication, but these do not lead to brain damage or death of the patient provided immediate and correct treatment is given. For therapeutic procedures for CNS intoxication, see Chap. 6, p. 66.

**Pseudoaneurysms**

Formation of a pseudoaneurysm of the axillary artery [16, 36, 75], accompanied by postoperative paresthesias and plexus paralysis.
Axillary block of the brachial plexus

„Single-shot“-technique  □ Right  □ Left

Name: __________________________ Date: __________________________
Diagnosis: __________________________
Premedication: □ No  □ Yes __________________________
Neurological abnormalities: □ No __________________________
 □ Yes (which?) __________________________
Purpose of block: □ Surgical  □ Diagnostic  □ Therapeutic
i. v. access: □ Yes __________________________
Monitoring: □ ECG  □ Pulse oximetry __________________________
Ventilation facilities: □ Yes (equipment checked) __________________________
Emergency equipment (drugs): □ Checked __________________________
Patient: □ Informed __________________________

Position: □ Supine  □ Abducted upper arm (90-100°) __________________________
Needle type: □ Plexufix® 24 G (45°) □ 25 mm □ 50 mm __________________________
 □ Stimuplex® D __________ mm __________________________
 □ Other __________________________
Puncture technique: □ Perivascular  □ Paresthesias __________________________
 □ Transarterial  □ Electrostimulation __________________________
Local anesthetic: __________ mt. __________ % (in incremental doses) __________________________
Addition to injection solution: □ No  □ Yes __________ μg/mg __________________________
Patient’s remarks during injection: □ None  □ Paresthesias  □ Warmth __________________________
Pain triggered (intraneural location?) __________________________
Nerve region __________________________
Objective block effect after 15 min: □ Cold test  □ Temperature measurement: right __________ °C  left __________ °C __________________________
 □ Motor __________________________
Monitoring after block: □ < 1 h  □ > 1 h __________________________
Time of discharge __________________________
Complications: □ None  □ Signs of intoxication __________________________
 □ Hematoma  □ Neurological injuries (median nerve, ulnar nerve, radial nerve) __________________________
Subjective effects of the block: __________________________
 □ None  □ Increased pain  □ Reduced pain  □ Relief of pain __________________________

VISUAL ANALOG SCALE

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Continuous axillary block

Indications

Surgical
This is the method of choice as a continuous [26, 45, 46, 55] or single block in all general, vascular, neurosurgical or orthopedic interventions and manipulations in the arm below the elbow and in the hand region.

Prophylactic
Postoperative analgesia.
Prevention or reduction of post-amputation pain. It is recommended that the continuous block is started 2–3 days before the planned intervention, if possible.

Therapeutic
After surgical reimplantation.
Poor perfusion of the upper extremity.
Arterial occlusive disease.
Edema after radiotherapy (with additional corticoids).
Post-amputation pain (in acute pain).
Pain caused by trauma.

Specific and relative contraindications
The contraindications are similar to those for the single-shot block.

Procedure

This block should only be carried out by experienced anesthetists. Patients should receive full information before the procedure.

Continuous administration requires continuous monitoring, daily checking of the catheter position, daily change of the bacterial filter and dressing, as well as an obligatory test dose before every subsequent injection.

Preparations
(See the section on the interscalene block, p. 85)

Materials (Fig. 9.45)
Stimuplex® HNS 11 nerve stimulator (B. Braun Melsungen).
Syringes (2 mL, 10 mL, 20 mL), catheter set (e.g. Contiplex® D or Contiplex®-Tuohy continuous set – e.g. B. Braun Melsungen; see Fig. 9.6c and d), drape, stylet, disinfectant, bacterial filters, cooled physiological saline.

Skin prep
In all blocks.

Patient positioning
As for the single-shot block.

Landmarks and location of the injection site
The anatomical orientation, with high proximal palpation and fixing of the axillary artery, is the same as for the single-shot block.

Injection technique
After careful skin prep of the axilla and draping, the skin is infiltrated immediately above the fixed artery. The skin is incised at the infiltration site and the needle is introduced at an angle of ca. 30° in the direction of the neurovascular sheath. To avoid vascular and neural injury, the needle should be advanced as slowly as possible and its bevel should be turned towards the axillary artery (Fig. 9.46).

Needle position
"Fascial clicks" and the loss of resistance technique [29] or electrical nerve stimulation [40, 54, 58] can be used to confirm that the neurovascular sheath has been reached and that the needle is positioned within the fascial compartment.

Introducing the catheter
When the injection needle is securely positioned in the neurovascular sheath, the metal stylet is fixed and the Teflon cannula is advanced over the needle as far as the mark. For this purpose, the needle is lowered to ca. 10–20°, to allow it to be advanced parallel to the artery as much as possible (Fig. 9.47).
After removal of the needle and aspiration, 5 mL of cold physiological saline is injected via the Teflon cannula. Any paresthesia, and low resistance during the injection in particular, will confirm correct positioning in the neurovascular sheath. The catheter is introduced through the cannula as far as the 10-cm mark if possible (mark II), so as to avoid dislodgement (Fig. 9.48).

**Injection of the local anesthetic**
After removal of the cannula, fixation of the catheter and placement of a bacterial filter and after careful aspiration and injection of a test dose, bolus administration of the local anesthetic is carried out.

**Dosage** [5, 26, 45, 55]
The choice and dosage of the local anesthetic depend on the goal of treatment:
- Anesthesia for surgery with subsequent pain therapy.
- Analgesia for mobilization treatment.
- Sympatholytic treatment in peripheral perfusion disturbances.

**Initial bolus administration**
Test dose: 3–5 mL local anesthetic – e.g. 0.375–0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine).
Bolus administration: 20–40 mL local anesthetic – e.g. 0.375–0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine).

**Maintenance dose**

Individual adjustment of the dosage and period of treatment is absolutely necessary. The following information therefore only serves for general guidance.

**Intermittent administration**
Every 5–6 h, 5–10 mL local anesthetic – e.g. 0.5–0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine), after a prior test dose. Reduction of the dosage and/or dosage intervals depending on the clinical picture.

**Continuous infusion**
Infusion of the local anesthetic via the plexus catheter should be started ca. 1 h after the bolus administration. A test dose is obligatory.

The following dosages have proved their value:
- 6–14 mL/h 0.2% ropivacaine (max. 37.5 mg/h)
- 8–18 mL/h (usually 10–14 mL) 0.125% bupivacaine (0.125% levobupivacaine), or 4–16 mL (usually 8–10 mL) 0.25% bupivacaine (0.25% levobupivacaine).
If necessary, the infusion can be supplemented with bolus doses of 5–10 mL 0.5–0.75% ropivacaine or 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine).

**Patient-controlled analgesia (PCA)**

**Baseline rate** of 6–8 mL/h 0.2% ropivacaine.

**Bolus administration** of 4–6 mL 0.2% ropivacaine.

**Lockout interval** of 20–30 min.

**Side effects and complications**

Hematoma formation due to puncture of the axillary artery.

Formation of a pseudoaneurysm on the axillary artery [16, 36, 75], accompanied by postoperative paresthesias and plexus paralysis.

Traumatic nerve injury (extremely rare).

Intravascular injection into the axillary artery or axillary vein [15] (extremely rare).

CNS intoxication (very rare) due to local anesthetic overdose, rapid absorption at the injection site, or inadvertent intravascular injection.

Bacterial colonization of the catheter, with or without local or systemic infection.

Prophylaxis: daily exchange of the bacterial filter, limitation of the period of catheter placement [26, 55].

Catheter dislodgement.

Catheter leakage, particularly at infusion speeds of more than 15 mL/h.
Axillary block of the brachial plexus

Continuous technique

- **Right**
- **Left**

**Purpose of block:** □ Surgical □ Therapeutic

- **i. v. access:** □ Yes □ No

- **Monitoring:** □ ECG □ Pulse oximetry

- **Ventilation facilities:** □ Yes (equipment checked) □ No

- **Emergency equipment (drugs):** □ Checked □ No

- **Patient:** □ Informed □ Uninformed

**Position:** □ Supine □ Abducted upper arm (90°-100°)

**Puncture technique:** □ Electrostimulation

- **Needle type:** □ Contiplex® D mm G □ Tuohy mm G □ Other

- **Catheter:** □ Advanced cm

- **Aspiration test:** □ Carried out □ Not carried out

- **Bacterial filter:** □ Yes □ No

**Test dose:** mL %

**Bolus administration:** mL %

(in incremental doses)

**Addition to injection solution:** □ No □ Yes μg/mg

**Patient's remarks during injection:** □ None □ Parasthesias □ Warmth

**Pain triggered (intraneural location?):**

**Nerve region:**

- **Objective block effect after 15 min:**
  □ Cold test □ Temperature measurement: right °C left °C
  □ Sensory □ Motor □ Continuous monitoring

**Infusion for postoperative analgesia**

- **Local anesthetic:** % ml/h
  **Addition to LA:** mg μg

- **Patient-controlled anesthesia (PCA)**
  □ Local anesthetic: %
  □ Addition:
  □ Baseline rate ml/h
  □ Bolus administration mL
  □ Lockout interval min

**Complications:** □ None □ Signs of intoxication □ Hematoma □ Neurological injuries (median nerve, ulnar nerve, radial nerve)

**Subjective effects of the block:**

- **Duration:**

**Duration:**

**VISUAL ANALOG SCALE**

- **Special notes:**

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Interscalene, subclavian perivascular and axillary blocks of the brachial plexus: advantages and disadvantages

Interscalene block

Advantages
Clear anatomical landmarks: interscalene groove, sternocleidomastoid muscle, transverse process (C6). Can therefore be carried out even with distorted anatomy — e.g., in obese patients.
Patient cooperation is not absolutely necessary.
No special positioning of the arm is required.
Technically simple procedure.
Due to the proximal injection at the level of C6, most of the plexus is anesthetized and the block can be carried out even in cases of infection or malignant disease in the arm. In addition, the caudal parts of the cervical plexus are included.
Surgery and pain treatment are possible in the whole region of the shoulder and upper arm.
Subsequent intraoperative injections are possible in extended interventions.
The risk of pneumothorax is very low. The needle is advanced at a reasonable distance from the dome of the pleura.

Disadvantages
It is necessary to produce paresthesias.
The ulnar nerve territory is not always adequately anesthetized.
The potential complications — although these are extremely rare — include: neural injury, epidural or subarachnoid injection, intravascular injection, CNS intoxication.

Subclavian perivascular block

Advantages
Clear anatomical landmarks: caudal part of the interscalene groove, subclavian artery, midpoint of the clavicle.
Injection of the local anesthetic is possible without repositioning the upper extremity.
There is no risk of subarachnoid or epidural injection, nor of puncturing the vertebral artery.
Infections in the arm do not represent a contraindication to this technique.

Disadvantages
Risk of pneumothorax.
Puncture of the subclavian artery is possible.
Very rarely, applying a tourniquet requires an additional block of the intercostobrachial nerve (T2) and medial brachial cutaneous nerve.
No applications in pain therapy.

Infraclavicular block

Advantages
No positioning difficulties (e.g., in fractures, rheumatism).
Precise positioning of the needle reduces the complication rate.
More favorable distribution of the local anesthetic in the infraclavicular space (lower doses).
The catheter is easily fixed, leading to a lower repositioning rate and unrestricted movement for the patient.
Easy catheter maintenance.
No influence on respiratory function [42].

Disadvantages
Catheter placement is more difficult than with the axillary access route (the puncture angle is not parallel to the neurovascular sheath).
Risk of pneumothorax.
Possible incorrect intravascular positioning.
Arterial pulsation is not available for guidance.

Axillary block

Advantages
Clear anatomical landmarks: axillary artery.
Easily conducted due to the superficial position of the neurovascular sheath. Can also be used in children and in patients with pulmonary problems or renal insufficiency (e.g., inserting an arteriovenous shunt).
Also applicable as a continuous block.
A safe method of anesthesia for surgery and pain therapy treatment, particularly in the forearm and hand.
The following complications and side effects are excluded: pneumothorax, epidural or subarachnoid injection, concomitant block of the vagus, phrenic and recurrent laryngeal nerves or of the stellate ganglion.
This is the method of choice for outpatients and emergency patients.

Disadvantages
Abduction of the upper arm is required.
The anesthesia is not sufficient for surgery on the shoulder or upper arm.
The musculocutaneous nerve and/or axillary nerve are often not adequately anesthetized.
Extremely rare but possible complications are: nerve injury, intravascular injection and CNS intoxication.
Plexus catheter in outpatients?

The catheter technique also allows plexus anesthesia to be used in operations lasting longer than the duration of local anesthetics. Independently of the surgical technique, postoperative blood perfusion disturbances almost always occur, particularly after microsurgical interventions – partly due to the body's reaction to the invasive procedure. With continuous sympatholysis, the catheter technique allows substantial improvement in the perfusion of the operated arm. Continuous administration of local anesthetics and the consequent postoperative analgesia allow effective physiotherapy and therefore speedy mobilization of the operated arm.

In inpatients, continuous plexus block for appropriate indications is also an excellent anesthetic procedure in the context of acute pain therapy and sympatholysis. However, in this situation, the continuous method requires constant monitoring and checking that the technique is successful. This includes in particular:

- Daily checking of the catheter position, to ensure early recognition of intravascular dislocation or dislocation of the catheter from the neurovascular sheath.
- Daily exchanging of the bacterial filter and dressing, to keep the risk of bacterial colonization of the catheter and the associated risk of infection as low as possible.

In outpatient pain therapy, the use of a catheter for continuous plexus anesthesia is therefore rare and it is only possible with very cooperative patients. Additional reasons why the present author has for many years preferred single injections in the context of block series are as follows:

- At the beginning of the therapy, the period of treatment that will be needed is often difficult to estimate and may extend (as the cases described on the following pages show) for 2–3 months. The frequency of treatment necessary during this period is more easily determined using single injections.
- Although complication-free catheter placement for 2–3 weeks (or up to 7 weeks in individual cases) has been reported in the literature [29], this is not sufficient and is associated with too many risks in outpatients.
- The goal of pain therapy blocks – e.g. in complex regional pain syndrome – is to allow physiotherapy and intensive exercise at home for the patient. Many patients find the catheter disturbing (with irritation and a foreign-body sensation) or even obstructive, and there is a risk of inadvertent dislodgement.

The need for continuous monitoring of the effectiveness of the block and for adjustment of the local anesthetic dose, if necessary, makes self-administration by the patient impossible.
Example cases of axillary block of the brachial plexus

Case 1
Total number of blocks: 17.

Patient W. M., a 44-year-old woman
Ongoing pain after surgery for reduction of forearm fracture. After 2 months of unsuccessful treatment, including calcitonin therapy, the patient was referred to our outpatient pain department.

Findings on admission, 18 April 1994
Development of puffy edema (hand and distal part of the forearm), extreme pain when moving the hand, physiotherapy impossible (Fig. 9.49).

Therapy
Starting on the day of presentation, a 3-week series of 10 axillary plexus blocks in all (each dosage 20 mL 0.25% bupivacaine). After the blocks, the patient received physiotherapy and carried out intensive exercise at home [39, 60].
Due to marked improvement in the symptoms (Fig. 9.50), treatment was continued. During the subsequent 3 weeks, the patient received four blocks at a reduced dosage (10 mL 0.25% bupivacaine), with the physiotherapy and home exercises continuing. The mobility of the hand was significantly improved with these measures (Fig. 9.51).
Treatment was concluded with three blocks, again at a reduced dosage (10 mL 0.125% bupivacaine).

Final findings, 6 July 1994
Complete disappearance of symptoms.

Case 2
Total number of blocks: 23.

Patient G. H., a 46-year-old woman
Radius fracture in the right arm on 16 January 1994; removal of the external fixation on 17 March 1994, with incorrect hand position and development of puffy edema (hand and distal part of the forearm). After 3 months of unsuccessful treatment, the patient was referred to our outpatient pain department as therapy-resistant.

Findings on admission, 18 April 1994
Development of puffy edema, extreme pain, movement of the hand impossible, physiotherapy impossible (Fig. 9.52).
Therapy
Starting on the day of presentation, a 3-week series of 10 axillary plexus blocks (each dosage 20 mL 0.25% bupivacaine). Following the blocks, the patient received physiotherapy and carried out intensive exercises at home [39, 60].

Due to marked improvement in the mobility of the hand (Fig. 9.53) and a 60% reduction in pain, the treatment was continued after 5 May 1994. During the subsequent 3 weeks, the patient received five blocks at a reduced dosage (10 mL 0.25% bupivacaine). Physiotherapy and home exercise were continued and the pain reduction was increased up to 80% (Fig. 9.54).

Treatment was concluded with a further eight blocks (with reduction of the dosage to 10 mL 0.125% bupivacaine).

Final findings, 11 July 1994
Complete resolution of the edema, reduced pain and improvement in the mobility of the hand by more than 80% (Fig. 9.55). Partial contractures in the area of the little finger and ring finger. The patient was able to return to work.

Case 3
Total number of blocks: 29 (including four stellate blocks and four cervicobrachial plexus blocks).

Patient S. G., a 47-year-old woman
Humerus fracture after a bicycle accident on 28 September 1994. Emergency operation (with internal fixation). Wrist-drop with severe injury to the radial nerve and injury to the median nerve. Development of causalgia. On 6 December 1994, neurolysis of the radial nerve with subsequent deterioration in symptoms and edema formation. Three and a half months after the accident, the patient was referred to our outpatient pain department as therapy-resistant (calcitonin, antidepressants, physiotherapy) with a prognosis of "hopeless."

Findings on admission, 16 January 1995
In addition to the symptoms described above, there was the characteristic clinical picture of "frozen shoulder." Access to the axilla was therefore not possible in this patient (Fig. 9.56).

Therapy
At the patient’s request, the calcitonin treatment and antidepressant administration were stopped. During the first 3 weeks, the patient received four blocks of the cervicothoracic (stellate) ganglion, followed by four blocks of the cervicobrachial plexus. There was no
improvement in the original symptoms. However, the mobility of the shoulder improved sufficiently to allow partial abduction of the arm, making it possible to carry out axillary plexus blocks.

On 15 February 1995, a 3-week series of six axillary blocks of the brachial plexus was started (each dosage 20 mL 0.25% bupivacaine). Following the blocks, this very cooperative patient received physiotherapy and carried out intensive exercise at home [39, 60]. On 6 March 1995 (Fig. 9.57), her condition had already clearly improved: the edema had resolved and the wrist was partly mobile.

Treatment was continued with a further 15 blocks (each dose reduced to 10 mL 0.25% bupivacaine). The continued neurological follow-up confirmed increasing improvement in the reinnervation of the hand.

Physiotherapy and home exercises were continued, the mobility of the hand continually increased and the pain declined (Fig. 9.58).

**Final findings, 25 April 1995**

Complete resolution of the edema and “frozen shoulder.” Almost complete absence of pain, mobility of the hand restored to about 85% (Figs. 9.59 and 9.60). Neurological follow-up showed 80% recovery. In March 1996, some of the internal fixation was removed.
Shoulder region
The suprascapular nerve receives fibers from the fifth and sixth cervical spinal nerves. It branches off from the superior trunk of the brachial plexus (Fig. 10.1) and courses through the supraclavicular fossa along the lateral edge of the plexus as far as the scapular notch. It enters the supraspinous fossa through the notch. Covered by the supraspinatus muscle, the suprascapular nerve passes to the neck of the scapula and under the transverse scapular ligament to the infraspinous fossa. It supplies the supraspinatus and infraspinatus muscles, and sends off fibers to the shoulder and acromioclavicular joint, as well as to the suprascapular vessels (Fig. 10.2).

**Indications**

**Diagnostic**
- Painful conditions in the shoulder region and shoulder joint.

**Therapeutic**
- Rheumatic and degenerative diseases of the shoulder girdle
- "Frozen shoulder," pseudoparetic shoulder, stiff shoulder (mobilization in shoulder ankylosis).

**Specific contraindications**
- Anticoagulant treatment.

**Procedure**

Prior discussion with the patient is an absolute necessity.

**Preparations**
- Check that the emergency equipment is complete and in working order. Sterile precautions, intravenous access, intubation kit, emergency medication.

**Materials**
- 5-mL syringe, 10-mL syringe, 22-G needle (50 mm or 70 mm), swabs, disinfectant (Fig. 10.3).

**Skin prep**
- In all blocks.

**Patient positioning**
- Sitting, with the neck tilted forward comfortably (so-called "pharaoh posture").

**Landmarks**
- Acromion, spine of scapula (Fig. 10.4). A line is drawn along the spine of the scapula between the acromion and the medial edge of the shoulder blade. A second line parallel to the line of the spinous processes of the vertebrae transects the connecting line. The injection site lies about 2.5–3 cm cranial to the intersection of the two straight lines (Fig. 10.5).
Chapter 10

Fig. 10.2 Anatomy:
(1) supraspinatus muscle,
(2) spine of scapula,
(3) deltoid muscle,
(4) suprascapular artery,
(5) suprascapular nerve,
(6) teres minor muscle,
(7) infraspinatus muscle,
(8) teres major muscle,
(9) latissimus dorsi muscle

Fig. 10.3 Materials

Fig. 10.4 Anatomical orientation
**Injection technique**

After skin prep, a needle 50 mm or 70 mm long, depending on the patient’s anatomy, is slowly advanced perpendicular to the skin surface in the direction of the scapular notch (Fig. 10.6). Depending on the anatomy, bone contact is made after 3.5–5 cm. The needle is then corrected medially and laterally, until the scapular notch is reached. After careful aspiration, the local anesthetic is slowly injected; aspiration must be repeated during the injection.

**Dosage**

*Diagnostic*

5 mL local anesthetic – e.g. 1% prilocaine or 1% mepivacaine.

*Therapeutic*

5–10 mL local anesthetic – e.g. 0.75% ropivacaine or 0.5% bupivacaine (0.5% levobupivacaine).

In acute conditions, 2–4 mg dexamethasone can be added in each of the first and second blocks.

**Block series**

If there is a trend toward improvement after the first and second treatment, a series of six to eight blocks is useful in all indications.

**Side effects**

If the dose is too large, transient weakness can occur in the supraspinatus and infraspinatus muscles, and outpatients in particular should be informed about this.

**Complications**

Intravascular injection (suprascapular artery), extremely rare.

Pneumothorax, extremely rare (Fig. 10.7).

Prophylaxis: only advance the needle until bone contact is made.
The activation of trigger points in the subscapular and other muscles in what is known as the “rotator cuff” and neighboring muscles (Table 11.1), and irritation of the neighboring nerves, create pain that has a classic distribution pattern [15]. The pattern involves pain during movement and at rest, with nocturnal exacerbation. “Frozen shoulder” or stiff shoulder is a descriptive term that should not be regarded as a diagnosis. “Frozen shoulder” is regarded by some authors as being the end stage of various shoulder diseases, while others regard it as being an independent, idiopathic disease.

The current clinical nomenclature includes three categories of “frozen shoulder”: idiopathic “frozen shoulder”; adhesive capsulitis; and subacromial fibrosis [1, 15]. Other possible etiologies are: irritation of the acromioclavicular joint [1], compression of the suprascapular nerve [8], prolonged immobilization of the arm [4], cervical radiculopathy [4], muscular spasm [15], hemiplegia [7], myocardial infarction [3, 4], biceps tendinitis [1], and others. Some authors regard “frozen shoulder” as an algoneurodystrophic process [16], while others have identified similarities with the clinical picture of Dupuytren’s contracture [6]. The key role of the subscapular muscle in the etiology of “frozen shoulder” is often emphasized [9]. There is no specific and standardized treatment for “frozen shoulder” syndrome. Active physiotherapy should be started as soon as possible in order to prevent adhesions from developing. Pain can be reduced by various supportive measures (ice or heat application, ultrasound, transcutaneous electric nerve stimulation (TENS), nonsteroidal anti-inflammatory drugs, opioids, local or systemic steroid administration, targeted injection at trigger points, etc.).

Mobilization and manipulation of the shoulder joint shows good results in the early stages of “frozen shoulder.” Rhythmic stabilization exercises and therapeutic blocking of the suprascapular and subscapular nerves are recommended [7].

**Fig. 11.1 Anatomy (anterior view):**
(1) cords of the brachial plexus,
(2) subscapular nerve,
(3) thoracodorsal nerve,
(4) subscapular muscle,
(5) circumflex scapular artery
Starting physiotherapy at an early stage is an essential part of the treatment. The main problem here is that due to severe pain, the treatment cannot be carried out adequately in a large number of patients. The use of nerve blocks and targeted injections into the trigger points in the affected muscles shortly before carrying out physiotherapy makes it possible to achieve pain-free and effective treatment.

**Anatomy (Figs. 11.1 and 11.2)**

The subscapular nerves consist of two or three nerves emerging from various parts of the brachial plexus for the subscapular, teres major, and latissimus dorsi muscles. The longest and most important of these is the thoracodorsal nerve, which runs along the axillary border of the scapula and supplies the latissimus dorsi muscle.

The superior subscapular nerve emerges from C5 and C6 (C7) and enters the subscapular muscle. The medi- al subscapular nerve (C5-6) arises from the posterior secondary trunks and supplies the lateral lower part of the subscapular muscle and teres major muscle.

The inferior subscapular nerve (thoracodorsal nerve) is the largest in this group. It arises from the posterior secondary branches or from the axillary nerve, or more rarely from the radial nerve, and passes along the lateral edge of the scapula to the latissimus dorsi muscle.

The subscapular muscle is one of the most important of what are known as the rotator cuff muscles (see Table 11.1, Fig. 11.2 and Chapter 10, Fig. 10.2).

**Anatomical insertions**

The anatomical insertions of the subscapular muscle are medial to the interior surface of the scapula (Fig. 11.2) and lateral to the lesser tubercle on the anterior surface of the humerus.

**Innervation and function**

See Table 11.1.

---

### Table 11.1 Rotator cuff muscle (dark blue) and neighboring muscles: innervation and function

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Innervation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraspinatus</td>
<td>Suprascapular nerve (C5**: superior trunk*)</td>
<td>Abducts the upper arm and pulls the head of the upper arm into the glenoid cavity</td>
</tr>
<tr>
<td>Infraspinatus</td>
<td>Suprascapular nerve (C5, C6**: superior trunk*)</td>
<td>External rotation of the arm; stabilizes the head of the humerus in the glenoid cavity</td>
</tr>
<tr>
<td>Teres minor</td>
<td>Axillary nerve</td>
<td>Almost identical to the infraspinatus muscle</td>
</tr>
<tr>
<td>Subscapularis</td>
<td>Subscapular nerves (C5, C6**: posterior fascicle*)</td>
<td>Internal rotation and adduction of the upper arm in the shoulder</td>
</tr>
<tr>
<td>Teres major</td>
<td>Inferior subscapular nerve (C5, C6**: posterior fascicle*)</td>
<td>Supports adduction, internal rotation and extension of the upper arm from a bent position</td>
</tr>
<tr>
<td>Deltoid</td>
<td>Axillary nerve</td>
<td>Helps the supraspinatus muscle to abduct the upper arm in the shoulder</td>
</tr>
<tr>
<td>Latissimus dorsi</td>
<td>Thoracodorsal nerve (C6-C8**: posterior fascicle*)</td>
<td>Adduction and internal rotation of the arm; strong downward movement of the scapula</td>
</tr>
<tr>
<td>Coracobrachialis</td>
<td>Musculocutaneous nerve (C6, C7**: lateral fascicle*)</td>
<td></td>
</tr>
</tbody>
</table>

* Brachial plexus.
** Spinal nerves
Symptoms

Activation of the trigger points and irritation of the neighboring nerves gives rise to pain with a classic distribution pattern. The pain involves the scapula, the posterior deltoid region, elbow and dorsum of the wrist.

Indications and contraindications

See Chapter 10, p. 125.

Procedure

Preparations

Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access. Prior information for the patient is an absolute necessity.

Materials (Fig. 11.3)

Fine 25-mm long 26-G needle for local anesthesia, 70-mm long 20-G needle (with the needle shaft angled by about 20°), local anesthetic, disinfectant, swabs, 2 mL and 10 mL syringes.

Technique

Position

Sitting, with the neck comfortably tilted and the shoulders relaxed.

Location (Fig. 11.4)

- The patient’s arm is pulled back, so that the contours of the scapula are easily recognized. The center of the medial border of the scapula is marked as the injection point.
- Acromion.

Skin prep, local anesthesia, drawing up the local anesthetic, testing the injection needle for patency.

- Before the injection, the shaft of the injection needle should be bent by about 20°.
- Targeted paresthesias are not elicited.
- During the injection, observe the skin for possible subcutaneous spread of the local anesthetic.

Injection technique

Introduce the 20° angled needle into the center of the medial border of the scapula, in the direction of the acromion (Figs. 11.5 and 11.6).

- The needle is introduced subscapularly parallel to the skin surface between the anterior surface of the
Subscapular nerve blocks. Infiltration of subscapular muscle trigger points ("frozen shoulder")

scapula (costal surface) and the posterior thoracic wall (ribs), into the subscapular fossa. If the needle meets the edge of the ribs, it is withdrawn as far as the subcutaneous tissue and reintroduced. At a depth of 4 cm, then 5 cm and finally 6 cm – depending on the anatomy – a total of 10–15 mL local anesthetic is then injected after prior aspiration (Fig. 11.5).

The signs of a successful injection are: spread extending into the shoulder joint, upper arm, and often as far as the wrist, corresponding to the radiation pattern of the trigger points of the subscapular muscle (Fig. 11.7) [15].

**Dosage**

*Diagnostic*

5 mL local anesthetic – e.g. 1% prilocaine or 1% mepivacaine.

*Therapeutic*

10–15 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine). In acute pain, the addition of 40 mg triamcinolone has proved useful.

In our experience, this block is superior to blocking the suprascapular nerve. A combination of the two techniques is possible and often desirable (Table 11.2).

---

Fig. 11.6 Introducing the needle in the direction of the acromion (skeletal model)

**Block series**

In all indications, a series of six to eight blocks is useful if an improvement trend is seen after the first and second treatments.

---

Fig. 11.7 Magnetic resonance images 10 min after injection of 10 mL ropivacaine, without radiographic contrast medium, into the subscapular fossa. **A** Axial (cross-section), **B** Paracoronal.

(1) Thorax wall, (2) subscapular muscle and subscapular fossa, (3) head of the humerus, (4) teres minor muscle, (5) deltoid muscle, (6) scapula, (7) infraspinatus muscle
Table 11.2 Shoulder-arm region: blocking techniques in pain therapy
Comparison of interscalene block of the brachial plexus, blocks of the subscapular and suprascapular nerves and blocks of the stellate ganglion

<table>
<thead>
<tr>
<th>Surgical</th>
<th>Postoperative</th>
<th>Acute and chronic pain conditions</th>
<th>Mobilization of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pain therapy</td>
<td>Target area</td>
<td>the shoulder</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interscalene*</td>
<td>Interscalene**</td>
<td>Subscapular nerves</td>
<td>Interscalene</td>
</tr>
<tr>
<td>Dosage: 20-25 mL</td>
<td>20-25 mL 0.375-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)</td>
<td>10-15 mL 0.5-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)</td>
<td>20-25 mL 0.375-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subscapular nerves**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 mL 0.5-0.75% ropivacaine or 0.25-0.375% bupivacaine (0.25-0.375% levobupivacaine)</td>
<td>Interscalene***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-15 mL 0.375-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)</td>
<td>10-15 mL 0.5-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stellate ganglion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>++</td>
<td>++</td>
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<tr>
<td></td>
<td></td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subscapular nerves***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-15 mL 0.5-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)</td>
<td>10-15 mL 0.5-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine)</td>
</tr>
</tbody>
</table>

+++++ Best method.
++++ Very suitable method.
+++ Suitable method.
++ Method suitable with some qualifications.
+ Less suitable method.
* Usually in combination with basic general anesthesia. This provides excellent pain relief.
** In severe pain, a combination of the two techniques is possible.
*** Usually in combination with a suprascapular nerve block: 8-10 mL 0.5-0.75% ropivacaine or 0.25% bupivacaine (0.25% levobupivacaine).

Side effects
If the dosage is too high, transient weakness may occur in the shoulder and upper arm. Outpatients should be informed about this. A partial block of the intercostal nerves is possible due to spread of the local anesthetic, and is often desirable.

Complications
- There is a potential risk of pneumothorax (unlikely if the correct technique is observed).
- Intravascular injection.
12 Rotator cuff muscles
Injection techniques in the myofascial trigger points

### Subscapular muscle

See Chapter 11.

### Supraspinatus muscle

**Anatomical insertions**
The anatomical insertions are medial to the supraspinous fossa and lateral to the greater tubercle of the humerus (Fig. 12.1).

**Innervation and function**
See Chapter 11, Table 11.1.

**Myotatic unit**
This covers the middle part of the deltoid muscle and the upper part of the trapezius muscle, as synergists for abduction.

**Trigger points**
The two trigger points (TrPs) in the supraspinatus muscle are located deep in the supraspinous fossa of the scapulae, underneath the relatively thick part of the trapezius muscle. The medial TrP lies directly above the spine of the scapula, lateral to the medial border of the scapula. The lateral TrP can be palpated medial to the acromion. A third TrP may be located in the tendon of the muscle at its lateral insertion on the joint capsule and the greater tuberosity (Fig. 12.1) [15].

**Symptoms**
Pain in the middle deltoid region, sometimes radiating to the upper and lower arm, particularly in the area of the lateral epicondyle.

**Procedure**

**Materials**
Sterile precautions, 23-G needle 30 mm long, 2-mL and 5-mL syringes, local anesthetic.

**Injection technique**
The lower arm of the seated patient is placed behind the back at waist level (“hand behind the back”; Fig. 12.2). After palpation, injection into the medial TrP is carried out in the direction of the suprascapular notch (Fig. 12.3). After careful aspiration, injection of the local anesthetic follows. The lateral TrP is sought directly medial to the acromion. The muscle’s insertion point at the greater tubercle of the humerus requires perpendicular puncture until bone contact is made (Fig. 12.4).

**Dosage**
1–2 mL local anesthetic – e.g. 0.2–0.375% ropivacaine.

**Complications**
Pneumothorax must be regarded as a potential complication when injecting into the medial TrP of the supraspinatus muscle.

![Fig. 12.1 Supraspinatus muscle. Anatomic insertions and myofascial trigger points (yellow circles), adapted from Travell and Simons [15]. (1) Infraspinatus muscle, (2) supraspinous fascia, (3) spine of the scapula, (4) greater tuberosity of the humerus](image)
Fig. 12.2 Supraspinatus muscle. Positioning for trigger point injection ("hand behind the back" position)

Fig. 12.3 Supraspinatus muscle. Injection into the medial trigger point in the direction of the suprascapular notch

Fig. 12.4 Supraspinatus muscle. Infiltration of the insertion site at the greater tubercle of the humerus
**Infraspinatus muscle**

**Anatomic insertions**
The anatomic insertions are located medial to the infraspinous fossa of the scapula and lateral to the greater tuberosity of the humerus (Fig. 12.5).

**Innervation and function**
See Chapter 11, Table 11.1.

**Myotatic unit**
With the exception of external rotation of the arm, the infraspinatus muscle acts synergistically with the teres minor muscle (with almost identical function) and the posterior part of the deltoid muscle.

**Trigger points**
Two active trigger points (medial and lateral) can be located approximately 2 cm below the spine of the scapula, and sometimes there is also another possible trigger point slightly caudally (Figs. 12.5, 12.7) [15].

**Symptoms**
The symptoms consist of referred pain when sleeping in the lateral position and an inability to reach the rear trouser pockets or bra fastener, or to comb the hair or brush the teeth.

**Procedure**

**Materials**
Sterile precautions, 23-G needle 30 mm long, 2-mL and 5-mL syringes, local anesthetic.

**Injection technique**
The patient lies on the side that is not being treated. The arm is bent to 90° and the elbow is laid on a cushion. The contour of the scapula has to be clearly defined.
After careful disinfection and palpation of the trigger point (TrP), the needle is slowly introduced in the direction of the TrP. During injection into the medial TrP, the left middle finger is pressed against the caudal edge of the spine of the scapula. During injection into the lateral TrP, the left ring finger presses against the caudal edge of the spine of the scapula (Fig. 12.6).
The puncture has to be carried out sensitively, as the scapula bones (part of the infraspinous fossa) sometimes offer very little resistance (resembling a fibrous membrane, so that there is a risk of pneumothorax). The insertion site of the muscle into the greater tuberosity of the humerus requires a perpendicular position to be maintained until bone contact is made (Fig. 12.8).

**Dosage**
1–2 mL local anesthetic – e.g. 0.2–0.375% ropivacaine.

**Complications**
- Pneumothorax is a potential complication [15].
- Infection.

![Fig. 12.8 Infraspinatus muscle. Infiltration of the insertion site on the greater tuberosity of the humerus](image)

**Teres minor muscle**

**Anatomic insertions**
The muscle’s anatomic insertions are located directly alongside and caudal to those of the infraspinatus muscle (Fig. 12.9).

**Innervation and function**
See Chapter 11, Table 11.1.

**Myotatic unit**
The teres minor muscle acts synergistically with the infraspinatus muscle.

**Trigger points**
The teres minor muscle is one of the most rarely affected muscles in the rotator cuff (only involved in 7% of cases). The trigger point usually lies in the center of the muscle (Fig. 12.9) [15]. The teres minor muscle is located above the teres major muscle.

**Symptoms**
Pain in the posterior deltoid area.

![Fig. 12.9 Teres minor muscle. Anatomic insertions and myofascial trigger points (yellow circles); adapted from Travell and Simons [15]. (1) Teres minor muscle, (2) teres major muscle, (3) inferior angle of the scapula, (4) greater tuberosity of the humerus](image)
Rotator cuff muscles. Injection techniques in the myofascial trigger points

**Procedure**

**Materials**
Sterile precautions, 23-G needle 30 mm long, 2-mL and 5-mL syringes, local anesthetic.

**Injection technique**
The arm is bent to 90°. The contour of the scapula has to be clearly defined (Fig. 12.10). The TrPs are sought between the teres major and infraspinatus muscles, near the lateral edge of the scapula. The index and middle finger fix the TrP. The 30-mm needle is directed toward the scapula (Fig. 12.11). The insertion site of the muscle on the greater tuberosity of the humerus requires a perpendicular needle direction until bone contact is made (Fig. 12.12).

**Dosage**
2 mL local anesthetic – e.g. 0.2–0.375% ropivacaine.

**Complications**
Pneumothorax is a potential complication.
Indications
Synovial inflammatory conditions (capsulitis), severe resting pain, humeroscapular periarthritic, after shoulder bruising, rheumatoid arthritis. The anatomy of the shoulder joint is shown in Fig. 13.1a, b.

Materials
25-G needle 30–40 mm long, 2-mL and 5-mL syringes, sterile swabs, disinfectant, sterile gloves, sterile drape.

Injection techniques

Ventral access route
Landmarks (Fig. 13.1a, b)
Coracoid process
Head of the humerus
Clavicle

Technique
The patient is seated with the supinated arm hanging freely, and the articular cavity is palpated directly medial to the head of the humerus. The needle is introduced underneath the clavicle, directly lateral to the coracoid process toward the outside and back. The path to the joint is very short with this approach (Fig. 13.2).

Dosage
2 mL local anesthetic – e.g. 0.5–0.75% ropivacaine or 0.25% bupivacaine mixed with 40 mg methylprednisolone.

Dorsal access route
Landmarks (Fig. 13.1a, b)
Spine of the scapula
Lateral corner of the acromion
Coracoid process

Fig. 13.1a Anatomy of the shoulder joint.
(1) Humerus, (2) scapula, (3) articular capsule, (4) tendon of the biceps brachii muscle, (5) subscapular muscle, (6) acromion, (7) coracoid process

Fig. 13.1b Shoulder joint. Articular cavity and articular capsule.
(1) Articular capsule, (2) articular cavity, (3) scapula, (4) acromion
Shoulder region. Intra-articular injections

**Technique**
The patient is seated, with the upper arm slightly abducted and rotated inward, and the lateral corner of the acromion is palpated. The injection is made directly underneath this point and the needle is advanced between the posterior edge of the deltoid muscle and the tendon of the infraspinatus muscle (the muscle’s dorsolateral tendon) in the direction of the coracoid process (Fig. 13.3). The articular cavity is reached after approximately 3–4 cm. After injection into the joint, a further 1 mL is distributed circumarticularly as the needle is withdrawn.

**Dosage**
2 mL local anesthetic – e.g. 0.5–0.75% ropivacaine or 0.25% bupivacaine mixed with 40 mg methylprednisolone.

**Indications**
Shoulder pain radiating to behind the ear, restricted mobility in the shoulder joint.

**Landmarks**
- Lateral edge of the clavicle
- Acromion
- Acromioclavicular ligament (Fig. 13.4)

The acromioclavicular joint has a very small volume, so that only a small amount of the injection solution is needed.

**Injection technique**
The patient is seated, and the articular cavity between the lateral end of the clavicle and the acromion is palpated. The needle is advanced perpendicularly from above through the acromioclavicular ligament to a maximum depth of 1 cm. Provided there is no resistance, a small amount of the injection solution is injected (Fig. 13.5).

**Dosage**
0.5–1 mL local anesthetic – e.g. 0.5–0.75% ropivacaine or 0.25% bupivacaine mixed with 40 mg methylprednisolone or triamcinolone.

**Side effects**
Some 25% of patients report a transient increase in pain after an intra-articular injection in the shoulder joint. The patient should be advised of this potential side effect.
Complications

Infection

Hematoma (prophylactic compression should be carried out after the injection).

Fig. 13.4 Anatomy of the acromioclavicular joint and neighboring structures. (1) Scapula, (2) articular capsule, (3) glenoid cavity, (4) coracoid process, (5) clavicle, (6) coracoclavicular ligament, (7) coracoacromial ligament, (8) acromioclavicular joint, (9) acromion

Fig. 13.5 Intra-articular injection into the acromioclavicular joint
Elbow and hand region
Anatomy

**Ulnar nerve**
The ulnar nerve originates from the medial cord of the brachial plexus (C8–T1, C7). The nerve runs on the medial side of the lower third of the upper arm, in the groove of the ulnar nerve on the posterior side of the medial epicondyle of the humerus. The nerve is easily palpated at this location. In the forearm, it runs between the humeral and ulnar head of the flexor carpi ulnaris muscle on the medial side of the forearm.

**Median nerve**
The median nerve originates from the medial and lateral cords of the brachial plexus (C5, C6–C8, T1). At the elbow, it lies medial to the brachial artery, courses along the medial surface of the brachialis muscle downwards in the elbow, where it can be found behind the bicipital aponeurosis and in front of the insertion of the brachialis muscle and elbow joint.

**Radial nerve and lateral antebrachial cutaneous nerve (musculocutaneous nerve)**
These two nerves innervate the radial half of the forearm and the back of the hand, and have a close anatomical relationship.
The radial nerve (C5–C8, T1) is the longest branch of the brachial plexus, and represents a direct continuation of the posterior cord. It runs in the middle of the upper arm in the groove of the radial nerve along the dorsal side of the humerus. Before the lateral epicondyle of the humerus and the elbow joint capsule, it then enters the fissure between the brachioradialis muscle and the biceps muscle. At the level of the head of the radius, it divides into the deep branch (anterior interosseous nerve, mainly motor) and the superficial branch (mainly sensory). The latter follows the course of the radial artery.

Lateral antebrachial cutaneous nerve
The musculocutaneous nerve (C4, C5–C7) arises from the lateral cord of the brachial plexus. At the level of the elbow joint, it passes between the biceps muscle and the brachioradialis muscle to the brachial fascia.
Chapter 14

Contraindications

Relative
Local neuritis
Carpal tunnel syndrome (median nerve)

Distal blocks of the peripheral nerves of the arm are associated with a high incidence of nerve injury (particularly to the ulnar nerve). It is therefore advisable not to use these injections on a routine basis. During the injection, intraneural positioning of the needle must be excluded.

Procedure

Preparations
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access.

Materials (Fig. 14.2)
35-50 mm long atraumatic 25-G needle (1 1/2”), with injection lead (“immobile needle”) – e.g. Stimuplex D® (B. Braun Melsungen) or 24-G Plexufix needles, 25–50 mm long, local anesthetic, disinfectant, swabs, drape, syringes: 2, 5, and 10 mL.

Technique

Ulnar nerve (Fig. 14.3)
Positioning
Supine, with the arm rotated outward and the elbow bent to 90°.

Location
The medial epicondyle of the humerus and olecranon are palpated. The ulnar nerve runs in the groove of the ulnar nerve at a depth of 0.5–1 cm, and can usually be palpated.

Skin prep, local anesthesia, covering with a sterile drape, drawing up the local anesthetic, drawing the patency of the needle and functioning of the nerve stimulator, attaching electrodes.

Injection
After definite localization of the groove of the ulnar nerve, the needle should be introduced through infiltrated skin ca. 1–2 cm above this point at an angle of 90° to the long axis of the humerus.

After paresthesias have been elicited and intraneural positioning of the needle has been excluded, withdraw...
the needle slightly and carry out a fan-shaped injection after aspiration.

**Median nerve** (Fig. 14.4)

Positioning
Supine, elbow joint extended.

Location
The intercondylar line is marked. Palpation of the brachial artery.

Injection technique
After palpation of the brachial artery, the needle is introduced through infiltrated skin, on the ulnar side of the artery. At a depth of 0.5–1 cm, paresthesias are elicited. After aspiration and exclusion of intraneural positioning of the needle, a fan-shaped injection is carried out.

**Radial nerve and lateral antebrachial cutaneous nerve** *(musculocutaneous nerve)* (Fig. 14.4)

These two nerves are closely related to one another anatomically, so that both can be blocked using this technique.

Positioning
Supine, elbow joint extended.

Location
Lateral humeral epicondyle, biceps tendon, brachioradial muscle.

Injection technique
At the level of the intercondylar line, the fissure between the brachioradialis muscle and the biceps tendon is palpated. The needle is introduced through infiltrated skin about 2 cm lateral to the biceps tendon, in a proximal and lateral direction towards the lateral epicondyle. After paresthesias have been elicited, intraneural positioning has been excluded, and aspiration has been carried out. 5–8 mL of a local anesthetic are injected. After withdrawal of the needle, fan-shaped infiltration of 5 mL local anesthetic is carried out as far as the subcutaneous tissue. If no paresthesias can be elicited, the needle is introduced as far as the lateral surface of the lateral humeral epicondyle, and after bone contact the first dose of 3–4 mL of the local anesthetic is injected. The needle is then withdrawn to a subcutaneous level and, after altering the direction slightly medially, the procedure is repeated two or three times. On each occasion, 2–3 mL of local anesthetic is injected. Finally, when withdrawing the needle, a fan-shaped infiltration of 5 mL local anesthetic as far as the subcutaneous tissue is carried out.

**Dosage**

- Ulnar nerve: 2–5 mL local anesthetic.
- Median nerve: 5 mL local anesthetic.
- Radial nerve (and lateral antebrachial cutaneous nerve): 10–15 mL local anesthetic.

- 0.75% ropivacaine
- 0.5% bupivacaine
- 1% prilocaine
- 1% mepivacaine
- 1% lidocaine

**Complications**

Neuritis after nerve puncture (particularly in the ulnar nerve).
15 Peripheral nerve blocks in the wrist region

Anatomy

**Ulnar nerve** (Fig. 15.1)
In the medial distal third of the forearm, about 5 cm proximal to the wrist, the ulnar nerve divides into a sensory branch – the dorsal branch; and a mixed branch – the palmar branch. The latter runs along the tendon of the flexor carpi ulnaris muscle in a distal direction. The ulnar artery lies directly radially, alongside the nerve.

**Median nerve** (Fig. 15.1)
The median nerve lies between the tendons of the palmaris longus muscle and the flexor carpi radialis muscle. It runs in the direction of the long axis of the radius.

**Radial nerve** (Fig. 15.2)
The superficial branch of the radial nerve runs – together with the radial artery, initially – in the forearm along the medial side of the brachioradialis muscle in the direction of the wrist. About 7–8 cm proximal to the wrist, it crosses under the tendon of the brachioradialis muscle and reaches the extensor side of the forearm. At the level of the wrist, the radial nerve divides into several peripheral branches.

Indications

**Surgical**
- Minor surgical interventions in the innervated area.
- Supplementation of an incomplete block of the brachial plexus.

**Care** must be taken to avoid nerve injury, since paresthesias do not occur here as a warning signal (see Chapter 9, brachial plexus, p. 110).

**Diagnostic**
- Differential diagnosis of painful conditions in the hand.

**Therapeutic**
- None.

Contraindications

**Relative**
- Neuritis.

Procedure

**Preparations**
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access.

**Materials** (Fig. 15.3)
- 35-mm long, atraumatic 25-G needle (15"), with injection lead – e.g. Stimuplex D® (B. Braun Melsungen; exception: circular block of the radial nerve; fine 25-G needles, 25 mm long).
- Local anesthetic, disinfectant, swabs, drape, syringes: 2, 5, and 10 mL.
Technique
Skin prep, local anesthesia, drawing up the local anesthetic, checking patency of the injection needle and functioning of the nerve stimulator, attaching electrodes.

Ulnar nerve (Fig. 15.4)
Positioning
Supine, with wrist slightly flexed.

Location
Styloid process of ulna, ulnar artery, flexor carpi ulnaris muscle.

Injection technique
**Palmar branch**: proximal to the styloid process of the ulna, the ulnar artery and tendon of the flexor carpi ulnaris muscle are palpated. The needle is introduced perpendicularly between the tendon and the artery, in the direction of the pisiform bone. After paresthesias have been elicited (1–2 cm), the needle is minimally withdrawn. After excluding intraneural positioning of the needle and aspiration, the needle is fixed and the local anesthetic is injected. If no paresthesias can be elicited, the needle is advanced until bone contact is made, and 1 mL of local anesthetic is injected. During withdrawal of the needle, fan-shaped infiltration is then carried out. A further 3–5 mL of the local anesthetic is used for this.

**Dorsal branch**: fan-shaped infiltration medial to the tendon of the flexor carpi ulnaris muscle, in the direction of the styloid process of the ulna.

Median nerve (Fig. 15.4)
Positioning
Supine, with the elbow extended. The forearm musculature is tensed by making a fist, so that the muscular tendons become easily visible.

Location
Styloid process of the ulna, tendons of the palmaris longus and flexor carpi radialis muscles.

Injection technique
The needle is introduced perpendicularly at the level of the proximal crease of the wrist, in between the tendons of the palmaris longus and flexor carpi radialis muscle. After paresthesias have been elicited (0.5–1 cm), the needle is minimally withdrawn, an intraneural location is excluded, and after aspiration the local anesthetic is injected.
Chapter 15

Fig. 15.3 Materials

Radial nerve (Fig. 15.5)
Positioning
Supine, with hand supinated.

Location
Level of the styloid process of the ulna, radial artery.

Injection technique
The needle is introduced through a skin spot perpendicular to the skin surface and lateral to the radial artery (0.5–1 cm). After paresthesias have been elicited, the needle is minimally withdrawn, an intraneural position is excluded, and after prior aspiration, the local anesthetic is injected. Supplementation of the block can be provided by subcutaneous infiltration of the peripheral branches and circularly between the radial artery on the ventral side and the tendons of the extensor pollicis longus and brevis muscles on the dorsal side. It is helpful for the patient to extend the thumb.

Dosage
Ulnar nerve: 3–5 mL local anesthetic.
Median nerve: 3–5 mL local anesthetic.
Radial nerve: 5–8 mL local anesthetic.

- 0.75% ropivacaine
- 0.5% bupivacaine
- 1% prilocaine
- 1% mepivacaine
- 1% lidocaine

Complications
Neuritis after puncture of a nerve.
Hand extensors

The extensor carpi radialis brevis and longus muscles (origin: distal lateral border of the humerus and lateral epicondyle of the humerus; insertion: base of metacarpal bones II and III; function: dorsal flexion and radial abduction in the wrist; innervation: radial nerve, C6, C7) and the extensor carpi ulnaris muscle (origin: lateral epicondyle of the humerus and antebrachial fascia; insertion: base of metacarpal bone V; function: dorsal flexion and ulnar abduction in the wrist; innervation: radial nerve, C7, C8) extend the hand at the wrist (Fig. 16.1).

The extensor carpi radialis brevis and longus muscles and the extensor digitorum muscle are the main muscles that cause “weak grip.” The active trigger points (TrPs) in this “extensor muscle group” are located immediately next to each other in the proximal forearm, slightly distal to the lateral epicondyle of the humerus (Fig. 16.1).

Symptoms

The pain first appears in the lateral epicondyle and spreads to the back of the hand in the region of the articular facet of the radial head (Fig. 16.1). This type of pain is often referred to as “tennis elbow” (see also supinator muscle).

Procedure

Materials

Sterile precautions, 22-G needle 30 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.

Injection technique

The patient lies supine, with the arm on a cushion. As all of the hand extensors are located fairly superficially, their TrPs can be precisely located by palpation. The location and injection technique for the TrPs is illustrated in Fig. 16.2 (extensor carpi radialis brevis and longus muscles) and Fig. 16.3 (extensor carpi ulnaris muscle).
Dosage
1 mL local anesthetic per TrP – e.g. 0.5% ropivacaine, 1% prilocaine.

Finger extensors (extensor digitorum muscle, extensor indicis muscle)

Pain referred from the extensor digitorum muscle (origin: lateral epicondyle of the humerus, antebrachial fascia; insertion: dorsal aponeurosis of fingers II–V; function: extension in the first joints of fingers II–V and middle and end joints, supports ulnar abduction in the wrist; innervation: deep nerve of the radial nerve, C7, C8) is projected along the forearm downward toward the back of the hand and often to the fingers (middle finger and ring finger; Fig. 16.1).

Symptoms
Patients report elbow pain or arthritic-like pain in the fingers (middle and ring finger).

Procedure

Materials
Sterile precautions, 22 G needle 30 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.
Elbow and wrist, Infiltration of the myofascial trigger points and intra-articular injections

Injection technique

The arm lies on a cushion, with the hand and fingers relaxed (this stretches the finger extensors slightly). The injection is carried out at a depth of ca. 2 cm. The deeper-lying TrP in the supinator muscle is sometimes reached (Fig. 16.4).

Dosage

1–2 mL local anesthetic per TrP – e.g. 0.5% ropivacaine, 1% prilocaine.

Supinator muscle ("tennis elbow")

"Tennis elbow" or lateral epicondylitis very often has a myofascial origin and can be traced back to the formation of trigger points in the supinator muscle (see hand extensors, above).

The origin of the supinator muscle is on the lateral epicondyle of the humerus, the radial collateral ligaments and annular ligaments and the ulna. Its insertion is located in the upper third of the lateral surface of the radius. Its function is supination of the forearm and its innervation is from the radial nerve (C5–C7; Fig. 16.5).

Symptoms

Stabbing elbow pain (lateral epicondyle) radiating as far as the thumb (Fig. 16.5). Almost all patients with pain in the area of the lateral epicondyle have an active TrP in the supinator muscle.
Procedure

Materials
Sterile precautions, 23-G needle 30 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.

Injection technique
The needle is introduced directly lateral to the insertion of the biceps tendon (with the brachioradialis muscle pushed to the side) and advanced until bone contact is made with the radius. The needle is withdrawn slightly and the local anesthetic is then injected (Fig. 16.6). The extensor carpi radialis brevis muscle is usually penetrated as this is done.

Dosage
1 mL local anesthetic per TrP – e.g. 0.5% ropivacaine or 1% prilocaine (which may be mixed with 40 mg methylprednisolone if needed).

Area of the medial epicondyle ("golfer’s elbow")
The area of the medial epicondyle, with its muscular components (pronator teres muscle, flexor carpi radialis and ulnaris muscles, and palmaris longus muscle) is often affected in golfers.

Palmaris longus muscle (Dupuytren’s contracture)
The anatomical insertions of this muscle are located on the medial epicondyle of the humerus and on the palmar fascia, between the flexor carpi radialis muscle and the flexor carpi ulnaris muscle (Fig. 16.7). The innervation is from the median nerve.

Symptoms
The referred pain focuses on the wrist in the form of a superficial, needle-pricking pain. Experience shows that patients with Dupuytren’s contracture often have one or more active trigger points (TrPs) in the fibers of the palmaris longus muscle (Fig. 16.7).

Procedure

Materials
Sterile precautions, 23-G needle 30 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.
Injection technique
The patient lies supine, with the affected elbow extended (Fig. 16.8a). After palpation of the TrP, the needle is introduced perpendicularly (Fig. 16.8b), the TrP is located and the local anesthetic is injected.

Dosage
1 mL local anesthetic per TrP – e.g. 0.5% ropivacaine or 1% prilocaine.

Pronator teres muscle
The pronator teres muscle is responsible for pronation of the forearm and flexion of the elbow. Its origin is on the medial epicondyle of the humerus, the antebrachial fascia and the coronoid process of the ulna, and its insertion is on the dorsal surface of the middle third of the radius. The innervation is from the median nerve (C6 and C7; Fig. 16.7).

Procedure

Materials
Sterile precautions, 22-G needle 30 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.

Injection technique
The patient lies supine, with the affected elbow extended (Fig. 16.8a). The injection technique is illustrated in Fig. 16.9. The flexor carpi radialis muscle is often also involved.

Dosage
1 mL local anesthetic per TrP – e.g. 0.5% ropivacaine or 1% prilocaine.

Hand and finger flexors in the forearm: flexor carpi radialis and ulnaris muscles

The anatomic insertions of the hand and finger flexors are located on the medial epicondyle and the distal phalanges of all of the fingers (Fig. 16.7). The flexor carpi radialis muscle is responsible for palmar flexion and radial abduction in the wrist, for pronation and elbow flexion, and the flexor carpi ulnaris muscle is responsible for palmar flexion and ulnar abduction in the wrist.

The innervation of the flexor carpi radialis muscle is from the median nerve (C6–C8), while that of the flexor carpi ulnaris muscle is from the ulnar nerve (C8, T1).

Fig. 16.7 Area of (1) the medial condyle of the humerus, (2) Pronator teres muscle, (3) flexor carpi ulnaris muscle, (4) palmaris longus muscle, (5) flexor carpi radialis muscle. Myofascial trigger points (yellow circles) and referred pain (hatched, yellow = flexor carpi radialis muscle, blue = flexor carpi ulnaris muscle, green = palmaris longus muscle). Adapted from Travell and Simons [3]
Fig. 16.8a Pronator teres muscle (a), palmaris longus muscle (b). Medial epicondyle of the humerus (1). Locating the injection sites

Fig. 16.8b Palmaris longus muscle. Injection

Fig. 16.9 Pronator teres muscle. Injection

Fig. 16.10 Flexor carpi radialis muscle. Locating the injection site. (1) Medial epicondyle of the humerus, (2) muscle tendon

Fig. 16.11 Flexor carpi radialis muscle. Injection

Fig. 16.12 Flexor carpi ulnaris muscle. Locating the injection site. (1) Medial epicondyle of the humerus, (2) styloid process of the ulna
Elbow and wrist, Infiltration of the myofascial trigger points and intra-articular injections

**Symptoms**
Pain in the radial part of the palmar wrist fold (flexor carpi radialis muscle) or radiating to the ulnar side of the palmar surface of the hand (flexor carpi ulnaris muscle; Fig. 16.7).

**Procedure**

**Materials**
Sterile precautions, 23-G needle 30 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic.

**Injection technique**

**Flexor carpi radialis muscle:** the patient lies in the supine position, with the affected elbow extended. After location and palpation (Fig. 16.10), the needle is introduced perpendicularly until bone contact is made. It is then withdrawn as far as the subcutaneous tissue and the injection is carried out (Fig. 16.11). To infiltrate an active TrP in the flexor carpi ulnaris muscle (the most superficial muscle), the patient's arm is bent, the TrP is located using extensive palpation (Fig. 16.12), and infiltration is carried out with direct tactile guidance (Fig. 16.13).

**Dosage**
1 mL local anesthetic per TrP – e.g. 0.5% ropivacaine or 1% prilocaine.

**Intra-articular injection into the elbow joint**

The anatomy of the elbow joint is shown in Fig. 16.14.

**Indications**
Pain on movement of the elbow joint, difficulty and pain in extending and bending the distal phalanx.

**Procedure**

**Materials**
Sterile precautions, 22-G needle 30 mm long, 2-mL and 5-mL syringes, swabs, local anesthetic (corticosteroids).

**Injection technique**

As strict as possible aseptic conditions!

The patient places the forearm on the table, so that the upper arm and forearm form an angle of 90°. The needle is introduced from the dorsal direction, between the lateral epicondyle and the olecranon into the olecranon fossa in a mediopalmar direction (lateral to the tendon of the triceps muscle; Fig. 16.15). The articular cavity is reached after ca. 1 cm.

**Dosage**
1–2 mL local anesthetic – e.g. 0.5–0.75% ropivacaine (which may be mixed with 40 mg methylprednisolone if needed).

**Complications**
Infection (prophylaxis: as strict as possible aseptic conditions), hematoma (prophylactic compression should be carried out after the injection).
Wrist

Adductor pollicis and opponens pollicis muscles ("Weeder's Thumb")

An active trigger point (TrP) in the adductor pollicis muscle causes severe pain along the radial side of the thumb and in the hand at the base of the thumb distal to the fold of the wrist. Pain from TrPs in this muscle is referred to the palmar surface of most of the thumb and wrist (Fig. 16.16). The adductor pollicis muscle adducts the carpometacarpal joint and metacarpophalangeal joint. Its innervation is from the ulnar nerve (C8, T1). The function of the opponens pollicis muscle (Fig. 16.16) is opposition at the carpometacarpal joint of the thumb (flexion, abduction and slight rotation). Its innervation is from the median nerve (C7, C8, T1).

Symptoms
Pain, poorly controlled movements, and absence of fine movement in the thumb.

Procedure

Materials
Sterile precautions, 22-G needle 30 mm long, swabs, local anesthetic.

Injection technique
Adductor pollicis muscle: the thumb is abducted and the located trigger points are infiltrated from the dorsal direction, in the area of the fold (Fig. 16.17). With the thumb abducted, the TrP of the opponens pollicis muscle is reached in the upper thenar area and in the direction of the metacarpal bone (Fig. 16.18). The injection may be painful.

Infiltration therapy in carpal tunnel syndrome

The most frequent peripheral nerve compression syndrome is carpal tunnel syndrome. Predisposing factors include obesity, chronic polyarthritis, diabetes mellitus, gout and dysproteinemia. The feature common to all of these conditions is that they increase the content of the carpal tunnel. This compresses the median nerve (Fig. 156).
Elbow and wrist, Infiltration of the myofascial trigger points and intra-articular injections

Fig. 16.17a Adductor pollicis muscle. Locating the injection site

Fig. 16.18a Opponens pollicis muscle. Locating the injection site

Fig. 16.17b Adductor pollicis muscle. Injection

Fig. 16.18b Opponens pollicis muscle. Injection
Chapter 16

16.16; see also Chapter 15, Fig. 15.1). Typically, carpal tunnel syndrome is associated with sensory and later with motor disturbances. Patients wake in the morning or at night with a feeling that their hands have "gone to sleep." The symptoms are provoked by pressure on the flexor retinaculum.

**Procedure**

**Materials**
Sterile precautions, **very short-beveled needle** – e.g. 24-G Plexufix 25 mm long (see Chapter 9, brachial plexus, Fig. 9.6a), swabs, local anesthetic, corticosteroid.

**Injection technique**
The needle is introduced at the level of the proximal wrist crease between the tendons of the **palmaris longus muscle** and the **flexor carpi radialis muscle** (Fig. 16.19). At a depth of 0.5–1 cm, paresthesias (median nerve) are often elicited. The needle is then withdrawn minimally, an intraneural position is excluded, and after aspiration the local anesthetic is injected.

**Dosage**
2 mL local anesthetic – e.g. 0.5–0.75% ropivacaine mixed with 40 mg methylprednisolone.

**Complications**
The injection of local anesthetics into a vein in an exsanguinated extremity was first described by August Bier in 1908. It caused anesthesia and a motor block.

**Indications**

Outpatient surgical procedures with a maximum length of 1 hour in the forearm or hand (standard application) and in the lower leg and foot (more rarely; Figs. 17.1–17.3).

**Specific contraindications**

- Patient refusal
- Local infection in the area to be anesthetized
- Local nerve damage
- Peripheral vascular diseases
- Severe decompensated hypovolemia, shock
- Certain cardiovascular diseases
- Hypertonia, bradycardia, second-degree AV block, any history of a tendency to syncope
- Musculoskeletal diseases

**Procedure**

This block should only be carried out when full anesthetic facilities are available. Full prior information for the patient is mandatory.

**Preparations**

Check that the appropriate emergency equipment is present and in working order. Sterile precautions. Two intravenous access points (in the healthy extremity as well as the one being operated on), BP and ECG monitoring, pulse oximetry, anesthesia machine. Patient preparation is the same as for general anesthesia.

**Materials** (Fig. 17.4)

- 20-mL and 50-mL syringes, saline, cotton-wool padding, pneumatic tourniquet (double-lumen), Esmarch bandage, local anesthetic, disinfectant, pneumatic tourniquet device (e.g. VBM Medizintechnik Ltd., Sulz am Neckar, Germany; Fig. 17.5).

**Patient positioning**

Supine, with the extremity free.
Technical procedure

1. Insert two intravenous catheters – one in a healthy extremity and the other as distally as possible in the extremity being operated on.
2. Place the extremity being operated on in a free position and put soft padding under the tourniquet to help prevent nerve injury (Fig. 17.6).
3. Position the double-lumen tourniquet.
4. Elevate and massage the limb for a few minutes, then wrap it completely with an Esmarch bandage (Fig. 17.7).
5. Inflate the proximal cuff: the pressure in the cuff has to be ca. 80–100 mmHg higher than the patient's systolic blood pressure. The pressure that should be used depends on the thickness of the muscles being compressed. A pulse oximeter is used to document changes in, and cessation of, the pulse ("pulse occlusion pressure"), and the disappearance of the pulse in the radial artery. The "pulse occlusion pressure" can be used to determine the optimal pressure in the proximal cuff (Fig. 17.8).
6. Remove the bandage and place the extremity in a horizontal position.
7. Slowly inject the local anesthetic (20 mL/min; Fig. 17.9).
8. Perform stroking massage of the extremity (this improves the spread of the local anesthetic) and remove the catheters.
9. Good analgesia and muscle relaxation develop after ca. 5–10 min.
10. Inflation of the distal cuff, which is now in the analgesic area, so that the cuff is better tolerated. Deflate the proximal cuff. After the anesthetic effect has been tested, the operation can begin.

- Minimum tourniquet time is 15–20 min after injection of the local anesthetic. The tourniquet must not be released during this period (risk of toxic reactions!).
- Tourniquet pressure must be monitored continuously.
- After completion of the procedure: intermittent deflation over a period of 10 min, with complete inflation in between (Fig. 17.10).
Fig. 17.7 Wrapping with an Esmarch bandage

Fig. 17.8 Inflation of the tourniquet

Fig. 17.9 Injection of the local anesthetic

Fig. 17.10 Intermittent deflation of the cuff over a period of 10 minutes
Chapter 17

Dosage

Only local anesthetics that contain no vasoconstrictors may be used!

40–50 mL local anesthetic, e.g. Prilocaine 0.5%, 3–4 (5) mg/kg body weight [6,7]. Amongst the amide local anesthetics, prilocaine provides the best ratio between anesthetic potency and toxicity, and should be regarded as the agent of choice for intravenous regional anesthesia (see Chapter 1, p. 12). Mepivacaine 0.5% or lidocaine 0.5%, 1.5–3 mg/kg b.w. [6].

Additions to local anesthetic agents
Clonidine 1 μg/kg or ketamine 0.1 mg/kg b.w. [3]
Fentanyl (0.1–0.2 mg) [1]
Morphine (1–6 mg) [2]

Complications
Systemic toxic reactions can occur if the local anesthetic enters the circulation due to release of the tourniquet cuff (see Chapter 1, Table 1.7 and Chapter 6, p. 66). Prophylaxis: intermittent opening of the tourniquet, maintaining verbal contact with the patient, avoiding strong premedication.

Advantages
Simple technique
No specific anatomical expertise is needed
Wide safety margins and very high success rate (>98%) [7]
Fast onset of effect (5–10 min)
Good muscle relaxation
Controllable spread of the anesthesia (below the tourniquet cuff)
Fast return of sensation
No risk of infection

Disadvantages
Tourniquet cuff is needed
Limited operating time (<1 h)
Procedures in the upper arm are not possible
Tourniquet pain during the procedure
Nerve damage due to the tourniquet cuff
Does not provide a blood-free operating area
Insufficient postoperative analgesia due to fast recovery from the anesthesia

Toxic effects on the cardiovascular system only occur after very high doses of local anesthetic and become apparent as a drop in blood pressure, bradycardia, circulatory collapse and cardiac arrest. This type of complication rarely occurs in intravenous regional anesthesia. Nerve damage due to the cuff pressure.
# Intravenous regional anesthesia

**Name:**  
**Date:**  
**Diagnosis:**

**Premedication:**  
- [ ] No  
- [x] Yes

**Purpose of block:**  
- [ ] Surgical

**I.v. access:**  
- [ ] No. 1  
- [ ] No. 2

**Monitoring:**  
- [ ] ECG  
- [ ] Pulse oximetry

**Ventilation facilities:**  
- [ ] Yes (equipment checked)

**Emergency equipment (drugs):**  
- [ ] Checked

**Patient:**  
- [ ] Informed

**Position:**  
- [ ] Supine  
- [ ] Other

**Location of the tourniquet cuff:**  
- [ ] Right  
- [ ] Left

**BP:**  
- _________ mmHg  
- Pulse _________ min

**Ischemia:**  
- _________ mmHg  
- At _________

**Local anesthetic:**  
- _________ mL  
- _________ %  
- _________ μg

**Ischemia:**  
- From _________ to _________

**Cuff release over:**  
- [ ] 5 min  
- [ ] 10 min intermittently

**Patient's remarks during injection:**  
- [ ] None  
- [ ] Pain  
- [ ] Paresthesias  
- [ ] Warmth  
- [ ] Cold

**Objective block effect after:**  
- [ ] 5 min  
- [ ] 10 min

**Temperature measurement right:**  
- _________ °C  
- left _________ °C

**Sensory**  
- [ ] Motor

**Monitoring after block:**  
- [ ] < 1 h  
- [ ] > 1 h

**Time of discharge:**

**Complications and side effects:**  
- [ ] None

**BP reduction**  
- [ ] Bradycardia  
- [ ] Cardiac arrhythmia

**Fatigue**  
- [ ] Tingling lips  
- [ ] Tongue paresthesia

**Perioral numbness**  
- [ ] Metallic taste  
- [ ] Anxiety

**Restlessness**  
- [ ] Trembling  
- [ ] Other

**Special notes:**

---

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Guanethidine (1-[2-(perhydroazocin-1-y)ethyl]guanidine monosulfate) is an inhibitor substance that acts at the postganglionic sympathetic efferents. Its pharmacological effect is based on depleting norepinephrine stores, with consequent block of the reuptake of the transmitter for several days. The substance, also used as an antihypertensive drug, is around 6800 times more effective than procaine for intravenous sympathetic block (microsympathectomy), and has been described as the “local anesthetic for the sympathetic nervous system” [5]. Other sympathetic blocking drugs have been used, such as reserpine or brotylium. There is controversy surrounding the need for guanethidine and whether it produces any useful effect.

Figures 17.1–17.3 (see Chapter 17, p. 159) show the most frequent areas of application for i.v. regional anesthesia.

Intravenous sympathetic block with guanethidine

Indications
Intravenous sympathetic block is a good alternative to stellate ganglion or plexus blocks when these are contraindicated or regional anesthesia cannot be used in patients receiving anticoagulant treatment.

Diagnostic
Complex regional pain syndrome (CRPS)

Therapeutic
Complex regional pain syndrome (CRPS) type I (sympathetic reflex dystrophy) and type II (causalgia)
Perfusion disturbances in the extremities with burning pain, accompanied by hyperesthesia, hyperpathia, sensitivity to cold
Post-sympathectomy syndrome
Raynaud’s disease
Ischemic ulcers

Specific contraindications
Infected extremity.

Procedure
This block should only be carried out when full anesthetic facilities are available.

Preparations
Check that the emergency equipment is complete and in working order. Sterile precautions. Two intravenous access points (healthy extremity and extremity being treated), BP and ECG monitoring, pulse oximetry, anesthetic machine.

Materials
5-mL syringe, 10-mL syringe, 20-mL syringe, 50-mL perfusion syringe, saline, cotton-wool cushioning, tourniquet (two-lumen with color-indicated proximal and distal parts), intubation kit, emergency drugs ready to hand, disinfectant (Fig. 18.1).

Skin prep
In all blocks.

Patient positioning
Supine, with the extremity free.
Intravenous sympathetic block with guanethidine (Ismelin®)

Technical procedure
1. Place two plastic indwelling catheters, the first in a healthy extremity, and the second as distally as possible in the extremity being treated.
2. Place the extremity being treated in a free position and protect the tourniquet area for prophylaxis against nerve injury (Fig. 18.2).
3. Place the double-lumen cuff, with colored markers at the proximal and distal ends (Fig. 18.3).
4. Raise the extremity for ca. 5 min and massage it (Fig. 18.4).
5. Inflate the proximal cuff. The pressure must be ca. 100 mmHg higher than the patient’s systolic blood pressure (Fig. 18.5). The change in the pulse wave amplitude is documented using a pulse oximeter.
6. Place the extremity horizontally and inject 5 mL local anesthetic – e.g. 1% prilocaine – through the plastic indwelling catheter (Fig. 18.6). Administration of the local anesthetic serves to reduce both pressure pain and pain after guanethidine administration to a tolerable level.
7. The distal cuff is then inflated. Here again, the pressure must be ca. 100 mmHg higher than the patient’s systolic blood pressure. The distal cuff now lies in the anesthetized area, and the cuff pressure is better tolerated. Release the proximal cuff. Inject the guanethidine and allow it ca. 20 min to bind (Figs. 18.7 and 18.8).
8. To improve the distribution of the sympatholytic agent, the extremity must be moved about and constantly massaged during this period (Fig. 18.9).
9. After ca. 20 min, inflate the proximal cuff once again (ca. 100 mmHg above the patient’s systolic pressure; Fig. 18.10).
0. After a further 10 min, slowly deflate the distal and proximal cuffs alternately, step by step (Fig. 18.11).

The tourniquet should be applied as far distally as possible. This allows an optimal dose–effect ratio. During the block, the pressure in the block cuff must be constantly checked. Since accidental intravenous spread of the local anesthetic and/or the guanethidine can never be excluded, the patient must be carefully and constantly monitored.
Effects of the block

Two frequently occurring effects of the block are vasodilation (increased skin temperature and pulse wave) and inhibition of sweat gland function.

In particular, measurement of skin temperature before and after the block and comparison with the contralateral side is a reliable criterion for a successful block. Usually, the extremity being treated feels warmest on the first day after the block.

During informed consent, the patient should be informed that fatigue, and rarely general weakness, may occur on the day of treatment or the following day. Complete elimination of the guanethidine takes up to 3 weeks.
Dosage

Diagnostic
5–10 mg guanethidine in 20 mL sodium chloride solution.

No prophylactic administration of local anesthetic.

Therapeutic
Prophylactic administration of 5 mL of a local anesthetic – e.g. 1% prilocaine.
Forearm: 10–15 mg guanethidine in 20 mL sodium chloride solution.
Upper arm: 15–20 mg guanethidine in 30 mL sodium chloride solution.
Lower leg: 20–25 mg guanethidine in 50 mL sodium chloride solution.

Block series
An initial series of two or three therapeutic blocks can be carried out at intervals of 3–5 days. Thereafter, and only if there is clear evidence of effectiveness, periodic repetition is possible.

Side effects
Injection pain, tourniquet pain (prophylactic administration of a local anesthetic in therapeutic blocks, possibly with mild sedation), hypotension.

Complications
When the details of the technical procedure and dosage are precisely observed, no complications are expected.
# Intravenous sympathetic block

<table>
<thead>
<tr>
<th>Block no.</th>
<th>□ Right</th>
<th>□ Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: ____________________</td>
<td>Date: ____________________</td>
<td></td>
</tr>
<tr>
<td>Diagnosis: ____________________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Premedication: □ No</td>
<td>□ Yes</td>
<td></td>
</tr>
<tr>
<td>Purpose of block: □ Diagnostic</td>
<td>□ Therapeutic</td>
<td></td>
</tr>
<tr>
<td>i.v. access: □ No. 1</td>
<td>□ No. 2</td>
<td></td>
</tr>
<tr>
<td>Monitoring: □ ECG</td>
<td>□ Pulse oximetry</td>
<td></td>
</tr>
<tr>
<td>Ventilation facilities: □ Yes (equipment checked)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency equipment (drugs): □ Checked</td>
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<td></td>
</tr>
<tr>
<td>Patient: □ Informed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position: □ Supine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location of the tourniquet cuff:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Forearm</td>
<td>□ Upper arm</td>
<td>□ Lower leg</td>
</tr>
<tr>
<td>Local anesthetic: □ No</td>
<td>□ Yes □ mL □ %</td>
<td></td>
</tr>
<tr>
<td>Injection mixture: Guanethidine □ mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaCl 0,9 % □ mL</td>
<td></td>
<td></td>
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<tr>
<td>Ischemic time: From ____ To ____ □ 20 min □ 25 min □ 30 min</td>
<td></td>
<td></td>
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<tr>
<td>Cuff release over: □ 5 min □ 10 min intermittently</td>
<td></td>
<td></td>
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<tr>
<td>Patient’s remarks during injection: □ None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Pain</td>
<td>□ Paresthesias</td>
<td>□ Warmth</td>
</tr>
<tr>
<td>Objective block effect after 15 min:</td>
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<td></td>
</tr>
<tr>
<td>□ Temperature measurement right □ °C left □ °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Sensory</td>
<td>□ Motor</td>
<td></td>
</tr>
<tr>
<td>Monitoring after block: □ &lt; 1 h</td>
<td>□ &gt; 1 h</td>
<td></td>
</tr>
<tr>
<td>Time of discharge: ____________________</td>
<td></td>
<td></td>
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<tr>
<td>Complications and side effects:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ BP reduction</td>
<td>□ Bradycardia</td>
<td>□ Fatigue</td>
</tr>
<tr>
<td>□ Cardiac arrhythmia</td>
<td>□ Other</td>
<td></td>
</tr>
<tr>
<td>Subjective effects of the block: Duration: ____________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ None</td>
<td>□ Increased pain</td>
<td></td>
</tr>
<tr>
<td>□ Reduced pain</td>
<td>□ Relief of pain</td>
<td></td>
</tr>
<tr>
<td>VISUAL ANALOG SCALE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
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<td></td>
<td>220</td>
<td>200</td>
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<td></td>
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</table>

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Thorax, abdomen, lumbar spinal and sacral region
### Thoracic spinal nerve blocks

#### Anatomy

The thoracic spinal nerves form 12 pairs, which with the exception of the first two are narrow compared with the lower half of the cervical nerves. These spinal nerves emerge from the spinal cord with two roots – the receptor sensory dorsal root (posterior) and the effector motor ventral root (anterior) (Fig. 19.1). After leaving the dural sac, the two roots are surrounded by a dural sheath. The sensory root expands by taking up numerous nerve cells to form the spinal ganglion. Beyond the ganglion, the roots form a common mixed spinal nerve trunk, which divides into four branches after exiting through the intervertebral foramen:

- The **dorsal primary rami**, the **ventral primary rami**, the **meningeal branches** (which supply the spinal canal and the meninges), and
- The **white and gray communicating branches**, which Anastomose with each neighboring ganglion of the sympathetic trunk and thus extend to the viscera and vessels, mediating and involving the sympathetic nervous system. They also carry sympathetic fibers to the spine.

The **dorsal rami of the thoracic nerves** pass between the two transverse processes to their area of distribution, and divide into the two typical branches, the medial and lateral branches; they give off muscular branches (back muscles) and cutaneous branches (spine, posterior wall of the thorax, and lumbar region).

The **ventral rami of the thoracic nerves** are also termed **intercostal nerves**, and they are distributed segmentally (Fig. 19.2).

The 11 upper nerves are (relative to the thoracic ribs) genuinely intercostal, while the twelfth lies caudal to the twelfth rib and is known as the **subcostal nerve**. The six upper intercostal nerves run entirely in the intercostal muscles, while the lower six are distributed through the muscles and skin above the spinal column.
tercostal spaces, as far as the edge of the sternum; the six lower ones reach the area of the linea alba. All of the intercostal nerves, with the exception of the twelfth, run in the relevant intercostal space in front of the superior costotransverse ligament and on the inner surface of the external intercostal muscles.

The **internal intercostal muscles** are absent from the spine far as the costal angle. Over this area, the intercostal nerves are only covered by the **endothoracic fascia** and **costal pleura**.

At the start of the internal intercostal muscles, the nerves lie between these muscles and the external intercostal muscles, and they are accompanied by the **intercostal vessels** (the intercostal artery and vein). They lie caudal to the vessels. Special care needs to be taken during procedures, as due to the proximity of blood vessels to the nerves, toxic concentrations of local anesthetic can easily be reached.

**Branches of the intercostal nerves**

**Muscular branches**

It is advisable to distinguish between the six upper intercostal nerve pairs (which supply the subcostal muscle, serratus posterior superior muscle, and transversus thoracis muscle) and the lower five (which supply the subcostal muscle, serratus posterior inferior muscle, and transversus, obliquus, and rectus abdominis muscles).

**Lateral cutaneous branches**

For the skin and lateral sides of the thorax and abdomen. A small part of the first intercostal nerve (inferior trunk of the brachial plexus) supplies the skin of the axilla.

**Anterior cutaneous branches**

Supply the anterior side of the thorax.

**Pleural and peritoneal branches**

Supply the pleura and thoracic wall and the peritoneum of the lateral and anterior abdominal wall, as well as the pleural and peritoneal covering at the origin of the diaphragm.

**Thoracic paravertebral somatic nerve block**

**Definition**

A dorsal somatic block of the thoracic intercostal nerve below the transverse process, in its area of origin just after it exits from the intervertebral foramen and courses through the paravertebral space.

---

**Fig. 19.2 Intercostal nerves.**

(1) Ventral branches (intercostal nerves), (2) lateral cutaneous branch, (3) anterior cutaneous branch, (4) posterior intercostal artery, (5) posterior intercostal vein, (6) spinal cord, (7) spinal nerve, (8) sympathetic trunk, (9) thoracic aorta, (10) azygos vein, (11) external intercostal muscles, (12) internal intercostal muscles.
Indications

Surgical
Inguinal herniorrhaphy (in combination with a lumbar paravertebral somatic block, T10-L2) [9, 14]. Large doses of local anesthetic will be required.

Diagnostic
Differential diagnosis of somatic and autonomic pain. Differentiation and localization of intercostal neuralgia, causalgia, cardiac pain, etc.

Therapeutic
A series of blocks in the appropriate dermatome is particularly useful in the acute phase of herpes zoster. Pain in the intercostal area (neuralgia, causalgia). Pain after fractured ribs or contusions of the chest wall. Postoperative pain after upper abdominal or thoracic operations (providing relief for coughing and deep breathing).

In most of the indications mentioned, an indwelling epidural catheter is preferred (see Chapters 41 and 42).

Block series
A series of six to eight blocks is recommended. When there is evidence of improvement in the symptoms, additional blocks can also be carried out.

Contraindications

Specific
Anticoagulant treatment. Infections and skin diseases in the injection area.

Relative
Slim patients. Chronic obstructive lung diseases.

Procedure
This block should only be carried out by experienced anesthetists, or under their supervision. A specific indication is required. Prior information for the patient is necessary.

Preparations
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

Materials (Fig. 19.3)
Fine 26-G needle, 25 mm long, for local anesthesia. Atraumatic 24-G needle, 0.7 x 80 mm (15") with injection lead (e.g. Stimuplex D®, B. Braun Melsungen) or 24-G spinal needle, 0.6 x 80 mm. Syringes: 2, 5, and 10 mL. Local anesthetic, disinfectant, swabs, sterile gloves and drape; flat, firm pillow.

Patient positioning
Prone position: cushioned with a pillow under the lower thorax and upper abdomen. The patient's arms hang to the sides (Fig. 19.4). For blocks of the upper four thoracic nerves, it is recommended that the patient's head is positioned projecting over the end of the table, supported by an assistant (Fig. 19.10). Sitting: with the trunk leant forward (Fig. 19.13b).

Location
Vertebra prominens (nuchal tubercle) (count down caudally). Iliac crest line of L4 (count up cranially).
Upper edge of the transverse process selected. A horizontal line is drawn on the segment above the level being blocked. The injection point is located ca. 3.5–4 cm (two fingerbreadths) paramedian to this.

Skin prep, local anesthesia, covering with a sterile drape, drawing up the local anesthetic, testing the patency of the injection needle.

During the injection, the following points must be observed without fail:
- The person carrying out the injection must stand on the side being blocked.
- The injection point must not be located more than 4 cm lateral to the midline (rib contact, risk of pneumothorax!)
- There is a risk of perforating the dural cuff if the injection is made too far medially (epidural or subarachnoid injection).
- The transverse process is ca. 0.6–0.7 cm thick.
- If there is no bone contact after 2.5–5 cm (depending on the anatomy), the direction of the needle must be corrected (the transverse process has been missed; risk of pleural puncture).
- If the patient coughs, it indicates pleural irritation. The procedure should be halted.
- Eliciting paresthesias is not obligatory.
- The injection should be carried out on an incremental basis, with frequent aspiration (blood, CSF?).

**Injection technique**

The injection needle is introduced perpendicular to the skin surface (Fig. 19.5) until bone contact is made (transverse process) (Fig. 19.6).

Depending on the anatomy, bone contact is made at a depth of 2.5–5 cm. The needle depth is marked.
The needle is withdrawn to lie subcutaneously, and introduced at an angle of 15–20° in a caudal or cranial direction, past the transverse process, up to 2 cm deeper (Fig. 19.7).

Eliciting paresthesias is helpful, and confirms the correct position of the needle, but it is not obligatory, since optimal effectiveness of the block can be achieved with local anesthetic spread.

After aspiration at various levels (blood, CSF?), incremental injection of local anesthetic is carried out.

**Dosage**

**Surgical**

5 mL local anesthetic per segment (T10–L2) – e.g. 0.75 % ropivacaine or 0.5 % bupivacaine with the addition of epinephrine 1 : 400 000 [9] or 0.5 % levobupivacaine.

**Diagnostic**

5 mL local anesthetic per segment – e.g. 0.5% prilocaine, 0.5% mepivacaine, 0.5% lidocaine.

**Therapeutic**

5–10 mL local anesthetic per segment – e.g. 0.375% ropivacaine, 0.25–0.375% bupivacaine (0.25–0.375% levobupivacaine). In acute conditions (e.g. herpes zoster in the innervated area), 2–4 mg dexamethasone can be added.

**Complications**

**Pneumothorax** (Fig. 19.8):

This is a rare complication if the technique is carried out correctly. It is usually a small pneumothorax with spontaneous resorption. If there is any suspicion, however, a chest radiograph should be taken after 4–6 hours.

Epidural or subarachnoid injection (avoid injecting too medially!) (see Chapter 36 and Chapter 41).

Intravascular injection with toxic reactions (see Chapter 6, p. 65).

Hypotension due to accompanying sympathetic block (e.g. with larger volumes of the local anesthetic).
Record and checklist

Thoracic paravertebral nerve block

Block no. □ Right □ Left

Name: __________________ Date: ____________

Diagnosis: ___________________________

Premedication: □ No □ Yes

Neurological abnormalities: □ No □ Yes

Purpose of block: □ Diagnostic □ Therapeutic □ Surgical

Needle: G _______ Length _______ cm

i.v. access: □ Yes

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

Position: □ Prone □ Sitting

Injection level: □ T _______

Injection:
Local anesthetic: __________ ml ______ %
(in incremental doses)
Addition to LA: □ Yes __________ μg/mg □ No

Patient’s remarks during injection:
□ None □ Paresthesias □ Warmth □ Pain

Nerve area: _______

Objective block effect after 15 min:
□ Cold test □ Temperature measurement right ______°C left ______°C

Segments affected: _______

Monitoring after block: □ < 1 h □ > 1 h

Complications:
□ None □ Intravascular injection □ Subarachnoid epidural
□ Pneumothorax □ Other

Subjective effects of the block: Duration: _______
□ None □ Increased pain
□ Reduced pain □ Relief of pain

VISUAL ANALOG SCALE

0 10 20 30 40 50 60 70 80 90 100

Special notes:

________________________________________________________________________
________________________________________________________________________

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Blocks of the intercostal nerves

Definition
Block of one or more intercostal nerves at various points in their course, most often paravertebrally in the area of the costal angle, or dorsomedially in the area of the posterior axillary line; more rarely in the area of the anterior axillary line, or parasternally.

Indications
Surgical
Superficial surgery in the innervation area.
Insertion of a chest drain.

Diagnostic
Differential diagnosis of somatic and autonomic pain conditions.

Therapeutic
Pain in the intercostal area (neuralgia and causalgia).
Pain after rib fractures or contusions of the thoracic wall, pleuritic pain.
Acute phase of herpes zoster (in combination with a somatic paravertebral block).
Postoperative pain therapy after upper abdominal and thoracic surgery, to relieve muscular spasms and wound pain (to allow coughing and deep breathing).

In most of the indications mentioned, an epidural catheter procedure is preferable (see Chapters 41 and 42).

Contraindications
Specific
Anticoagulant treatment.
Infections and skin diseases in the injection area.

Relative
Slim patients.
Chronic obstructive lung disease.

Procedure
Preparations
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access, ECG monitoring, pulse oximetry, endotracheal anesthesia set, ventilation facilities, emergency medication.

Materials (Fig. 19.9)
Fine 26-G needle, 25 mm long, for local anesthesia. Atraumatic 25-G needle, 0.5 × 35 mm (15") with injection lead (e.g., Stimuplex D®, B. Braun Melsungen) or 24-G Plexufix needle, 0.55 × 25 mm. Syringes: 2, 5, and 10 mL.
Local anesthetic, disinfectant, swabs, sterile gloves and drape, flat, firm pillow (prone position).

Fig. 19.9 Materials
Chapter 19

The first four intercostal nerves are blocked paravertebrally, ca. 3.5–4 cm (ca. two fingerbreadths) lateral to the spinous processes (Fig. 19.10).

Intercostal block in the area of the costal angle

Patient positioning

- **Prone position**: with a pillow under the mid-abdomen, between the arch of the ribs and the iliac crest line, with the patient’s arms hanging (Fig. 19.11). This position is particularly preferred with bilateral blocks.
- **Lateral recumbent**: more rarely, and with unilateral blocks (Fig. 19.12).
- **Supine**: (Fig. 19.13a).
- **Sitting**: e.g. in rib fractures (Fig. 19.13b).

Location

- Twelfth rib (count cranially).
- Costal angle (ca. 7–8 cm – four fingerbreadths – lateral to the midline and lateral to the musculature of the erector muscle of the spine) (Fig. 19.11).
- Caudal boundary of the rib being blocked (Fig. 19.14).

Skin prep, local anesthesia, covering with a sterile drape, drawing up the local anesthetic, checking the patency of the injection needle.

During the injection, the following points must be observed:
- The person carrying out the injection must stand on the side being blocked.
- The intercostal nerve runs dorsocaudal to the vessels in the inferior costal groove.
- The rib is ca. 0.6–0.7 cm thick.
- Start with the lowest rib.
- The injection must only be carried out after definite identification of the rib being blocked.
- Targeted paresthesias are not elicited.
- If the patient coughs, it indicates pleural irritation. The procedure should be halted.
- Injection should be carried out on an incremental basis, with frequent aspiration.
Injection technique

The index and middle fingers of the left hand palpate the rib being blocked, and press the skin around the contours of the ribs. The index finger locates the lower edge of the rib.

A 3.5-cm long needle is advanced at an angle of 80° to the skin surface until bone contact (costal periosteum) is made (Fig. 19.15).

The needle is withdrawn slightly, and the skin and needle are then simultaneously pushed caudally until the needle slides under the lower edge of the rib (Fig. 19.16a).

After loss of bone contact, the needle must only be introduced 2–3 mm deeper (Fig. 19.16b).

The hub of the needle is fixed between the thumb and index finger as this is done; the middle finger fixes the shaft and directs the needle. The side of the left hand (left hypothenar eminence) rests on the patient’s back; initially it serves as a brake, and then during the injection it serves as fixation (Fig. 19.17).

After aspiration at various levels, the local anesthetic is injected on an incremental basis.

Effects of the block

Block of the skin, lateral and anterior thoracic wall, motor block of the intercostal muscles, as well as of the pleura and thoracic wall.

The six lower intercostal nerves reach the area of the linea alba, leading to motor block of the abdominal musculature and sensory block of the skin and abdomen, as well as of the peritoneum and lateral and anterior thoracic wall.

Dosage

3–5 mL local anesthetic per segment – e.g. 0.5–0.75% ropivacaine, 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine).
**Fig. 19.15** The needle is advanced as far as the costal periosteum

**Fig. 19.16a, b** The skin and the needle are simultaneously pushed caudally, and the needle is then introduced a further 2–3 mm

As intercostal block is the procedure in which the highest blood levels of local anesthetic per milligram injected are achieved (due to very fast absorption), there is a risk of overdose. The individual maximum dose must be carefully calculated, and must never be exceeded.

**Fig. 19.17** Guiding the needle
Dorsolateral intercostal block in the area of the posterior axillary line

This block is carried out ca. 2 cm dorsomedial to the posterior axillary line, with the patient in a supine position. Cushioning with a flat pillow under the back allows the relevant side of the chest to be raised at a slight angle. The patient’s ipsilateral arm lies under the neck (Fig. 19.18).

This technique is suitable for blocking the lateral cutaneous branch of the intercostal nerve.

The materials and preparation, injection technique, dosage and complications are the same as those for the block of the costal angle described above.

More rarely, blocks of the intercostal nerves are carried out in the area of the anterior axillary line (distal third of the ribs and sternum), or parasternally (e.g. in sternum fractures).

Complications

Pneumothorax.

Toxic reactions due to overdosage (see Chapter 1, p. 9 and Chapter 6, p. 66).

Intravascular injection (see Chapter 6, p. 65).
Record and checklist

Intercostal nerve block

Block no. □ Right □ Left

Name: ___________________________ Date: ___________________________

Diagnosis: ___________________________

Premedication: □ No □ Yes

Neurological abnormalities: □ No □ Yes

Purpose of block: □ Diagnostic □ Therapeutic □ Surgical

Needle: g ___________ Length ___________ cm

i.v. access: □ No □ Yes

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

Position: □ Prone □ Lateral recumbent □ Sitting □ Supine

Access: □ Costal angle □ Posterior axillary line □ Anterior axillary line □ Parasternal

No. of nerves blocked: T ___________________________

Injection:

Local anesthetic: ___________________________ mL ___________ %

Addition to LA: □ Yes ___________________________ µg/mg □ No

Patient's remarks during injection:

□ None □ Paresthesias □ Warmth □ Pain

Nerve area:

Objective block effect after 15 min:

□ Cold test □ Temperature measurement right ___ °C left ___ °C

Monitoring after block: □ < 1 h □ > 1 h

Time of discharge ___________________________

Complications:

□ None □ Intravascular injection □ Pneumothorax □ Toxic reaction

Subjective effects of the block:

□ None □ Increased pain □ Reduced pain □ Relief of pain

VISUAL ANALOG SCALE

0 10 20 30 40 50 60 70 80 90 100

Duration: ___________________________

Special notes: ___________________________

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
**Thoracic spinal nerve blocks**

**Anatomy**

The posterior branches of the spinal nerve supply the skin of the back and the back musculature. Their area of distribution in the thoracic section stretches over the area between the spinous processes of the vertebrae and the costal angles (Fig. 19.19).

The posterior branches of the thoracic nerves each run between two transverse processes to their area of distribution, and divide shortly thereafter into a medial branch and a lateral branch. Together, these both supply the deep muscles of the back, but only one of each pair penetrates the subcutaneous tissue to become a cutaneous nerve.

Normally, the posterior branches of the eight upper thoracic nerves send off thick medial cutaneous branches, while the four lower ones send off thick lateral cutaneous branches.

The medial cutaneous branches pass through the trapezius muscle alongside the spinous processes of the vertebrae. The point of exit of the lateral cutaneous branches lies in the area of the musculotendinous line of the latissimus dorsi muscle.

**Indications**

**Therapeutic**

Muscular tension in the area of the trapezius muscle, serratus anterior and posterior muscles, rhomboideus muscle, levator scapulae muscle, splenius capitis muscle, and splenius cervicis muscle.

Spasm of the deep paraspinal musculature.

Shoulder pain, supplementing a block of the suprascapular and subscapular nerves (see Chapters 10 and 11).

**Specific contraindications**

None.

**Procedure**

**Preparations**

Check that the emergency equipment is complete and in working order. Sterile precautions.
Materials (Fig. 19.20)
2-mL syringe, 5-mL syringe, fine 23-G needle (40 mm long), disinfectant.
Skin prep in all blocks.

Patient positioning
Sitting, with the head tilted forward slightly and the back muscles relaxed (“pharaoh posture”).

Location
Spinous processes of the vertebral column in the C7–T1 and T2–T7 areas.

Injection technique
The intervertebral space between two neighboring spinous processes is palpated, and the needle is introduced at an angle of ca. 45° laterally, up to a depth of ca. 3–4 cm (Fig. 19.21). After aspiration at various levels, the local anesthetic is injected slowly. When indicated, the neighboring segments can be anesthetized, starting at C7–T1 up to T7 and further along the spine (Fig. 19.22).

Effects of the block
Relaxation and pain relief in the area of the musculature of the nape of the neck and in the paraspinal musculature of the spine.
C7–T1: After the injection, a pleasant sensation of warmth develops, which radiates laterally to the shoulder and often cranially as far as the suboccipital area.
T2–T7: The lateral thoracic spread, with a sensation of warmth and slight itching, is about 20 cm.

Dosage
1–1.5 mL local anesthetic per segment – e.g. 0.5–0.75 ropivacaine, 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine). Up to 10–15 mL local anesthetic in total.

Side effects
No side effects are expected.
### Spinal nerves (posterior branches)

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**Diagnosis:**

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<th>☐ Therapeutic</th>
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**Needle:**

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<th>☐ 23 G</th>
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<th>☐ 40 mm</th>
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**i. v. access:**

<table>
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<th>☐ No</th>
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**Monitoring:**

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**Access:**

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**Local anesthetic:**

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<th>mL</th>
<th>% per segment</th>
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**Addition to injection solution:**

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<th>☐ Yes</th>
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**Patient's remarks during injection:**

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<tr>
<th>☐ None</th>
<th>☐ Pain</th>
<th>☐ Paresthesias</th>
<th>☐ Warmth</th>
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**Objective block effect after 15 min:**

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<th>☐ Cold test</th>
<th>☐ Temperature measurement right ___ °C left ___ °C</th>
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<tr>
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<td>☐ No</td>
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**Segments affected:**

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**Objective block effect after 15 min:**

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**Segments affected:**

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**Monitoring after block:**

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<th>☐ Yes</th>
<th>☐ No</th>
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**Complications:**

<table>
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<th>☐ None</th>
<th>☐ Yes (which?)</th>
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**Subjective effects of the block:**

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<th>☐ Increased pain</th>
<th>☐ Reduced pain</th>
<th>☐ Relief of pain</th>
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**VISUAL ANALOG SCALE**

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**Special notes:**

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Lumbar spinal region

20 Lumbar paravertebral somatic nerve block

Definition
Dorsal somatic block of a lumbar nerve below the transverse process in its area of origin, just after it exits from the intervertebral foramen and runs through the paravertebral space.

Anatomy
Shortly after they exit from the intervertebral foramina, the spinal nerves divide into ventral branches (anterior) and dorsal branches (posterior). The smaller posterior branches turn dorsally and supply the skin and musculature of the back.

Together with the twelfth thoracic nerve, the longer ventral branches of the first four lumbar nerves form the lumbar plexus. The shorter muscular branches supply the psoas muscle and quadratus lumborum muscle (see pp. 218f). The lumbar plexus is connected to the lumbar part of the sympathetic chain via two or three long communicating branches.

Indications
Surgical
Inguinal herniorrhaphy (in combination with a thoracic paravertebral somatic block, T10–L2) [9, 14]. High doses of local anesthetic are usually required.

Diagnostic
Differentiation and localization of painful conditions in the lower abdominal quadrants, back, and lower extremities.

Therapeutic
Pain in the lumbar, inguinal, and thigh region.
Acute phase of herpes zoster in the appropriate dermatome.

Block series
A series of six to eight blocks is recommended. When there is evidence of improvement, additional blocks can be carried out.

Contraindications
Specific
- Anticoagulant treatment.
- Infections and skin diseases in the injection area.

Procedure
This block should only be carried out by experienced anesthetists, or under their supervision. Prior information for the patient is mandatory.

Preparations
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.
Lumbar paravertebral somatic nerve block

Materials (Fig. 20.1)
Fine 26-G needle, 25 mm long, for local anesthesia. Atraumatic 24-G needle, 0.7 x 80 mm (0.7 x 120 mm) (15°) with injection lead (e.g. Stimuplex D®, B. Braun Melsungen) or 24-G spinal needle, 0.6 x 80 mm, or 21-G spinal needle, 0.8 x 120 mm. Syringes: 2, 5, and 10 mL. Local anesthetics, disinfectant, swabs, sterile gloves, drape, flat, firm pillow.

Patient positioning
- Prone position: cushioned with a pillow in the mid-abdomen, to eliminate lumbar lordosis. The patient’s arms should be dangling. It is also possible to carry out the injection with the patient in a sitting or lateral position.

Location
- Iliac crest line L4 (count cranially).
- Upper edge of the selected spinous process.

Each of the lumbar somatic nerves leaves the intervertebral foramina slightly caudal and ventral to the transverse process. The upper edge of each spinous process in the lumbar region lies more or less on the same horizontal line as its own transverse process. After palpation of the upper edge of the spinous process, a horizontal line is drawn laterally. The injection point is located ca. 2.5–4 cm paramedially.

Skin prep, local anesthesia, covering with a sterile drape, drawing up the local anesthetic, checking the patency of the injection needle.

During the injection, the following points must be observed without fail:
- The person carrying out the injection must stand on the side being blocked.
- There is a risk of perforating the dural cuff if the injection is made too far medially (epidural or subarachnoid injection).
- The transverse process is ca. 0.6–0.7 cm thick.
- If there is no bone contact after 3.5–5 cm (depending on the anatomy), the direction of the needle must be corrected (the needle is located between two transverse processes).
- Producing paresthesias is not obligatory.
- The injection should be carried out incrementally, with frequent aspiration (blood, CSF?).
- Motor weakness in the leg must always be expected. Patients should be warned of this.

Injection technique
The injection needle is introduced perpendicular to the skin surface (Fig. 20.2) until bone contact is made (transverse process). Depending on the anatomy, bone contact is made at a depth of ca. 3–5 cm. The depth of the needle is marked (Fig. 20.3).

Fig. 20.1 Materials

Fig. 20.2 The injection needle is introduced perpendicular to the skin surface
The needle is then withdrawn to lie subcutaneously, and introduced at an angle of ca. 15–20° caudally (or cranially), past the transverse process, for a further 2–2.5 cm deeper (Fig. 20.4). Eliciting paresthesias is helpful, and confirms the correct positioning of the needle, but it is not obligatory, since the optimal effect of the block can be achieved by spread of the local anesthetic. After aspiration at various levels (blood, CSF?), the local anesthetic is injected on an incremental basis.

After a successful somatic paravertebral block in the lumbar region, the injected local anesthetic diffuses through the plethora of communicating branches that are present (particularly in the first and second lumbar nerves, but more rarely in the third) towards the neighboring sympathetic chain, which is almost always blocked as well.
Dosage

Surgical
5 mL local anesthetic per segment (T10-L2) – e.g. 0.75% ropivacaine, 0.5% bupivacaine with 1 : 400000 epinephrine [9] (0.5% levobupivacaine).

Diagnostic
5 mL local anesthetic per segment – e.g. 0.5% prilocaine, 0.5% mepivacaine, 0.5% lidocaine.

Therapeutic
5–10 mL local anesthetic per segment – e.g. 0.5% ropivacaine, 0.25–0.375% bupivacaine (0.25–0.375% levobupivacaine). In acute conditions (e.g. herpes zoster), 2–4 mg dexamethasone can be added.

Important notes for outpatients
See Chapter 26, p. 224.

Complications
- Epidural or subarachnoid injection (avoid injecting too medially! See Chapters 36 and 41).
- Intravascular injection with toxic reactions (see Chapter 1, p. 9 and Chapter 6, p. 66).
- Intra-abdominal and retroperitoneal injection, or injection into the peritoneum (severe complications are not expected).
- Hypotension due to accompanying sympathetic block (e.g. with larger volumes of local anesthetic or too deep an injection).
### Lumbar paravertebral nerve block

<table>
<thead>
<tr>
<th>Block no.</th>
<th>□ Right</th>
<th>□ Left</th>
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**Name:** __________________________ Date: __________________________

**Diagnosis:** __________________________

**Premedication:**
- □ No
- □ Yes

**Neurological abnormalities:**
- □ No
- □ Yes

**Purpose of block:**
- □ Diagnostic
- □ Therapeutic
- □ Surgical

**Needle:** G _______ Length _______ cm

**i.v. access:** □ Yes

**Monitoring:** □ ECG
- □ Pulse oximetry

**Ventilation facilities:** □ Yes (equipment checked)

**Emergency equipment (drugs):** □ Checked

**Patient:** □ Informed (what to do after block)

**Position:** □ Prone

**Injection level:** □ _______ _______

**Injection:**
- Local anesthetic: _______ mL _______ %
  (in incremental doses)
- Addition to LA: □ Yes _______ µg/mg _______ □ No

**Patient’s remarks during injection:**
- □ None
- □ Paresthesias
- □ Warmth
- □ Pain

**Nerve area:** __________________________

**Objective block effect after 15 min:**
- □ Cold test
- □ Temperature measurement right _______ °C left _______ °C

**Segments affected:** L _______

**Monitoring after block:** □ < 1 h □ > 1 h

**Time of discharge:** _______ Motor / sensory status checked

**Complications:**
- □ None
- □ Intravascular injection
- □ Subarachnoid / epidural
- □ Other

**Subjective effects of the block:**
- □ None
- □ Increased pain
- □ Relief of pain

**Duration:** _______

**VISUAL ANALOG SCALE**

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**Special notes:** __________________________

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21 Lumbar sympathetic block

Definition
Injection of a local anesthetic or neurolytic in the sympathetic ganglia of the lumbar sympathetic trunk.

Anatomy (Figs. 21.1, 21.2)

From the T12 ganglion, the sympathetic trunk passes into the abdominal cavity. The abdominal part of the trunk reaches the anterolateral surface of the lumbar vertebrae, lying directly medial to the origin of the psoas, to the right behind the inferior vena cava and cisterna chyli and to the left beside the aorta. The lumbar part of the sympathetic trunk usually contains only four lumbar ganglia (due to fusion of the twelfth thoracic and first lumbar ganglion), with a spindle shape or oval shape. The final ganglion is usually the largest. The average length of the ganglia is ca. 3–5 mm (more rarely, up to 10–15 mm). The psoas muscle and its fascia separate the sympathetic nerve trunk from the lumbar somatic spinal nerves.

The sympathetic trunks give off and receive communicating and visceral branches, as well as vascular, muscular, osseous and articular branches. White communicating branches only reach the lumbar sympathetic ganglia from the two cranial spinal nerves, as well as from the three lumbar spinal nerves. They carry preganglionic fibers and visceral afferents. Gray communicating branches are given off from the corresponding ganglia to all the lumbar spinal nerves. They contain vasomotor, sudomotor and pilomotor fibers, which are distributed with the lumbar spinal nerves. From the lumbar part of the sympathetic chain, some branches run to the renal plexus, but most pass to the abdominal aortic plexus and the hypogastric plexus. Most of the sympathetic nerve fibers responsible for the lower extremity pass through the L2 (dominant) and L3 ganglia.

Indications

Diagnostic and prognostic
Differentiation between various forms of vasospastic disease in the area of the lower extremities.
Prognostic block to establish an indication for surgical sympathectomy or a neurolytic block.
Checking (confirmation) of a surgical sympathectomy.

Therapeutic

Pain caused by perfusion disturbances in vasospastic diseases in the region of the lower extremities, in the form of arterial or venous dysfunction or a combination of the two.
Intermittent claudication.
Embolism and thrombosis.
Thrombophlebitis and post-phlebitic edema.
Post-reconstructive vascular procedures.
After frostbite or trauma.
Complex regional pain syndrome (CRPS) types I and II.
Phantom limb pain.
Erythromelalgia.
Acrocyanosis.
Phlegmasia alba dolens (milk leg).
Persistent infection of the leg.
Poorly healing ulcers.
Neuropathy after radiotherapy.
Hyperhidrosis of the lower body.
Acute phase of herpes zoster.
Visceral pain (e.g. renal colic).

Block series
A series of six to eight blocks is recommended. When there is evidence of improvement in the symptoms, additional blocks can also be carried out.
Contraindications
Anticoagulant treatment.
Infections and skin diseases in the injection area.
Addition of vasopressors in patients with peripheral circulatory disturbances.

Procedure
This block should only be carried out by experienced anesthetists, or under their supervision. Full information should be given to the patient.

Preparations
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

Materials (Fig. 21.3)
Fine 26-G needle, 25 mm long, for local anesthesia. Atraumatic 22-G needle, 0.7 x 120 mm (15") with injection lead (e.g. Stimuplex D®, B. Braun Melsungen) or spinal needle, 0.7 (0.9) x 120 mm (150 mm), 20–22 G (e.g. Spinocon®, B. Braun Melsungen). Syringes: 2, 5 and 10 mL. Disinfectant, swabs, compresses, sterile gloves and drape, flat, firm pillow.

Fig. 21.1 Anatomy (anterior view):
(1) sympathetic trunk with communicating branches,
(2) lumbar plexus,
(3) lumbosacral trunk,
(4) quadratus lumborum muscle,
(5) psoas major muscle,
(6) iliac muscle
Patient positioning

Prone position: support with a pillow in the mid-abdomen (to eliminate lumbar lordosis). The patient’s arms should be dangling.

The patient should breathe with the mouth open, to reduce tension in the back muscles.

This position is preferable, particularly when the block is carried out under radiographic control using an image intensifier.

Lateral decubitus: the flank is supported with a pillow. The side being blocked should be uppermost.

Landmarks (Fig. 21.4)

L4 iliac crest line.
L2: a parallel line is drawn ca. four fingerbreadths (7 cm) from the midline. The intersection point between this line and the twelfth rib is at the level of L2.
Mid-point of each spinous process of the relevant lumbar vertebra.

Disinfection, generous local anesthetic infiltration of the injection channel, covering with a sterile drape, drawing up the local anesthetic, testing the patency of the injection needle.

Fig. 21.2a Lumbar sympathetic block (anatomy and diagram). (1) Aorta, (2) sympathetic ganglion, (3) epidural space, (4) medial tract of back muscles, (5) intervertebral joint, (6) interspinous ligament, (7) superior articular process of L3, (8) inferior articular process of L4, (9) lateral tract of back muscles, (10) vena cava, (11) filum terminale


Fig. 21.2b CT section in the center of the L4 vertebra. The sympathetic ganglia are well delineated in the fatty tissue on each side. Neighboring structures, such as the vessels and ureters, can also be precisely differentiated


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Chapter 21

**Fig. 21.3 Materials**

**Fig. 21.4a, b Localization**

**Fig. 21.5 Injection technique**

The injection needle is introduced in the direction of the intended vertebra, ca. four fingerbreadths (7 cm) lateral to the midline and at an angle of ca. 30–40° to the skin surface and slightly cranially (Fig. 21.5).

Locating the transverse process at a depth of ca. 3–5 cm is helpful. The depth of the transverse process is marked (Fig. 21.6).

The needle is withdrawn to lie subcutaneously. The needle is then reintroduced slightly more steeply, with stepwise correction of the direction cranially or caudally (to avoid the transverse process) and medially (to obtain contact with the vertebral periosteum).
After contact with the periosteum, the needle is rotated 180° so that the bevel is directed toward the vertebra and can slide off the bony edge. After sliding off, the needle is further advanced by 1–2 cm (Fig. 21.8).

The lumbar sympathetic trunk lies about twice as deep as the distance between the skin and the transverse process (Fig. 21.7). The distance from the transverse process and the ganglia of the lumbar sympathetic trunk is ca. 3.8–5 cm and is relatively constant. The distance from the skin to the transverse process depends on the anatomy and is rather more variable.

Confirming the correct needle position

Radiographic control.

Loss-of-resistance technique with 0.9% saline or air.

Perforation of the psoas fascia is similar to the sensation experienced when carrying out an epidural.

A false loss of resistance can occur when the needle is positioned superficially between the psoas muscle and the quadratus lumborum muscle, leading to inadvertent block of the lumbar somatic nerves, with consequent numbness of the lower extremity during the period of effect of the local anesthetic.

Injection of a neurolytic into this area without prior radiographic control of the position can have fatal consequences.

After careful aspiration testing at all levels, resistance-free incremental injection of the local anesthetic is carried out.
**Fig. 21.7** Position of the lumbar sympathetic trunk


**Fig. 21.8a** After the needle has been withdrawn to lie subcutaneously, it is reintroduced at a steeper angle, followed by contact with the vertebral periosteum and rotation of the needle by 180°. The needle is then advanced 1–2 cm

**Fig. 21.8b, c** In a skeleton (anterior and lateral views)
Neurolytic block
Injection of neurolytics – 45–95% ethanol, 7% phenol in water or 7–10% phenol in Conray (iothalamate meglumine) – at the lumbar sympathetic ganglia.
Prerequisite: the procedure must be carried out under radiographic guidance.
Usually, three needles are introduced at the level of L2, L3 and L4 and the neurolytic is only injected after definite confirmation of the correct needle position. After this, 1 mL of air is injected per needle, to clear any residual neurolytic from the needle.

Effects of the block
Signs of vascular dilation in the area of the ipsilateral leg are:
- Increase in skin temperature.
- Hyperthermia and anhidrosis.
- Loss of the sympathogalvanic reflex.
- Reduced pain or absence of pain.
- No signs of sensory or motor block (assuming that the lumbar somatic nerves have not been concomitantly anesthetized).

Dosage
Diagnostic
5 mL local anesthetic with contrast medium – e.g. 0.5 prilocaine, 0.5% mepivacaine, 0.5% lidocaine.

Therapeutic
20 mL local anesthetic (single-needle technique).
10 mL local anesthetic per needle (in the two-needle or three-needle technique) – e.g. 0.2–0.375% ropivacaine, 0.25% bupivacaine (0.25% levobupivacaine).

Neurolytics
3 mL per segment.

Side effects
- Transient motor weakness due to block of the lumbar somatic nerves. Paresthesias during the injection are a warning signal. This undesired effect is always liable to occur and is caused by superficial injection in the area of the lumbar somatic nerves or by spread after the administration of large volumes of a local anesthetic. It is therefore necessary to monitor the patient for at least 1 hour after the block (see Chapter 26, section on important notes for outpatients, p. 224).
- Fall in blood pressure due to sympathetic block.

Complications
Severe
- Intravascular injection (aorta, vena cava) with toxic reactions (see Chapter 6, p. 66).
- Epidural or subarachnoid injection (see Chapter 36 and Chapter 41).

Potential
- Retroperitoneal hemorrhage.
- Hemorrhage in the psoas area (with subsequent pain in the thigh and transient weakness in the quadriceps muscle).
- Renal injury accompanied by hematuria.
- Back pain.
- Perforation of an intervertebral disk.
- Ejaculation disturbances (in younger patients with bilateral block).

Complications of neurolytic block
- Injury to the lumbar somatic nerves (neuritis, 1%).
- Neuralgia in the genitofemoral nerve (5–10%).
- Ureteral stricture.
Lumbar sympathetic block

Block no. □ Right □ Left

Name: __________________ Date: __________________

Diagnosis: ____________________________________________

Premedication: □ No □ Yes

Neurological abnormalities: □ No □ Yes

Purpose of block: □ Diagnostic □ Therapeutic

Needle: G __________ Length ______ cm

i.v. access: □ Yes

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed (what to do after block)

Position: □ Prone □ Lateral recumbent

Injection level: □ 1 __________ __________

Injection technique: □ X-ray image intensifier □ Loss of resistance □ CT-guided

Injection:

Local anesthetic: __________ ml ______ %
(In incremental doses)

Addition to LA: □ Yes __________ μg/mg □ No

Neurolytic: __________ ml ______ %

Addition: □ Yes □ No

Patient’s remarks during injection:

□ None □ Paresthesias □ Warmth □ Pain

Nerve area: ____________________________

Objective block effect after 15 min:

□ Cold test □ Temperature measurement right ______°C left ______°C

Segments affected: L __________

Monitoring after block: □ < 1 h □ > 1 h

Time of discharge: __________ Motor/sensory status checked

Complications:

□ None □ Intravascular injection □ Subarachnoid epidural

□ Drop in BP □ Other

Subjective effects of the block:

□ None □ Increased pain

□ Reduced pain □ Relief of pain

VISUAL ANALOG SCALE

0 10 20 30 40 50 60 70 80 90 100

Special notes:

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Abdomen

22 Celiac plexus block

Definition
Injection of a local anesthetic or neurolytic in the region of the celiac plexus.

Anatomy (Fig. 22.1)
The celiac plexus is the largest of the three large sympathetic plexuses (cardiac plexus – thorax; celiac plexus – abdomen; hypogastric plexus – pelvis). It receives its primary innervation from the preganglionic splanchnic nerves (greater splanchnic nerve T5–10, lesser splanchnic nerve T10–11 and lowest splanchnic nerve T11–12), the postganglionic fibers of which, after synapsing in the celiac ganglion, radiate to the associated plexus and innervate most of the abdominal organs. This large network, with a diameter of about 50 mm, surrounds the origins of the celiac artery and superior mesenteric artery, extends laterally as far as the adrenal glands, upward as far as the aortic hiatus and downward as far as the root of the renal artery. It lies on the initial part of the abdominal aorta, at the level of the first lumbar vertebra, anterior to the medial crus of the diaphragm.

The most important roots of the celiac plexus are the splanchnic nerves, the abdominal branches of the vagus nerves and several branches of the last thoracic ganglion and two highest lumbar ganglia. Cranially, the celiac plexus is connected to the thoracic aortic plexus and caudally it continues into the abdominal aortic plexus. A paired celiac ganglion forms the basis for the celiac plexus. The left ganglion lies closer to the midline and partly on the aorta, while the right one (ventrolateral to the vena cava) lies slightly more to the side in the area of the fissure between the medial and lateral crura of the diaphragm. The two ganglia are connected to one another. With closer approximation and fusion, the double ganglion takes on a ring shape, which is also known as the solar ganglion (solar plexus).

The smaller superior mesenteric ganglion and aorticorenal ganglion are associated with the celiac ganglion.

The lesser splanchnic nerve usually enters the latter ganglion, while the greater splanchnic nerve passes to the posterior surface of the lateral part of the celiac ganglion. The phrenic ganglion is a third, unpaired, ganglion. The following, sometimes paired and sometimes unpaired, secondary (associated) plexuses emerge from the celiac plexus:
- Paired (phrenic plexus, suprarenal plexus, renal plexus and spermatic plexus).
- Unpaired (superior gastric plexus, hepatic plexus, splenic plexus and superior mesenteric plexus).

Indications
Diagnostic
Differential diagnosis of pain in the abdominal region (visceral, epigastric or cardiac pain).

Prognostic
In upper abdominal cancer pain, before a neurolytic block.

Therapeutic
Relief of upper abdominal pain (pancreas, stomach).
Treatment of the dumping syndrome.
Injection of neurolytics as a palliative measure in malignant intra-abdominal disease (pancreas, stomach).

Contraindications
Anticoagulant treatment.
Infections and skin diseases in the injection area.
Hypovolemia.
General debility.
Injection of a neurolytic without precise identification of the needle position (with guidance by CT or image intensifier).

Procedure
This block should be carried out by very experienced anesthetists. Full information for the patient is mandatory.
Preparations
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

Materials (Fig. 22.2)
Fine 26-G needle for local anesthesia.
20–22-G spinal needle, 0.7 (0.9) x 120 mm (150 mm) (e.g. Spinocan, B. Braun Melsungen).
Syringes: 2, 10 and 10 mL.
Disinfectant, swabs, compresses, sterile gloves and drape, flat, firm pillow.

Fig. 22.1 Anatomy.
(1) Celiac plexus, (2) aorta, (3) inferior vena cava, (4) pancreas, (5) renal plexus, (6) abdominal aortic plexus, (7) inferior mesenteric ganglion, (8) inferior mesenteric plexus, (9) superior hypogastric plexus, (10) inferior hypogastric plexus
Patient positioning

Prone position: supported with a pillow in the mid-abdomen (to relieve lumbar lordosis). The patient's arms are dangling, with the head lying to the side. The patient breathes with the mouth open, to reduce tension in the back muscles. This position is preferable.

Lateral decubitus position, with support under the flank. The side being blocked lies upward.

Location

L4 iliac crest line (count the spinous processes cranially).

L2: a parallel line is drawn about 7–8 cm lateral to the midline. The intersection between this line and the lower edge of the twelfth rib determines the level of the upper edge of L2 (see Chapter 21, Fig. 21.4b).

T12–L1 is located in the midline and joined with dots to the lower edge of the twelfth rib. This produces a triangle, the equal sides of which provide basic guidance for the needle direction (Fig. 22.3).

Skin prep, generous local anesthetic infiltration of the injection channel, covering with a sterile drape, drawing up the local anesthetic, checking the patency of the injection needle.

During the injection, the following points must be observed:

- In bilateral injections, it is advantageous to inject the left side first.
- For a diagnostic block, a bilateral injection is unnecessary.
- The operator performing the injection must stand on the side being blocked.
- In most patients, the distance between the skin and the celiac plexus is about 9–11 cm.
- Superficial bone contact (after 3–5 cm) indicates contact with the transverse process and requires correction.
- Paresthesias during the introduction of the needle arise due to stimulation of the lumbar somatic nerves.
- There is a risk of perforating the dural cuff (epidural or subarachnoid injection).
- If the patient coughs, it indicates pleural irritation or injury. The procedure should be halted.
- Aspirate frequently and inject on an incremental basis.
- The method of choice when administering neurolytics is CT guided injection.
Injection technique (dorsal, retrocrural)

About 7–8 cm lateral to the midline (lower edge of the twelfth rib), at an angle of 45° to the skin surface and directed slightly cranially, the injection needle is advanced toward the L1 vertebra (Fig. 22.4). Bone contact is usually made at a depth of about 7–9 cm (Figs. 22.5, 22.7).

The depth of the needle is marked visually.

The needle is withdrawn to lie subcutaneously.

The needle is then redirected at a steeper angle of 60° to the skin surface, so that it can just slide past the lateral edge of the L1 vertebra (Figs. 22.6, 22.7).

The needle introduced on the left (the side of the aorta) can then be carefully advanced a further 1.5–2 cm deeper. After the needle is positioned in the periaortic space, pulsations are transmitted via the needle shaft to the fingertips.

The needle introduced on the right side can be advanced in a similar fashion or slightly deeper (2–3 cm) (Figs. 22.7, 22.8).

The end of the needle must be observed for spontaneous backflow of liquid (blood, CSF, urine?).

Aspiration test at all four levels.

Test dose of the local anesthetic.

Resistance-free incremental injection of a local anesthetic.

It is now the standard procedure to carry out this injection with guidance using a radiographic image intensifier or computed tomography (CT).

Neurolytic block

Unilateral or bilateral injection of neurolytics (50% ethanol) in the region of the celiac plexus.
Celiac plexus block

A diagnostic block with local anesthetics is a prerequisite. This measure can only achieve the desired result if the disease is not too far advanced and is not producing additional neuropathic pain (e.g., extension to the epi-gastric nerves, intercostal nerves or lumbar plexus) [5].

**Effects of the block**
- Hyperthermia in the upper abdominal region (vascular dilatation in the splanchnic region).
- Increased intestinal motility.
- Pain reduction.

**Dosage**

*Diagnostic*
- 20–30 mL local anesthetic – e.g. 0.5–1% prilocaine, 0.5–1% mepivacaine, 0.5–1% lidocaine.

*Therapeutic*
- Local anesthetics
  - 20–30 mL local anesthetic – e.g. 0.375–0.5% ropivacaine, 0.25–0.375% bupivacaine.
  - A mixture with methylprednisolone is recommended in acute conditions.
- Neurolytics
  - 25–50 mL 50% ethanol in combination with 0.2% ropivacaine or 0.125% bupivacaine.
  - Some authors recommended prior administration of 5 mL 2% lidocaine to relieve the pain of the ethanol injection.

Fig. 22.6 Redirection of the needle at an angle of 60° to the skin surface.

Fig. 22.7 Path of the needle to the celiac plexus. Diagram: (a) contact with the L1 vertebra, (b) introduction of the needle at a steeper angle of 60° to the skin surface. (1) L1 vertebra, (2) aorta, (3) celiac plexus, (4) inferior vena cava.
Chapter 22

Side effects
Hypotension due to sympathetic block (caution in older patients).

Complications
Severe
Intravascular injections (aorta, vena cava, celiac artery, renal artery) with toxic reactions (see Chapter 6, p. 66).
Epidural or subarachnoid injection (see Chapter 36 and Chapter 41).
Pneumothorax.

Potential
Vascular injury (hemorrhage, retroperitoneal hematoma formation).
Injection into kidneys and other intra-abdominal organs.
Aortal pseudoaneurysm.
Abscess or cyst formation.
Intraosseous or psoas injection.

Complications of neurolytic block
Paraplegia [3, 15].
Monoparesis, with loss of sphincter function in the rectum and bladder.
Sexual dysfunction.
Diarrhea.
Retroperitoneal fibrosis.
Renal necrosis.
Chemical peritonitis [2].
Chemical pericarditis [12].
**Celiac plexus block**

**Block no.** □ Right □ Left

Name: __________________ Date: __________________

**Diagnosis:**

Premedication: □ No □ Yes

**Neurological abnormalities:** □ No □ Yes

**Purpose of block:** □ Diagnostic □ Therapeutic

Needle: G _______ Length _______ cm

i.v. access: □ Yes

**Monitoring:** □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

**Contraindications excluded:** □

Position: □ Prone □ Lateral recumbent

**Injection level:** □ L1

**Injection technique:** □ Dorsal □ Ventral □ X-ray image intensifier guidance

□ CT-guided

**Injection:**

Local anesthetic: ____________ mL __________% (in incremental doses)

Addition to LA: □ Yes □ No

Neurolytic: ____________ mL __________% (in incremental doses)

Addition: □ Yes □ No

**Patient's remarks during injection:**

□ None □ Paresthesias □ Warmth □ Pain

**Nerve area:**

**Objective block effect after 15 min:**

□ Cold test □ Temperature measurement before ______°C after ______°C

**Monitoring after block:** □ < 1 h □ > 1 h

**Time of discharge:** __________________

**Complications:**

□ None □ Intravascular injection □ Subarachnoid/epidural

□ Pneumothorax □ Drop in BP □ Nerve injury □ Other

**Subjective effects of the block:**

□ None □ Increased pain □ Reduced pain □ Relief of pain

**VISUAL ANALOG SCALE**

[Scale diagram]

**Duration:**

□ 0 □ 10 □ 20 □ 30 □ 40 □ 50 □ 60 □ 70 □ 80 □ 90 □ 100

**Special notes:**

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Lumbosacral region

**Definition**
Injection of a local anesthetic or a sclerosant solution along the ligamentous insertion points in the lumbosacral area.

**Anatomy (Fig. 23.1)**
The ligaments of the sacral and coccygeal region are very important, since they transfer the entire weight of the trunk via the hip bones to the lower extremities. This occurs through firm anchoring of the vertebrae, hip bones and sacrum. The pelvic girdle only has one ligamentous connection of its own, the obturator membrane of the hip bone. Ventrally, the connection between the two hip bones is created by the pubic symphysis. Dorsally, there are connections with the trunk or spinal column — with the sacrum and coccyx, as well as the lumbar spine, via the sacroiliac joint and a number of ligaments.

The **sacroiliac joint**
The articular bones are the sacrum, hip bone and iliac bone. The joint capsule is under firm tension and posteriorly its place is taken by the interosseous sacroiliac joint. The joint cavity is narrow and fissure-like. A number of ligaments are present as special features. The **direct strengthening ligaments** are the anterior sacroiliac ligament ventrally, and dorsally the posterior sacroiliac ligament and the interosseous sacroiliac ligament. The iliolumbar ligament, sacrospinous ligament and sacrotuberous ligament serve as **indirect strengthening ligaments**. The **anterior sacroiliac ligaments** are usually not particularly thick and lie on the pelvic side of the joint capsule. They run from the pelvic fascia of the sacrum to the iliac bone. The **posterior sacroiliac ligaments**, 1 cm thick, are anchored with their long fibers on the posterior superior iliac spine and the lateral parts of the third and fourth segments of the sacrum.

The **interosseous sacroiliac ligament** fills the deep cavity between the iliac tuberosity and the sacral tuberosity. The strongest ligament in this region, it is one of the body's thickest ligaments. The **iliolumbar ligament** originates, with its strong bands, from the transverse processes of the fourth and fifth lumbar vertebrae, radiating over the iliac crest and the neighboring parts of the anterior and posterior surfaces of the iliac bone. The **sacrotuberous ligament** is attached to the inferior surface of the ischial tuberosity and originates from the lateral margin of the sacrum and coccyx. It extends up as far as the posterior and superior inferior iliac spine. The **sacrospinous ligament** is shorter and thinner than the previous one and is connected to it. Its base is also attached to the lateral margin of the sacrum and coccyx, but its tip attaches to the ischial spine. The sacrotuberous ligament and sacrospinous ligament form an essential part of the pelvic diaphragm.

Fig. 23.1 Anatomy
(1) Posterior superior iliac spine, (2) iliolumbar ligament, (3) dorsal sacroiliac ligament, (4) sacrotuberous ligament, (5) sacrospinous ligament
Indications

Diagnostic
Differential diagnosis of various pain syndromes in the lumbosacral region.

Therapeutic
Pain in iliolumbosacral ligamentous insufficiency.

Block series
A series of six to eight blocks is recommended. When there is evidence of improvement in the symptoms, additional blocks can also be carried out.

Contraindications
Anticoagulant treatment.
Infections and skin diseases in the injection area.

Procedure

Full information for the patient is mandatory.

Preparations
Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access.

Materials (Fig. 23.2)
Fine 26-G needle, 25 mm long, for local anesthesia.
20–22-G needle, 70–80 mm long.
Syringes: 2 mL and 10 mL.
Local anesthetic, disinfectant, swabs, sterile gloves and flat, firm pillow.

Patient positioning
Prone position: pillow under the mid-abdomen (to eliminate lumbar lordosis). The patient’s arms are hanging.

Landmarks (Fig. 23.3)
Iliac crest line of L4.
The spinous process of the fifth lumbar vertebra is located about two fingerbreadths below the iliac crest line. The injection point is above the spinous process.

Injection targets (Fig. 23.4)
Transverse process of the fifth lumbar vertebra.
Dorsal cranial iliac spine.
Lateral edge of the caudal part of the sacral bone.

Skin prep, local anesthesia, drawing up the local anesthetic, testing the patency of the injection needle.
During the injection, the following points must be observed:

- The person carrying out the injection must stand on the opposite side to that being blocked.
- All insertions of the needle must be carried out from only one point.
- Elicit bone contact before injection.
- Aspirate before every injection.

**Injection technique**

_illiolumbar ligament_

The needle is introduced in the direction of the lateral part of the transverse process of the fifth lumbar vertebra, at an angle of 45° to the surface of the skin (Fig. 23.5).

Bone contact is made after about 4–6 cm; the needle is then withdrawn by 1 mm and, after aspiration, 1–2 mL of local anesthetic is administered.

The needle is then withdrawn to lie subcutaneously.

The needle is then reintroduced at an angle of ca. 30° in the direction of the iliac crest, which is marked on the outside by the operator’s index finger (Fig. 23.6).

After bone contact, the needle is withdrawn by 1 mm and after aspiration, 1 mL of local anesthetic is injected.

If bone contact is not made at this depth, correct the angle of the needle, either cranio-laterally or caudo-laterally.

_Sacroiliac, sacrotuberous and sacrospinous ligament_

The needle is withdrawn to lie subcutaneously.

The needle is reintroduced at an angle of 30° in the direction of the dorsal cranial iliac spine, which is marked on the outside by the operator’s index finger. After aspiration, 1 mL of local anesthetic is injected at two further points along the iliac spine.

The needle is withdrawn to lie subcutaneously once more and then reintroduced two or three times at an angle of 20° along the lower half of the sacrum. The lateral edge is infiltrated with 1 mL local anesthetic at each level (Fig. 23.7).

Pain may increase during the injection.
**Dosage**

*Diagnostic*
10–15 mL local anesthetic – e.g. 0.5–1% prilocaine, 0.5–1% mepivacaine.

*Therapeutic*
  - Unilateral block: 10 mL local anesthetic – e.g. 0.75% ropivacaine, 0.5% bupivacaine.
  - Bilateral block: 15 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.25–0.5% bupivacaine, distributed on both sides.

In acute cases, 4 mg dexamethasone can be added with benefit.

*Sclerosant solutions [4]*
- 6 mL 40% glucose + 4 mL 1% mepivacaine (1 mL per injection site)
- Barbor solution with local anesthetic:
  - Phenol crist. 2.0 vol%
  - Glucose monohydrate 27.5 vol%
  - Anhydrous glycerol 30.0 vol%
  - Methylene blue 1.0 vol%
  - Distilled water 39.5 vol%
- 6 mL Barbor solution + 4 mL 0.5% bupivacaine = 10 mL (1 mL per injection site)

Repeated injection of sclerosant solution shows no benefit in comparison with a block series with a local anesthetic.

**Complications**
Block of a lumbar somatic nerve, with accompanying motor weakness during the local anesthetic effect (prophylaxis: no injection without bone contact).
Monitoring is obligatory after the block. The patient should be supported by a nurse when first standing up and should first use the leg on the unblocked side.
Complications are extremely rare and occur mainly due to poor technique.
24 Ganglion impar (Walther ganglion) block

Definition
Injection of a local anesthetic or neurolytic into the region of the most inferior (unpaired) ganglion of the sympathetic trunk, on the ventral side of the sacrococcygeal joint.

Anatomy
At the level of the pelvic inlet, the lumbar part of the sympathetic trunk becomes the sacral part of the sympathetic trunk. This lies behind the parietal peritoneum and the rectum in the parietal pelvic fascia and on the ventral surface of the sacrum immediately medial to the sacral foramina, with the vessels and nerves that course through them. The sacral part of the sympathetic trunk (Fig. 24.1) consists of three (but sometimes four or five) sacral ganglia, which have connections with the contralateral ganglia. From the two (or three) cranial ganglia emerge (two or three) sacral splanchnic nerves, with efferent (usually postganglionic) and afferent fibers to the inferior hypogastric plexus. The two sacral sympathetic trunks approach closer to each other caudally and join to form the ganglion impar (Walther ganglion), which is located in front of the coccyx (Fig. 24.2). White rami communicantes are absent, but gray rami communicantes with postganglionic sympathetic fibers course from each of the sacral ganglia to the corresponding spinal nerves in the sacrococcygeal region. Along with branches of the sacrococcygeal plexus, these fibers reach vessels, sweat glands, erector muscles of the hair, cross-striated muscles, bones and joints.

Indications

Diagnostic
Differential diagnosis of pain in the anorectal and perineal region.

Prognostic
In cancer pain, before a neurolytic block.

Therapeutic
Pain conditions in the anorectal and perineal region. Injection of neurolytic agents as a palliative measure in malignant processes (rectum, cervix of the uterus, perineum, bladder, endometrium) [4–6].

Contraindications
Anticoagulant treatment.
Infections and skin diseases in the injection area.
Advanced rectal carcinoma (causing blockage of the access route to the ganglion impar).

Fig. 24.1 Sacral ganglia and sacral plexus. (1) Ganglion impar, (2) pudendal nerve, (3) prostatic plexus, (4) rectal plexus, (5) ventral part of the inferior hypogastric plexus, (6) sacral plexus, (7) ganglion of the sympathetic trunk, (8) lumbosacral ganglion of the sympathetic trunk
Procedure

This block should be carried out by very experienced anesthetists. Full information for the patient is mandatory.

Neurolytic agents should never be administered without precise localization of the needle position using radiographic guidance with an image intensifier. The method of choice is CT-guided injection.

Preparations

Check that the emergency equipment is complete and in working order; sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

Materials

A fine 26-G needle for local anesthesia. A stable 70–80-mm long 20–22-G needle. The needle shaft curves in a sickle shape (Fig. 24.3), so that the needle can pass atraumatically to the ventral surface of the sacroccocygeal joint.

Patient positioning

Prone, or alternatively lateral recumbent (see Chapter 47 on caudal anesthesia, p. 361).

Localization

Palpation of the tip of the coccyx or sacroccocygeal joint.

Disinfection, generous local anesthetic infiltration of the needle channel, covering with a sterile drape, drawing up the local anesthetic. The patency of the previously bent injection needle should be checked.

Fig. 24.2 Ganglion impar (Walther's ganglion). Ventral surface of the sacroccocygeal joint

Fig. 24.3 70–80-mm long 20–22-G needle. The needle shaft is bent to form a sickle shape
Injection technique
Approximately 3 cm laterally from the median sacral crest, thorough local anesthesia of the needle channel to a depth of ca. 3–4 cm is administered. After the onset of the local anesthetic effect, the sickle-shaped injection needle is introduced in a slightly cranial direction, toward the ventral surface of the sacrococcygeal joint (shown in Fig. 24.4a in a patient, Fig. 24.4b in the skeleton). After an intravascular position of the needle (aspiration of blood) has been excluded, as well as an intrarectal position (aspiration of air), and after aspiration, incremental injection of the local anesthetic is carried out.

Dosage
Diagnostic
5–10 mL local anesthetic – e.g. 1% prilocaine or 1% mepivacaine.

Therapeutic
- Local anesthetics:
  5–10 mL local anesthetic – e.g. ropivacaine
  0.2–0.375% mixed with 40 mg triamcinolone.
- Neurolytics:
  4–6 mL 10% phenol [4–6].

Complications
- Intravascular injection (see Chapter 6, p. 65).
- Rectal perforation.
- Subperiosteal position (becomes evident due to high resistance and severe pain during the injection).
- Needle breakage (strong needles should be used).
- Infection (sterile precautions).
### Ganglion impar block

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<th>Block no.</th>
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**Name:** ____________________  **Date:** ____________________  
**Diagnosis:** ____________________  
**Premedication:** □ No □ Yes  
**Neurological abnormalities:** □ No □ Yes  
**Purpose of block:** □ Diagnostic □ Therapeutic  
**Needle:** G ________ Length ________ cm, curved  
**i.v. access:** □ Yes  
**Monitoring:** □ ECG □ Pulse oximetry  
**Ventilation facilities:** □ Yes (equipment checked)  
**Emergency equipment (drugs):** □ Checked  
**Patient:** □ Informed  
**Contraindications excluded:** □  

**Position:** □ Prone □ Lateral recumbent  
**Injection level:** □ Sacrococcygeal joint  
**Injection technique:** □ X-ray image intensifier guidance □ CT-guided  
**Injection:**  
- Local anesthetic: ________ ml ________ %  
- Addition to LA: □ Yes □ No  
- Neurolytic: ________ ml ________ %  

**Patient's remarks during injection:** □ None □ Paresthesias □ Warmth □ Pain  
**Nerve area:** ________________________________________________________________  
**Objective block effect after 15 min:**  
- □ Cold test □ Temperature measurement before ________ °C after ________ °C  
**Monitoring after block:** □ < 1 h □ > 1 h  
**Time of discharge:** ____________________  

**Complications:** □ None □ Intravascular injection □ Subperiosteal position  
□ Rectal perforation □ Infection □ Coccygeal pain  

**Subjective effects of the block:**  
- □ None □ Increased pain □ Reduced pain □ Relief of pain  
**Duration:** ____________________  
**VISUAL ANALOG SCALE**  

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**Special notes:** ________________________________________________________________

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25 Infiltration of the piriform trigger points ("piriform syndrome")

Introduction

Activation of the trigger points in the piriform muscle ("double devil") and five other small external rotator muscles (the superior gemellus muscle, obturator internus muscle, inferior gemellus muscle, obturator externus muscle, and quadratus femoris muscle) and the resulting irritation of the neighboring nerves give rise to pain with a classic distribution pattern [14]. The name of the piriform muscle is derived from the Latin *pirum*, pear, and *forma*, shape. The muscle was named by the Flemish anatomist Adriaan van der Spieghel (Spigelius), who lived in the late sixteenth and early seventeenth centuries.

Anatomy

The piriform muscle, a thick, plump muscle, has its origin in the pelvis and anterior surface of the sacrum, between pelvic sacral foramina 1–4, and on the way to its insertion on the upper edge of the greater trochanter it passes through the greater sciatic foramen. This rigid opening is formed anteriorly and superiorly by the ilium, posteriorly by the sacrotuberal ligament, and inferiorly by the sacrospinal ligament (Fig. 25.1). The piriform muscle acts as an external rotator for the thigh and also supports abduction of the thigh. Its innervation is usually derived from the first and second sacral nerves. The neural structures in the greater sciatic foramen consist of: the superior gluteal nerve, sciatic nerve, pudendal nerve with the pudendal vessels, inferior gluteal nerve and the posterior cutaneous nerve of the thigh (Fig. 25.2). These nerves are jointly responsible for sensory-motor function of all the gluteal muscles, for sensory-motor function in the perineum, and for almost the whole of sensory-motor function in the posterior thigh and calf.

The most important blood vessels in this region are the superior gluteal artery and inferior gluteal artery.

Mechanism of pain

Numerous authors have recognized that contraction of the piriform muscle is capable of constricting the nerves and vessels that pass through the greater sciatic foramen.

The resulting inadequate blood supply to the muscle leads – due to accumulation of metabolic waste products that are normally disposed of by the circulating blood – to referred myofascial pain and often to blocking of the iliosacral joint.

Symptoms

Trigger points in the piriform muscle make a substantial contribution to complex myofascial pain syndromes in the area of the pelvis and hip. The piriform syndrome is often characterized by bizarre and initially apparently unconnected symptoms [11,14]. Patients report pain (and paresthesias) in the small of the back, groin, perineum, buttocks, hip, back of the thigh and calf, foot, and also in the rectum (during defecation) and in the area of the coccyx.

Some authors have suspected that contraction of the piriform muscle is an often overlooked cause of coccydynia [2,13]. Edwards described the syndrome as "neuritis of the branches of the sciatic nerve" [11], while Te Poorten suspected involvement of the peroneal nerve [11].

Fig. 25.1 Anatomy. (1) Greater sciatic foramen, (2) sacrospinal ligament, (3) sacrotuberal ligament, (4) lesser sciatic foramen
Swelling in the affected leg and disturbances of sexual function (dyspareunia in women and disturbances of potency in men) are very often present as accompanying symptoms.

Activation and provocation of trigger points in the piriform muscle can be initiated by the following factors: severe stress, trauma, prolonged immobility of the muscle, long car drives, chronic infections (pelvis, infectious sacroiliitis, arthritic hip), Morton’s anomaly in the foot, asymmetry in the body, etc. [14].

**Differential diagnoses** include: “post-laminectomy syndrome,” intervertebral disk prolapse, coccydynia, facet syndrome, spinal stenosis (bilateral pain), sacroilitis, malignant neoplasms, local infections, etc.

**Treatment** of this syndrome includes: therapeutic injections of local anesthetics and corticosteroids [2-5, 8, 10], botulinum toxin injection [16], osteopathic manipulation [10, 11], intermittent cooling and stretching [14], corrective measures [10, 11, 14], self-stretching [14], transrectal or transvaginal massage of the muscle [13], and finally surgical decompression [2, 11, 14].

**Procedure**

**Prior information for the patient is mandatory.**

**Preparations**

See Chapter 28, sciatic nerve block, p. 231.

**Materials**

- Nerve stimulator (e.g. Stimuplex® HNS 11, B. Braun Melsungen).
- 22-G Stimuplex D® needle (15°), 80 mm long, with an injection lead – “immobile needle” (B. Braun Melsungen).
- 22-G spinal needle 80 mm long.
- 2-mL, 10-mL, and 20-mL syringes.
- Local anesthetics, disinfectant, swabs, compresses, sterile gloves and drape.

**Technique**

**Positioning**

Figure 25.3 (see Chapter 28, p. 231).

**Landmarks**

The important landmarks are the greater trochanter and posterior superior iliac spine. From the mid-point of the line connecting these, a line is drawn in a medial direction and the injection site is marked at 5 cm (Fig. 25.3).
Injection technique

Transgluteal technique
The injection needle is introduced perpendicular to the skin (Fig. 25.4). Stimulation current starts at 1 mA at 2 Hz, with a stimulus duration of 0.1 ms. At a depth of ca. 6–8 cm, plantar flexion and dorsiflexion of the foot occurs in response to the stimulation of the tibial or perineal part of the sciatic nerve. The needle is then withdrawn slightly until the twitching completely disappears. After an aspiration test, injection of half of the planned amount of injection solution is carried out. The needle is then withdrawn to lie subcutaneously, and blindly advanced laterally in the direction of the greater trochanter in order to reach the muscle’s lateral trigger point. After aspiration, the rest of the solution is then injected.

Pace transgluteal technique
The trigger points in the piriform muscle are located by transrectal palpation. The palpating index finger of the left hand serves as a guide for the 80-mm long 22-G spinal needle, which is introduced in a dorsal and transgluteal position [10, 13]. Fan-shaped infiltration into the belly of the muscle is carried out. This method is usually painful for the patient.

Dosage [2–6, 10]
5–10 mL local anesthetic – e.g. 0.5% ropivacaine or 0.5% lidocaine.
5–10 mL 0.2% ropivacaine or 0.08–0.25% bupivacaine.
Mixture with 20–40 mg long-acting corticosteroid (e.g. long-acting methylprednisolone) is also recommended. Experience shows that long-acting local anesthetics do not provide any substantial advantages over short-acting local anesthetics [2, 6, 14]. It should be pointed out to the patient that spreading of the local anesthetic (particularly with a long-acting agent) in the region of the sciatic nerve can lead to the leg suddenly giving away later (note the information required for outpatients, see Chapter 26, p. 224).

Complications
See Chapter 28, p. 236.
Nerve injury (see Chapter 26, p. 225).
Injection of corticosteroid into the sciatic nerve must be avoided at all costs.
Intravascular injection (see Chapter 6).
CNS toxicity (see Chapters 1 and 6).
Infection.
Hematoma formation.
Perforation of the rectum (transgluteal technique after intrarectal palpation of the trigger points).
Lower extremity
These plexuses, closely related to one another, are formed by the ventral branches of the lumbar, sacral and coccygeal spinal nerves. The lumbar plexus lies in front of the transverse processes of the lumbar vertebrae. It mainly arises from the ventral branches, the first three lumbar nerves, most of the fourth lumbar nerve and the twelfth thoracic nerve (subcostal nerve).
The most important branches of the plexus are located in a fascial compartment that is enclosed ("sandwiched") by the quadratus lumborum, psoas major and iliacus muscles.
The first lumbar nerve, which contains a branch from the twelfth thoracic nerve, divides into an upper branch (iliohypogastric nerve and ilioinguinal nerve) and a lower branch (genitofemoral nerve).
Most of the second, third and parts of the fourth lumbar nerves form ventral and dorsal branches, from which the femoral nerve and obturator nerve branch off. The lateral femoral cutaneous nerve is formed from fibers of the dorsal branches of L2/L3.
The caudal parts of the ventral branches of L4 and L5 combine to form the lumbosacral trunk. Together with the ventral branches of the first three sacral nerves and the upper part of the ventral branch of the fourth sacral nerve, the lumbosacral trunk forms the sacral plexus, the largest branch of which is the sciatic nerve. The lumbar plexus is also connected with the lumbar part of the sympathetic nervous system via two or three long communicating branches.
The thickness of the ventral branches of the lumbar nerves increases markedly from the first to the fifth nerve (L1 has a diameter of ca. 2.5 mm, L2 is already ca. 4 mm, L3 and L4 are ca. 6 mm and L5 is as large as 7 mm).
The coccygeal plexus arises from the lower part of the ventral branches of the fourth and fifth sacral nerves, as well as the coccygeal nerves.
Anatomy: lumbar plexus, sacral plexus and coccygeal plexus.
(1) Lumbar plexus, (2) lumbosacral trunk, (3) sympathetic trunk, (4) sacral plexus, (5) lateral femoral cutaneous nerve, (6) femoral nerve, (7) obturator nerve, (8) iliohypogastric nerve, (9) ilioinguinal nerve, (10) subcostal nerve, (11) quadratus lumborum muscle, (12) psoas major muscle, (13) iliacus muscle, (14) genitofemoral nerve
Lumbar plexus blocks

26 Inguinal femoral paravascular block ("three-in-one" block)

Introduction

The concept underlying lumbar plexus blocks is that the course of the neural network from the transverse processes to the inguinal ligament lies within a perivascular and perineural space. Like the epidural space, this space limits the spread of the local anesthetic and conducts it to the various nerves.

Within the connective tissue and neural sheath, the concentration and volume of the local anesthetic determine the extent of the block's spread. Two techniques are described that belong to the standard methods for blocking the lumbar plexus:

The caudal (ventral) psoas compartment block ("three-in-one" inguinal femoral paravascular block).

The cranial (dorsal) psoas compartment block.

Definition

The "three-in-one" block is an infero–antero approach to the femoral nerve, lateral femoral cutaneous nerve and obturator nerve. These three nerves (Fig. 26.1) are blocked with a single injection into the common connective tissue and neural sheath (Fig. 26.2) immediately below the inguinal ligament.

A volume of at least 35–40 mL of local anesthetic is necessary to block all three nerves.

The success of the block depends directly on the amount of local anesthetic injected. To produce complete anesthesia in the leg, it should be combined with a sciatic nerve block (Figs. 26.7, 26.8).

Advantages

Suitable for postoperative or post-traumatic analgesia and for therapeutic blocks.

Suitable for patients in whom a unilateral block is desired – particularly in outpatient procedures.

Disadvantages

Success is unpredictable.

Larger amounts of local anesthetic are necessary (particularly if the sciatic nerve is also being blocked).

The likelihood of systemic toxicity is increased.

Longer onset times have to be expected (surgical indications).

Despite larger amounts of local anesthetic, not all nerves in the plexus are blocked (e.g. the lateral femoral cutaneous nerve).

For surgical procedures with ischemia or a tourniquet, neuraxial anesthesia is preferable.

Indications

Surgical

Superficial surgical interventions in the innervated area:

Wound care, skin grafts, muscle biopsies.

Blocking of the obturator reflex in transurethral prostate resection.

Analgesia for positioning for neuraxial block anesthesia in femoral neck fractures.

Performing surgical interventions in the area of the lower extremity in ischemia or tourniquet, in combination with sciatic nerve block.

Larger volumes of local anesthetic have to be used here (toxicity!).

Outpatient procedures.

Therapeutic

Postoperative pain therapy (e.g. after femoral neck, femoral shaft, tibial and patellar fractures, knee joint operations).

Post-traumatic pain.

Postoperative neurolysis or nerve reimplantations for better innervation.

Early mobilization after hip or knee joint operations.

Arterial occlusive disease and poor perfusion in the lower extremities.

Complex regional pain syndrome (CRPS) types I and II.
Inguinal femoral paravascular block ("three-in-one" block)

Postamputation pain.
Edema in the leg after radiotherapy.
Diabetic polyneuropathy.
Knee joint arthritis.
Elimination of adductor spasm in paraplegic patients.

Block series
A series of six to eight blocks is recommended. When there is evidence of improvement in the symptoms, additional blocks can also be carried out.

Prophylactic
Postoperative analgesia.
Prophylaxis against postamputation pain.
Prophylaxis against complex regional pain syndrome (CRPS).

Contraindications
Specific
Infections (e.g. osteomyelitis, pyoderma) or malignant diseases in the inguinal region.
Local hematoma.
Anticoagulant treatment.
Distorted anatomy (due to prior surgical interventions or trauma to the inguinal and thigh region).

Relative
The decision should be taken after carefully weighing up the risks and benefits:
Hemorrhagic diathesis.
Stable central nervous system disorders.
Local nerve injury (when it is difficult to determine whether the cause is surgical or anesthetic).
Contralateral nerve paresis.
Patients with a femoral bypass.

Procedure
This block should be carried out by experienced anesthetists, or under their supervision. Full information for the patient is mandatory.

Preparations
Check that the emergency equipment is complete and in working order. Sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

Materials (Fig. 26.3)
Fine 26-G needle, 25 mm long, for local anesthesia.
Nerve stimulator (e.g. Stimuplex® HNS 11, B. Braun Melsungen).

Fig. 26.1 Anatomy: femoral nerve, lateral femoral cutaneous nerve and obturator nerve. (1) Lateral femoral cutaneous nerve, (2) femoral nerve, (3) saphenous nerve, (4) obturator nerve, (5) psoas major muscle
Single-shot technique:
50 (80)-mm long atraumatic 22-G needle (15°) with injection lead (“immobile needle” – e.g. Stimuplex D®, B. Braun Melsungen).

Continuous technique:* 
Contiplex D® set: Contiplex® catheter 0.45 × 0.85 × 400 mm, with 18-G needle, 80 mm (15°), B. Braun Melsungen), or:
Contiplex®-Tuohy set: 52 (102)-mm long 18-G Tuohy needle with Contiplex® catheter.

Syringes: 2 and 20 mL.
Local anesthetics, disinfectant, swabs, compresses, sterile gloves and drape.

Patient positioning
Supine, with the thigh slightly abducted. The patient’s ipsilateral hand lies under the head. The person carrying out the injection must stand on the side being blocked.

Landmarks
The femoral artery is palpated 1–2 cm distal to the inguinal ligament. It is held between the spread index and middle finger. The injection point lies about 1–1.5 cm laterally.

Skin prep, subcutaneous local anesthesia, sterile drapes; draw up local anesthetic into 20-mL syringes, check patency of injection needles and functioning of nerve stimulator, attach electrodes.

Preliminary puncture with a large needle or stylet.

The quadriceps femoris muscle and the patella must be observed throughout the procedure.

Injection technique
Single injection technique
The injection is carried out in a cranial direction at an angle of about 30–40° to the skin surface, almost parallel to the course of the femoral artery. Stimulation current of 1–2 mA at 2 Hz is selected with a stimulus duration of 0.1 ms (Fig. 26.4).

The needle is advanced until contractions of the quadriceps femoris muscle and patellar movements become visible (“dancing patella”). Contractions of the sartorius muscle alone suggest incorrect positioning and are inadequate (Fig. 26.5).

* If technical difficulties arise, the catheter and Tuohy needle must always be removed simultaneously. A catheter must never be removed through the Tuohy needle (as the catheter may shear!).
Inguinal femoral paravascular block ("three-in-one" block)

**Do not** advance the needle further!
The stimulation current is reduced to 0.3 mA. Slight twitching suggests that the stimulation needle is in the immediate vicinity of the nerve.

**Aspiration test.**
Test dose of 3 mL local anesthetic (e.g. 1% prilocaine). During the injection, the twitching slowly disappears.

Incremental injection of a local anesthetic (injection–aspiration after each 3–4 mL).

After the injection, **compression massage** of the injection area is carried out and then **flexing of the thigh** for about 1 min (Fig. 26.6).

Careful cardiovascular monitoring.

The distribution of the anesthetic is indicated in Figure 26.7.

**Continuous technique**
The site is located in the same way as described for the unilateral technique. The injection is carried out about 2–2.5 cm below the inguinal ligament and 1–1.5 cm lateral to the femoral artery and in a cranial direction at an angle of about 30–40°.

Using the Seldinger technique, the catheter is advanced at least 10 cm deep into the fascial compartment.

An aspiration test, administration of a test dose, fixation of the catheter and placement of a bacterial filter then follow. After aspirating again, the local anesthetic is given on an incremental basis.

**Fig. 26.5** Note the contractions of the quadriceps femoris muscle and patellar movements. (1) Sartorius muscle, (2) rectus femoris muscle, (3) vastus lateralis muscle, (4) vastus medialis muscle

**Fig. 26.6** After the injection: flexing the thigh for about 1 min
Fig. 26.7 The neural areas most frequently blocked after administration of a “three-in-one” block

**Dosage**

**Surgical**

40–50 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

A combination of local anesthetics with longer-term and medium-term effect has proved particularly valuable for surgical indications – e.g. 1% prilocaine (20 mL) + 0.5–0.75% ropivacaine (20 mL) or 1% prilocaine (20 mL) + 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine; 20 mL).

**Therapeutic**

20 mL local anesthetic – e.g. 0.2–0.375% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

Important notes for outpatients

Long-lasting block can occur (even after administration of low-dose local anesthetics – e.g. 0.125% bupivacaine or 0.2% ropivacaine).

The blocked leg can give way even 10–18 hours after the injection.

The patient must therefore use walking aids during this period. The same rules apply to the treatment of post-amputation pain. During the period of effect of the local anesthetic, the patient should not wear a prosthesis.

A record must be kept of patient information and consent.

**Continuous technique**

**Test dose:** 3–5 mL 1% prilocaine (1% mepivacaine).

**Bolus administration:** 30 mL 0.5–0.75% ropivacaine or 0.25–0.5% bupivacaine.

**Maintenance dose:**

Intermittent administration:

15–20 mL of local anesthetic every 4–6 hours (0.5–0.75% ropivacaine or 0.25–0.5% bupivacaine) after a prior test dose.

Reduction of the dose and/or adjustment of the interval, depending on the clinical picture.

**Continuous infusion:**

Infusion of the local anesthetic via the catheter should be started 30–60 minutes after the bolus dose. A test dose is obligatory.

Ropivacaine: 0.2–0.375% 6–14 mL/h (max. 37.5 mg/h)

Levobupivacaine: 0.125–0.25% 8–15 mL/h

Bupivacaine: 0.125% 10–14 mL/h

Bupivacaine: 0.25% 8–10 mL/h

If necessary, the infusion can be supplemented with bolus doses of 5–10 mL 0.5–0.75% ropivacaine (0.25–0.5% bupivacaine or 0.25% levobupivacaine).

Individual adjustment of the dosage and period of treatment is essential.
Complications

Nerve injuries
Traumatic nerve injury is a rare complication of this technique. It can occur as a result of the use of sharp needles (due to nerve puncture), intraneural or microvascular injury (hematoma and its sequelae), prolonged ischemia, as well as toxic effects of intraneurally injected local anesthetic (see Chapter 9, p. n). Probable effects of intraneural injection include a transient neurological deficit (unexpected prolonged block, lasting up to 10 days) [6, 10]. A suspicion of intraneural needle positioning arises if there is strong twitching even at low levels of stimulation current (e.g., 0.2 mA) and if there is no cessation of the twitching after administration of the test dose. The local anesthetic may also be difficult to inject. Correction of the needle position is essential. (On prophylaxis, see Chapter 9, p. 111).

Intravascular injection (see Chapter 6, p. 65).
CNS intoxication (see Chapter 6, p. 66 and Chapter 1, p. 9).
Infection in the injection area (continuous techniques).
Hematoma formation (note the obligatory prophylactic compression).

Fig. 26.8 Comparison of the innervation areas of the femoral nerve, lateral femoral cutaneous nerve and obturator nerve (blue) with the innervation area of the sciatic nerve (red)
The psoas compartment block represents a cranial and dorsal paravertebral access route to the lumbar plexus. The concept is to block the closely juxtaposed branches of the lumbar plexus and parts of the sacral plexus by injecting local anesthetic through a high access route to the plexus (L4–L5). When the quality of the block is good, the area of distribution is comparable with that of the “three-in-one” block (see Chapter 26, Fig. 26.7). The following nerves are affected: lateral femoral cutaneous nerve, femoral nerve, genitofemoral nerve, obturator nerve, and parts of the sciatic and posterior femoral cutaneous nerve. A combination of this block with block of the sciatic nerve is necessary to achieve complete anesthesia of the lower extremity (see Chapter 26, Figs. 26.7, 26.8).

**Advantages**

- Better block quality in comparison with the “three-in-one” block.
- Suitable for patients in whom a unilateral block is desired, particularly in outpatient procedures.
- The method is suitable for postoperative and post-traumatic analgesia and for therapeutic blocks.

**Disadvantages**

- Success of the block is unpredictable.
- Larger quantities of local anesthetic are needed (particularly if the sciatic nerve is also being anesthetized).
- There is an increased likelihood of systemic toxicity.
- There is a potential risk of intrathecal or epidural injection.
- Slower onset must be expected (surgical indications).
- For surgical procedures with ischemia or tourniquet, neuraxial anesthesia is preferable.

**Indications**

**Surgical**

As a continuous or single-shot block for all surgical procedures in the region of the lower extremity, but in combination with a block of the sciatic nerve. A need for larger volumes of local anesthetics must be expected (toxicity!).

**Outpatient procedures**

- Postoperative and post-traumatic pain therapy.
- Early mobilization after hip and knee operations.
- Arterial occlusive disease and poor perfusion of the lower extremities.
- Complex regional pain syndrome (CRPS), types I and II.
- Post-surgical neurolysis or nerve reimplantations for better innervation.
- Edema after radiotherapy.
- Postamputation pain.
- Diabetic polyneuropathy.
- Tumors and metastases in the hip joint and pelvis.

**Block series**

A series of six to eight blocks is recommended. When there is evidence of improvement in the symptoms, additional blocks can also be carried out.

**Prophylactic**

- Postoperative analgesia.
- Prophylaxis against postamputation pain.
- Prophylaxis against complex regional pain syndrome.

**Contraindications**

**Specific**

- Infection or hematoma in the injection area.
- Anticoagulant treatment.
- Lesion in the nerves to be stimulated distal to the injection site.

**Relative**

- The decision should be taken after carefully weighing up the risks and benefits:
  - Hemorrhagic diathesis.
  - Stable systemic neurological diseases.
  - Local nerve injury (when there is doubt whether the fault lies with the surgeon or anesthesiologist).
  - Contralateral nerve paresis.

---

**27 Psoas compartment block (Cheyen approach)**
Procedure

This block should be carried out by experienced anesthetists, or under their supervision. Full information for the patient is mandatory.

Preparations

Check that the emergency equipment is complete and in working order. Sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

Materials (Fig. 27.1)

Fine 26-G needle, 25 mm long, for local anesthesia.

Electrostimulation technique:
Nerve stimulator (e.g. Stimuplex® HNS 11, B. Braun Melsungen).
120-mm long atraumatic 22-G needle (15°) with injection lead (“immobile needle” – e.g. Stimuplex D®, B. Braun Melsungen).

Loss-of-resistance technique:
120-mm (150-mm) long spinal needle, 20–22 G (e.g. Spinocan® 0.7–0.9 x 120 mm (150 mm), B. Braun Melsungen) and a smoothly moving 10-mL plastic or glass syringe.

Continuous technique*:
Contiplex®-Tuohy set: 1.3 x 102 (152) mm long 18-G Tuohy needle with Contiplex® catheter, or:
18-G (15°) Contiplex D® needle (1.3 x 110 mm with Contiplex® catheter, B. Braun Melsungen).

Syringes: 2 and 20 mL.
Local anesthetics, disinfectant, swabs, compresses, sterile gloves and drape.

Patient positioning

Lateral decubitus or sitting, as in the position for neuraxial anesthesia; legs drawn up, with the leg being blocked on top.

Landmarks

The iliac crest and the midline of the spinous process are located. From the intersection between these (L4 spinous process), a line is drawn 3 cm caudally, and from the end of it another line is drawn 5 cm laterally as far as the medial edge of the iliac crest, and marked as the injection point (Fig. 27.2).

Patient preparation

Skin prep, local anesthesia, sterile draping, drawing up the local anesthetic into 20-mL syringes, checking the patency of the injection needle and functioning of the nerve stimulator, attaching the electrodes.

Preliminary puncture with a large needle or stylet.

The quadriceps femoris muscle must be observed throughout the procedure (see Chapter 26, Fig. 26.5).
Injection technique

Electrostimulation technique

Introduce an electrostimulation needle perpendicu-
lar to the skin surface until bone contact is made
with the transverse process of L5 (Figs. 27.3, 27.5).
It is then withdrawn slightly and advanced further
cranially, past the transverse process (Figs. 27.4,
27.5).
Stimulation current of 1 mA at 2 Hz is selected with
a stimulus duration of 0.1 ms.
Advance the needle further until contractions of the
quadriiceps femoris muscle become visible.
Reduce the stimulation current to 0.3 mA. If con-
tractions of the muscle are still visible at this level of
current, the needle is in the correct position.
Aspiration test.
Test dose of 3–5 mL of a local anesthetic.
Incremental injection of a local anesthetic (injec-
tion–aspiration after each 3–4 mL).
Careful cardiovascular monitoring.

Loss-of-resistance technique

A 120-mm (150-mm) long 20-22-G spinal needle is
introduced perpendicularly until bone contact is
made with the transverse process of L5. After bone
contact, the needle is withdrawn slightly, as in the
paravertebral block, and then advanced in a cranial
direction past the transverse process as far as the
quadtratus lumbarum muscle.
Removal of the trochar and aspiration.
A 10-mL syringe filled with air or 0.9% saline is at-
tached.
The needle is slowly advanced with constant pres-
sure on the plunger.
After initial resistance from the surrounding muscle
mass, perforation of the muscle fascia occurs and
there is penetration into the fascial compartment
between the quadratus lumbarum muscle and the
psoas major muscle, characterized by “loss of resis-
tance.” Experience shows that this occurs at a
depth of about 12 ± 2 cm. Paresthesias are often,
but not always, elicited.
Once the psoas compartment has been reached,
10–20 mL of air is injected in order to dilate the
space.
Aspiration test.
Test dose of 3–5 mL of a local anesthetic.
Incremental injection of local anesthetic (injec-
tion–aspiration after each 3–4 mL).
The patient must remain in the same position for
about 5 min.
Precise cardiovascular monitoring.
Continuous technique
The Contiplex® catheter is advanced through the previously placed 18-G Tuohy–Contiplex® needle (or alternatively a 110-mm long (15°) Contiplex® D needle) ca. 5 cm deep into the fascial compartment.

Dosage
Surgical
40–50 mL local anesthetic – e.g. 1% prilocaine (20–30 mL) + 0.5–0.75% ropivacaine (20 mL); 1% prilocaine (20–30 mL) + 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine; 20 mL).

Therapeutic
30 mL local anesthetic – e.g. 0.2–0.375% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

Important notes for outpatients
See Chapter 26, p. 224.

Continuous
See Chapter 26, p. 224.

Complications
Nerve injury (extremely rare; see Chapter 26, p. 225).
Intravascular injection (see Chapter 6, p. 65).
CNS toxicity (see Chapter 6, p. 66 and Chapter 1, p. 9).
Subarachnoid or epidural injection (see Chapter 36 and Chapter 41).
Hematoma formation.
Intra-abdominal injuries.
Postinjection pain due to spasm in the lumbar paravertebral musculature.

Fig. 27.5 Diagram: (a) contact with the transverse process of L5; (b) the needle is advanced past the transverse process until contractions of the quadriceps femoris muscle become visible. (1) Erector spinae muscle, (2) quadratus lumborum muscle, (3) psoas muscle.
Definition
Block of the largest of the four nerves supplying the leg at the lower end of the lumbosacral plexus, after it exits from the greater sciatic foramen or infrapiriform foramen.

Anatomy (Fig. 28.1)
The sciatic nerve arises from the ventral branches of the spinal nerves from L4 to S3. Exiting from the pelvic cavity at the lower edge of the piriformis muscle (in about 2% of individuals, the nerve pierces the piriformis), its 16-20-mm thick trunk runs between the ischial tuberosity and the greater trochanter, turns downward over the gemelli, the obturator internus tendon and the quadratus femoris, which separate it from the hip joint, and leaves the buttock to enter the thigh beneath the lower border of the gluteus maximus.
Distal to this, the nerve lies on the posterior surface of the adductor magnus muscle, where it is covered by the flexor muscle originating from the ischial tuberosity and thus extends as far as the popliteal fossa. Here it lies slightly laterally and above the popliteal vein and artery, with thick popliteal fascia overlying it. At the proximal end of the popliteal fossa, the nerve usually divides into the thicker tibial nerve, which continues the trunk and the smaller common peroneal (fibular) nerve.
The sensory branches of the nerve innervate the dorsal thigh, the dorsolateral lower leg and lateral half of the foot, the hip and knee joint, as well as the femur. Its muscular branches are responsible for supplying the biceps femoris, semimembranosus, semitendinosus and adductor magnus muscles.

Indications
Surgical
Superficial procedures in the innervated area.
Carrying out surgical procedures in the region of the lower extremity under tourniquet, but in combination with a block of the lumbar plexus (“three-in-one” block or dorsal psas compartment block). A need for larger volumes of local anesthetics must be expected (toxicity!).

Fig. 28.1 Anatomy of the sciatic nerve.
(1) Sciatic nerve, (2) posterior femoral cutaneous nerve, (3) piriformis muscle, (4) tibial nerve, (5) common peroneal (fibular) nerve.
Sciatic nerve block

**Therapeutic**
An isolated block of the sciatic nerve is rarely indicated. A combination with block of the lumbar plexus or femoral nerve is recommended (see Chapters 26, 27 and 29).

**Block series**
A series of six to eight blocks is recommended. When there is evidence of improvement in the symptoms, additional blocks can also be carried out.

**Contraindications**

**Specific**
- Infection or hematoma in the injection area.
- Anticoagulant treatment.
- Lesion in the nerves to be blocked distal to the injection site.

**Relative**
The decision should be taken after carefully weighing up the risks and benefits:
- Hemorrhagic diathesis.
- Stable central nervous system diseases.
- Local nerve injury.

**Procedure**

This block should be carried out by experienced anesthetists, or under their supervision. Full prior information for the patient is mandatory.

**Preparations**

Check that the emergency equipment is complete and in working order. Sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

**Materials** (Fig. 28.2)
Nerve stimulator (e.g. Stimuplex HNS 11, B. Braun Melsungen).

**Single-shot technique:**
- Fine 26-G needle, 25 mm long, for local anesthesia.
- 80-mm long (120–150 mm for ventral access), atraumatic 22-G needle (15°) with injection lead ("immobile needle") – e.g. Stimuplex D®, B. Braun Melsungen).

**Continuous technique:**
- Contiplex®-Tuohy set: 102-mm long 18-G Tuohy needle with Contiplex® catheter.
- Contiplex D® set: 18-G Contiplex® needle (110 mm, 15°) with Contiplex® catheter.

**Syringes:** 2, 10 and 20 mL.
Local anesthetics, disinfectant, swabs, compresses, sterile gloves and drape.

**Classic dorsal transgluteal technique (Labat technique)**

**Patient positioning** (Fig. 28.3)
Lateral decubitus, with the leg being blocked on top (Sims position).
The upper leg is bent at the hip and knee joints and the upper knee lies on the table. The lower leg is straight.

**Landmarks** (Fig. 28.4)
The important landmarks are: the greater trochanter and posterior superior iliac spine (and/or sacral hiatus). The greater trochanter and posterior superior iliac spine are located. From the mid-point of the connecting line, a line is drawn medially and the injection point is marked at 5 cm (Labat line).
To check this, another line connecting the greater trochanter and the sacral hiatus is bisected (Winnie line). The two points should coincide.

Skin prep, local anesthesia, sterile draping, drawing up local anesthetic into a 20-mL syringe, checking patency of the injection needle and correct functioning of the nerve stimulator, attaching the electrodes.
Preliminary puncture with a large needle or stylet.

During the procedure, the biceps femoris, semimembranosus and semitendinosus muscles and the foot must be observed (Fig. 28.6).

Injection technique

**Electrostimulation**

- The injection needle is introduced perpendicular to the skin surface (Fig. 28.5).
- Stimulation current of 1 mA at 2 Hz is selected with a stimulus duration of 0.1 ms.
- After about 1–4 cm, there should be direct stimulation of the gluteus maximus muscle.
- At a depth of about 5 cm, contractions of the biceps femoris, semimembranosus and semitendinosus muscles are produced (Fig. 28.6).
- After the needle is advanced further, at a depth of about 6–8 cm there is plantar and dorsal flexion of the foot as a response to the stimulus from the tibial or peroneal part of the sciatic nerve.
- Do not advance the needle any further. The stimulation current is reduced to 0.3 mA. Slight twitching suggests that the needle is positioned in the immediate vicinity of the nerve.
- Aspiration test.
- Test dose of 3 mL local anesthetic (e.g. 1% prilocaine). During the injection, the twitching should slowly disappear.
- Incremental injection of a local anesthetic (injection-aspiration after each 3–4 mL).
- Careful cardiovascular monitoring.
- The area of anesthesia is shown in Figure 28.14.

**Eliciting paresthesias**

An atraumatic injection needle 80 mm long (rarely longer) is advanced using the technique described above until paresthesias are elicited that extend to the sole of the foot, or until bone contact is made, with subsequent correction of the needle direction. This technique is associated with a higher failure rate.

**Problem situations**

- Bone contact at a depth of 8 cm without visible twitching. The injection needle should be withdrawn and the direction should be altered laterally.
- Intraneural positioning:
  - The following signs suggest intraneural positioning of the injection needle:
    - Strong twitching (even at a stimulant current of 0.2 mA).
- No disappearance of the twitching during injection of a test dose.
- High resistance and severe pain during the injection.
  The injection must be stopped immediately and the needle must be withdrawn.

**Continuous technique**

The injection is carried out as in the single-shot technique.
An 18-G Tuohy needle 102 mm long or a Contiplex D® needle 110 mm long are usually used as stimulation needles. After correct stimulation and aspiration, a test dose is injected. The Contiplex® catheter is then advanced ca. 3 cm beyond the end of the container and the stimulation needle is slowly withdrawn while the thumb and index finger of the left hand simultaneously hold the catheter at the injection site. A bacterial filter is then placed and the catheter is fixed with a skin suture and dressing.

**Anterior approach**

**Patient positioning**
A supine position that is comfortable for the patient, with slight outward rotation of the leg being blocked.

**Landmarks**

Important landmarks are: the anterior superior iliac spine, pubic tubercle and greater trochanter. Two lines are drawn for orientation:
- A line connecting the anterior superior iliac spine with the pubic tubercle, which is marked into thirds.
- A second line parallel to the first, from the greater trochanter across the thigh.

A perpendicular line is drawn from the intersection of the medial and central third of the upper inguinal ligament line to the parallel line and marked as the injection point (Figs. 28.7, 28.8).

**Injection technique**

A 22-G (15°) atraumatic injection needle 120–150 mm long, with an injection lead, is advanced perpendicular to the skin until bone contact is made with the femur. The needle is then withdrawn slightly and introduced about 5 cm deeper, past the medial border of the femur.

The correct needle position is confirmed when paraesthesias or twitches are produced during electrostimulation. After aspiration and administration of a test dose, incremental injection of a local anesthetic is carried out.
Di Benedetto–Borghi subgluteal access route

Battista Borghi

The subgluteal block of the sciatic nerve has the advantage over the classic posterior transgluteal technique in that it is less stressful to the patient during the procedure, as the sciatic nerve has a more superficial course in the subgluteal region than in the gluteal region [4]. This access route also makes it easier to place and fix a catheter for postoperative analgesia.

Procedure

Patient positioning
Lateral decubitus, with the leg being blocked on top (Sims position; Fig. 28.3).

Landmarks
From the mid-point of a line connecting the greater trochanter and the ischial tuberosity, a second line is drawn to the upper edge of the popliteal fossa (known as the “sciatic line”). The injection site is located ca. 3–4 cm caudal to this (Fig. 28.9). If the patient is lying in the Sims position, for easier guidance one can palpate a groove along this line between the semitendinosus muscle and the biceps femoris muscle [4].

In this technique, the distance between the skin and the sciatic nerve is shorter (4.7 cm) than in Labat’s classic transgluteal access route (6.7 cm).
Preparations
Skin prep, local anesthesia, sterile draping, drawing up local anesthetic, checking the patency of the injection needle and correct functioning of the nerve stimulator, attaching the electrodes.

Injection
Preliminary puncture with a large needle or stylet.

During the procedure, the biceps femoris, semimembranosus and semitendinosus muscles and the foot must be observed.

An injection needle ca. 50 (80) mm long is introduced perpendicular to the skin (Fig. 28.10). Stimulation current is applied at 1–1.5 mA at 2 Hz with a stimulus duration 0.1 ms. At a depth of ca. 4 cm, plantar flexion and dorsiflexion of the foot occur in response to the stimulation of the tibial or peroneal parts of the sciatic nerve. The needle should not be advanced any further. The stimulation current is reduced to 0.3 mA. Slight twitching indicates that the stimulation needle is located in the immediate vicinity of the nerve. After an aspiration test, a test dose (e.g. 3 mL 1% prilocaine) is injected and incremental injection of the local anesthetic follows.

Continuous subgluteal block of the sciatic nerve
After skin prep, an adhesive sterile transparent drape with a hole is applied.

Materials
Contiplex®-Tuohy set: 52 (102) mm long 18-G Tuohy needle with a Contiplex® catheter, or
Contiplex D® set: 18-G Contiplex® needle 80–110 mm (15°) long with a Contiplex® catheter (B. Braun Melsungen).

Injection
The injection is carried out as in the single-shot technique. After injection of 5 mL 0.9% saline, the catheter is introduced through the already positioned needle. The catheter is advanced ca. 3–4 cm beyond the end of the needle or cannula (Fig. 28.11). After removal of the needle or cannula, fixing of the catheter and placement of a bacterial filter (Fig. 28.12), after careful aspiration and injection of a test dose, bolus administration of the local anesthetic is carried out (Fig. 28.13).
**Dosage**

**Surgical**

30–40 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

A combination of long-duration and medium-duration local anesthetics has proved particularly useful for surgical indications.

**Continuous administration**

0.2–0.375% ropivacaine, 5–15 mL/h (max. 37.5 mg/h)

Alternatively, as a bolus dose:

0.2–0.375% ropivacaine, 10–30 mL.

**Subgluteal access**

Patient-controlled analgesia (PCA) [4]: baseline rate of 4 mL/h 0.4% ropivacaine, 0.25% levobupivacaine, 0.25% bupivacaine.

Bolus dose of 2 mL.

Lockout time 10 min.

**Therapeutic**

10–20 mL local anesthetic – e.g. 0.2–0.375% ropivacaine, 0.125–0.25% bupivacaine.

**Important notes for outpatients**

See Chapter 26, p. 224.

**Complications**

Complications are rare, but possible:

- Nerve injury (see Chapter 9, p. 112 and Chapter 26, p. 225).
- Intravascular injection (see Chapter 6, p. 65).
- CNS toxicity (see Chapter 6, p. 66 and Chapter 1, p. 9).
- Infection in the area of the injection.
- Hematoma formation.
# Lumbosacral Plexus and Individual Nerves in the Plexus

<table>
<thead>
<tr>
<th>Block no.</th>
<th>Right</th>
<th>Left</th>
</tr>
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<tbody>
<tr>
<td>Name:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td></td>
<td></td>
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<tr>
<td>Diagnosis:</td>
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<td></td>
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<tr>
<td>Premedication:</td>
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<tr>
<td>Neurological abnormalities:</td>
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<td>Purpose of block:</td>
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<td>Needle: G ____ Length ____ cm</td>
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<td>30°</td>
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<td>i.v. access:</td>
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<tr>
<td>Monitoring:</td>
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<td>Ventilation facilities:</td>
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<tr>
<td>Emergency equipment (drugs):</td>
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<td>Patient:</td>
<td>Informed (behavior after block)</td>
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<td>Position:</td>
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<td>Injection:</td>
<td>Inguinal „3-in-one“ block</td>
<td>Dorsal psoas compartment block</td>
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<td>Sciatric nerve</td>
<td>Femoral nerve</td>
<td>Lateral cutaneous nerve of thigh</td>
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<tr>
<td>Obturator nerve</td>
<td>Ilioinguinal nerve/hypogastric nerve</td>
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<td>Location technique:</td>
<td>Electrostimulation</td>
<td>Paresthesias</td>
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<td>Femoral nerve</td>
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<td>Ilioinguinal nerve/hypogastric nerve</td>
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<td>Addition to LA</td>
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<td>Hematoma</td>
<td>Neurological complications</td>
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<td>VISUAL ANALOG SCALE</td>
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Blocking individual nerves in the lumbar plexus

29 Femoral nerve

Definition
Block of the largest nerve emerging from the lumbar plexus below the inguinal ligament.

Anatomy (Fig. 29.1)

The nerve, which is about 12 mm wide, arises from the ventral branches of the spinal nerves from L2–L4, runs through the psoas major muscle and the iliacus muscle and reaches the thigh behind the inguinal ligament. Above the inguinal ligament, the femoral nerve is located in a fascial compartment, which is surrounded by the iliac fascia laterally, the psoas fascia medially and the transversalis fascia ventrally. After passing the inguinal ligament, the nerve continues dorsolateral to the iliofemoral fascia, ventral to the inguinal ligament and fascia lata and medial to the iliopsoas fascia. Four to five centimeters below the inguinal ligament, the nerve divides into an anterior, mainly sensory, branch and a posterior, mainly motor one. Its largest sensory branch is the saphenous nerve, which separates from it in the femoral triangle. The femoral nerve provides the sensory supply to the upper thigh and shares in the innervation of the hip and knee joints as well as of the femur. Its sensory end branch, the saphenous nerve, innervates the medioventral lower leg and the medial half of the foot. Its muscular branches supply the pectineus, sartorius and quadriceps femoris muscles (see Chapter 26, Fig. 26.1).

Indications
See Chapter 26, p. 220.

Surgical
Superficial surgical procedures in the area of innervation, usually in combination with block of the neighboring lumbar plexus nerves or the sciatic nerve.

Therapeutic
Excellent results can be achieved with combined block of the femoral nerve and sciatic nerve (block series), particularly in:
- Postamputation pain.
- Complex regional pain syndrome (CRPS), types 1 and 2 (see case report, p. 240).
- In addition in perfusion problems of the lower extremity, arterial occlusive disease (caution in patients with a femoral bypass), polyneuropathies, arthrosis of the knee joint, etc.

Fig. 29.1 Anatomy
Contraindications
See Chapter 26, p. 221.

Procedure
Full prior information for the patient is mandatory.

Preparations
See Chapter 26, p. 221.

Materials (Fig. 29.2)
Fine 26-G needle 25 mm long, for local anesthesia.
Atraumatic 23–25-G needle (15°), 40 mm long, with
injection lead (“immobile needle” – e.g. Stimuplex D®,
B. Braun Melsungen).
Syringes: 2, 10 and 20 mL.
Local anesthetics, disinfectant, swabs, compresses, sterile
gloves and drape.

Patient positioning
Supine, with the thigh slightly abducted, with the ipsi-
lateral hand under the head.

Landmarks
The femoral artery is palpated 1–2 cm distal to the
inguinal ligament. It is held between the spread in-
dex finger and middle finger. The injection site is lo-
cated about 1–1.5 cm lateral to this. The person per-
forming the injection stands on the side being in-
jected.

Skin prep, subcutaneous local anesthesia, covering
with a sterile drape, drawing up the local anesthetic in-
to a 10-mL or 20-mL syringe, checking the patency of
the injection needle and correct functioning of the
nerve stimulator, attaching the electrodes.

Injection technique
After a preliminary puncture, the injection needle is
introduced perpendicular to the skin surface, with the
femoral artery being pushed in a medial direction by
the palpating finger (Fig. 29.3). The femoral nerve is lo-
cated at a depth of ca. 2–3 cm. Producing paresthesias
is helpful, but not obligatory.
After aspiration and administration of a test dose, in-
cremental injection of a local anesthetic is carried out.
If no paresthesias are produced, some of the local anes-
thetic is injected lateral to the artery in a fan-shaped
fashion. The onset of effect is slow. A successful block
is indicated if the patient is unable to extend the leg
(Fig. 29.4).
It is helpful to use a nerve stimulator, as this allows a
more targeted location of the nerve.
The distribution of anesthesia is shown in Fig. 29.5.
Dosage

Surgical
30 mL local anesthetic – e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

Therapeutic

Single block of the femoral nerve:
10–15 mL local anesthetic – e.g. 0.2% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

In combination with a sciatic nerve block:
Femoral nerve: 5–8 mL local anesthetic.
Sciatic nerve: 8–10 mL local anesthetic – e.g. 0.2–0.375% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

Important notes for outpatients
See Chapter 26, p. 224.

Complications
See Chapter 26, p. 225.

Example case
Patient W.W. aged 54, with a four-month history.
The following symptoms developed after an Achilles tendon strain:
Livid soft-tissue swelling in the area of the left foot and ankle joint, with sensitivity to touch and severe pain, resistant to treatment.
Radiography showed osteoporosis, with thinning of cortical bone.
Investigations indicated a diagnosis of Sudeck’s atrophy (CRPS).
Prior treatment with calcitonin, cortisone, NSAIDs and opioids had not led to any relief of the symptoms.

Start of treatment, 4 August 1994 (Fig. 29.6)
A series of blocks [19] of the femoral nerve and sciatic nerve with 0.5% bupivacaine, each 25 mL (femoral nerve 15 mL, sciatic nerve 10 mL).

End of treatment, 24 October 1994 (Fig. 29.7)
Complete resolution of the symptoms.
**Definition**
Block of this sensory nerve as it emerges from the lumbar plexus below the lateral inguinal ligament.

**Anatomy (Fig. 30.1)**

The lateral cutaneous femoral nerve arises from the ventral branches of the L2 and L3 spinal nerves, passing lateral to the psoas muscle and then to the iliacus muscle. Covered by the iliac fascia, it then runs to the region of the anterior superior iliac spine. It passes under the inguinal ligament and under the deep circumflex iliac artery, and enters the thigh, where it lies under the superficial sheet of the fascia and divides into a thicker descending branch and a smaller posterior branch, which penetrate the fascia separately. The posterior branch runs posteriorly over the tensor fascia lata muscle and reaches the gluteal region. The anterior branch runs 3–5 cm below the inguinal ligament, then downwards along the anterior surface of the vastus lateralis muscle as far as the lateral knee area, where it sends off lateral branches (see Chapter 26, Fig. 26.1).

**Indications**

**Surgical**
Mainly for relief of tourniquet pain in combination with block of the neighboring nerves from the lumbar plexus and of the sciatic nerve.

**Diagnostic**
Differentiation of various neuralgias in the thigh region.

**Therapeutic (block series)**
Meralgia paraesthetica.

**Contraindications**
Infection at the injection site.

**Procedure**
Full prior information for the patient is mandatory.

**Preparations**
See Chapter 26, p. 221.

**Materials (Fig. 30.2)**
Fine 26-G needle 25 mm long, for local anesthesia.
40 mm long, atraumatic 25-G needle (15°) with injection lead ("immobile needle" – e.g. Stimuplex D®, B. Braun Melsungen).
Syringes: 2, 5, and 10 mL.
Local anesthetic, disinfectant, swabs, sterile gloves, drape.

Patient positioning
Supine, with the ipsilateral hand under the head.

Landmarks
The anterior superior iliac spine is palpated. The injection point lies about 2.5 cm medial and 2.5 cm caudal to it. The person carrying out the injection stands on the side being injected.

Skin prep, subcutaneous local anesthesia, drawing up the local anesthetic, checking the patency of the injection needle and correct functioning of the nerve stimulator if used, attaching the electrodes.

Injection technique (Fig. 30.3)
The injection needle is introduced slowly and perpendicularly in the direction of the fascia lata, penetration of which is recognized by loss of resistance or “fascial clicks.” Paresthesias are not elicited. Fan-shaped injection of the local anesthetic is carried out medially and laterally, subfascially as far as the ilium and also subcutaneously when withdrawing the needle.

When the electrostimulation technique is used, stimulation of the sensory nerve fibers is produced with a stimulus duration of 0.1 ms. Cooperation on the part of the patient is a prerequisite for this technique.

The distribution of the block is shown in Fig. 30.4.

Dosage

Surgical
10–15 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

Therapeutic (block series)
5–10 mL local anesthetic – e.g. 0.2% ropivacaine, 0.125–0.25% bupivacaine (0.125–0.25% levobupivacaine).

Complications
No specific complications.
31 Obturator nerve

Definition
Block of the nerve emerging from the lumbar plexus in the obturator canal.

Anatomy (Fig. 31.1)

The obturator nerve arises from the ventral branches of the L2-L4 spinal nerves. The trunk runs downwards along the medial edge of the psoas muscle, passing behind the common iliac vessels to reach the pelvis and the obturator canal. Within the canal, it divides into its two end branches – the anterior and posterior branches. It provides the motor supply for the obturator externus muscle and the adductors of the thigh, sends off branches to the hip and knee joints and to the femur, and provides the sensory supply for a highly variable cutaneous area on the inside of the thigh and lower leg.

Indications

Surgical
For procedures in the knee joint and above the knee joint, as well as in urological surgery, particularly for resections of bladder tumors in combination with blocks of neighboring nerves from the lumbar plexus and of the sciatic nerve.

Diagnostic
Localization of hip joint pain.

Therapeutic
Hip joint pain and elimination of adductor spasm.

Contraindications
Infection in the injection area.

Procedure

Full prior information for the patient is mandatory.

Preparations
See Chapter 26, p. 221.

Materials (Fig. 31.2)
Fine 26-G needle, 2.5 cm long, for local anesthesia. 50 (80 mm long, atraumatic 22-G needle (15°) with injection lead (“immobile needle” – e.g. Stimuplex D®, B. Braun Melsungen), or an 80-mm long, 22-G spinal needle. Nerve stimulator (e.g. Stimuplex® HNS 11, B. Braun Melsungen). Syringes: 2, 10 and 20 mL. Local anesthetics, disinfectant, swabs, sterile gloves and drape.
Patient positioning
Supine, with slight abduction of the leg being blocked. The patient’s ipsilateral hand is under the head.

Landmarks
Anterior superior iliac spine, pubic tubercle. The pubic tubercle is located. The injection site lies about 1.5 cm lateral and 1.5 cm caudal to it.

Skin prep, local anesthesia, drawing up local anesthetic, checking patency of injection needle and correct functioning of the nerve stimulator, attaching electrodes.

The genitalia must be protected during skin prep.

Injection technique
The injection needle is introduced perpendicular to the skin. At a depth of about 1.5–4 cm (depending on the anatomy), bone contact is made with the upper part of the inferior branch of the pubic bone. This depth is marked (Fig. 31.3a, b). The needle is then withdrawn and advanced in a lateral and slightly caudal direction, close beneath the upper part of the pubic bone (Fig. 31.4a, b). Entry into the obturator canal takes place after the needle has been advanced about 2–3 cm deeper than the position marked after bone contact with the lower part of the pubic bone. Paresthesias are not produced.

When a nerve stimulator is being used, correct needle positioning is indicated when slight adductor twitches become visible after reduction of the stimulation current from 1 mA to 0.3 mA.

Aspiration test.
Injection of a local anesthetic is carried out on an incremental basis and in a fan shape (injection–aspiration).

Success of the block depends directly on the amount of local anesthetic injected. A successful block is characterized by restricted adduction in the thigh.

Fig. 31.2 Materials
Fig. 31.3a, b Bone contact with the inferior branch of the pubic bone. a In the skeleton, b in the patient
Disadvantage
This technique is not easy to perform and the success rate is variable.

The distribution of anesthesia (very variable) is shown in Fig. 31.5.

Dosage
10–15 mL local anesthetic – e.g. 0.375–0.5% ropivacaine, 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

Complications
Complications are very rare, but possible:
- Intravascular injection (the injection area is very well vascularized; see Chapter 6, p. 65).
- Hematoma formation.
- Puncture of or injury to the vagina or bladder.
**Definition**
Block of these two neighboring nerves originating from the upper part of the lumbar plexus.

**Anatomy (Fig. 32.1)**

The ilioinguinal and iliohypogastric nerves arise from the upper branch of the first lumbar nerve in the lumbar plexus; the genitofemoral nerve is formed from the lower branch of the first lumbar nerve and from a small branch of the second lumbar nerve. These three nerves run parallel to the intercostal nerves, and participate in the innervation of the transversus and obliquus abdominis muscles.

The *ilioinguinal nerve* penetrates the internal oblique muscle at the level of the anterior superior iliac spine, and runs between this and the external oblique muscle in the direction of the inguinal ligament and the canal around the skin of the mons pubis, the scrotum (or labia majora in women) and the adjoining part of the femoral triangle.

The lateral cutaneous branch of the *iliohypogastric nerve* innervates the skin of the anterolateral part of the gluteal region, and ends in its anterior branch above the pubic bone.

The *genitofemoral nerve* passes through the psoas major muscle and divides into a genital branch and a femoral branch.

**Indications**

*Surgical*
- As an important part of field block in the inguinal region when carrying out herniorrhaphy.

*Therapeutic*
- Scar pain after herniorrhaphy.
- Post-herpetic neuralgia.

**Contraindications**
None.

*Fig. 32.1 Anatomy.*
(1) Iliohypogastric nerve, (2) ilioinguinal nerve, (3) genitofemoral nerve (femoral branch), (4) genitofemoral nerve (genital branch)
Procedure

Full prior information for the patient is mandatory.

Preparations
See Chapter 26, p. 221.

Materials (Fig. 32.2)
40–50 mm long injection needle, 23–25 G. When a nerve stimulator is used, a 35–50 mm long atraumatic 22-G needle (15°) with an injection lead (e.g. Stimuplex D, B. Braun Melsungen).
Syringes: 2, 5, and 10 mL.
Local anesthetics, antiseptic, swabs, sterile gloves and drape.

Patient positioning
Supine, with the ipsilateral hand under the head.

Landmarks
A line is drawn connecting the anterior superior iliac spine and the umbilicus.
The injection site is located about 3 cm medial to the iliac spine on this line (Fig. 32.3).

Skin prep, subcutaneous local anesthesia, covering with a sterile drape, drawing up the local anesthetic.

Injection technique
The injection needle is introduced perpendicular and then slightly laterally until bone contact is made with the wing of the ilium. It is then withdrawn slightly, and after aspiration ca. 5 mL of the local anesthetic is injected.
The needle is then withdrawn to lie subcutaneously, and the direction is altered medially along the connecting line until there is penetration of the fascia of the external oblique muscle and internal and transverse oblique muscles.
After aspiration, fan-shaped injection of 10 mL of local anesthetic.

The cutaneous innervation of the ilioinguinal region is shown in Fig. 32.4.

Dosage
10–15 mL local anesthetic – e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

Complications
None.
In the distal part of the thigh, the **sciatic nerve** divides into the **tibial nerve**, which runs medially and straight, and a lateral branch, the **common peroneal (fibular) nerve**. A third nerve in the area of the knee joint, the **saphenous nerve**, is the largest and thickest branch of the **femoral nerve**.

**Sciatic nerve area**

**Tibial nerve** (Figs. 33.1, 33.3)

Almost twice as thick as the common peroneal nerve, the tibial nerve is the continuation of the sciatic nerve, running down through the middle of the popliteal fossa and lying posterior and slightly lateral to the popliteal vessels.

It then passes between the two heads of the gastrocnemius muscle to the upper edge of the soleus muscle. Between the posterior tibial muscle and the soleus muscle, it runs distally together with the posterior tibial artery through the calf musculature, as far as the midpoint between the medial malleolus and the calcaneus, to the medial side of the foot joint.

It divides into its two end branches, the medial and lateral plantar nerves, behind the medial malleolus. These pass under the flexor retinaculum to the sole of the foot and provide it with its sensory innervation. While in proximity to the common peroneal nerve as part of the sciatic nerve, it gives off branches to the obturator internus muscle, gemelli muscles, quadratus femoris muscle, semitendinosus muscle, semimembranosus muscle, adductor magnus muscle and long head of the biceps.

**Common peroneal (fibular) nerve** (Figs. 33.2, 33.3)

After separating from the tibial nerve, the common peroneal nerve runs along the medial edge of the biceps femoris muscle over the lateral head of the gastrocnemius muscle to the lateral angle of the popliteal fossa. At the neck of the fibula, it passes to the lateral surface of the bone. Before entering the peroneus longus muscle, which originates here, it divides into the mainly sensory superficial peroneal nerve and the mainly motor deep peroneal nerve.

Up to the point at which it divides, its small branches supply the short head of the biceps femoris muscle, the lateral and posterior parts of the joint capsule and the tibiofibular joint, and it gives off the lateral sural cutaneous nerve. The anterior branch of this runs subcutaneously to the lateral surface of the lower leg as far as the lateral malleolus, and its posterior branch runs subfasically and then subcutaneously until it unites with the medial sural cutaneous nerve from the tibial nerve.
Area supplied by the femoral nerve

Saphenous nerve (Fig. 33.4)
The wholly sensory saphenous nerve is the longest branch of the femoral nerve (see Chapter 26, Fig. 26.1). It forms the continuation of the posterior trunk, and in the thigh it lies initially on the lateral surface and, further down, on the anterior surface of the femoral artery. Along with the femoral vessels, it enters the adductor canal and penetrates its anterior wall and, covered by the sartorius muscle, runs between the vastus medialis muscle and adductor magnus muscle to the medial side of the knee. Here, at the tendon of the sartorius muscle, it passes to lie below the skin and runs up to the great saphenous vein, then down subcutaneously alongside this vein in the lower leg. Its terminal nerves supply the skin on the medial edge of the foot and medial malleolus. One branch connects with the superficial peroneal nerve in the ankle. Apart from a branch to the knee joint, it also gives off the infrapatellar branch to the skin on the medial side of the knee as far as the anterior surface of the patella, and the medial crural cutaneous nerves, which supply the skin over the medial surface of the tibia and the medial calf skin.

Indications

Surgical

Procedures on the lower leg (including those performed under tourniquet) using combined blocks of all three nerves, or superficial procedures in the region of the individual nerves, without using a tourniquet.

Particularly suitable for outpatient procedures.

Postoperative pain therapy.

Supplementation of incomplete epidural anesthesia or incomplete block of the sciatic or femoral nerves.

Care must be taken to avoid nerve injury, as paresthesias are not available as a warning signal (see Chapter 9, section on axillary block, and Chapter 26).
Contraindications
Lesions of the nerves being blocked distal to the injection site.
Anticoagulant therapy.
Infection in the injection area.

Procedure
Full prior information for the patient is mandatory.

Preparations
Check that the emergency equipment is complete and in working order. Sterile precautions, intravenous access, ECG monitoring, pulse oximetry, intubation kit, ventilation facilities, emergency medication.

Materials (Fig. 33.5)
Continuous technique for postoperative analgesia:
Contiplex® set: 18-G Contiplex® needle 55 (80) mm long (15°) with Contiplex® catheter, or:
Contiplex®–Tuohy set: 18-G Tuohy needle 52 (102) mm long with Contiplex® catheter.
Syringes: 2, 10 and 20 mL.
Local anesthetics, disinfectant, swabs, compresses, sterile gloves and drape.

Simultaneous block of the tibial and common peroneal (fibular) nerve in the popliteal area (distal sciatic nerve block)

Popliteal fossa (Fig. 33.6)
The caudal boundary of the popliteal fossa is determined medially and laterally by the gastrocnemius muscle, craniomedially by the semimembranosus and semitendinosus muscles and craniolaterally by the biceps femoris muscle. The two nerves lie superficially and are located at a depth of about 1.5–2 cm.

Patient positioning
Prone, with the treated leg stretched out. The person carrying out the injection stands on the side being injected.

Landmarks
The popliteal fossa is divided into a medial and a lateral triangle, the base of which is represented by the intercondylar line between the lateral and medial epicondyles. The midpoint of the base is marked, and from there a line is drawn 5 cm proximally and then 1 cm laterally. This point determines the injection site (Fig. 33.7).
Skin prep, local anesthesia, covering with a sterile drape, drawing up the local anesthetic, checking the patency of the injection needle and the functioning of the nerve stimulator, attaching electrodes.

**Injection technique (Fig. 33.7)**
The injection needle is advanced at an angle of 45–60° and in an anterosuperior direction. After paresthesias have been produced at a depth of about 1.5–2 cm, incremental injection of a local anesthetic is carried out after aspiration.

When a nerve stimulator is used, either plantar flexion (as a motor response from the tibial nerve) or plantar dorsiflexion (common peroneal nerve) are sought.

After removal of the needle, better distribution of the local anesthetic is encouraged with pressure compression (3–5 min) and simultaneous massaging of the injection area. This also serves for hematoma prophylaxis.

**Continuous technique**
The injection is carried out as in the single-shot technique. After correct stimulation and aspiration, a test dose is injected. The Contiplex® catheter is then advanced ca. 2–3 cm beyond the end of the needle or cannula and the stimulation needle is slowly withdrawn while the thumb and index finger of the left hand simultaneously hold the catheter at the injection site.

A bacterial filter is then placed and the catheter is fixed with a skin suture and dressing.

**Dosage**

Single-shot technique:
- 35–40 mL local anesthetic – e.g. 0.5–0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.
- A combination of long-duration and medium-duration local anesthetics has proved particularly suitable for surgical indications.

Continuous technique:
- 0.2–0.375% ropivacaine, 5–15 mL/h (max. 37.5 mg/h), or alternatively for bolus administration: 10–20 mL 0.2–0.375% ropivacaine.
- Patient-controlled analgesia (PCA): Baseline rate of 4–5 mL/h 0.375% ropivacaine (max. 37.5 mg/h).
- Bolus dose of 2–3 mL 0.375% ropivacaine.
- Lockout period of 10 min.
Complications
Complications are extremely rare, but possible:
- Neuritis and dysesthesia.
- Intravascular injection.
- Hematoma formation.

Tibial nerve block

Patient positioning
Prone, with the treated leg stretched out. The person carrying out the injection stands on the side being injected.

Landmarks
Popliteal fossa. The center of the connecting line between the lateral and medial epicondyles determines the injection point.

Injection technique (Fig. 33.8)
The injection needle is introduced perpendicular to the skin until paresthesias are produced. This normally occurs at a depth of about 1.5–3 cm. When a nerve stimulator is used, plantar flexion is noted as a motor response. After aspiration at two levels, incremental injection of local anesthetic is carried out.

Dosage
5–10 mL of local anesthetic - e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

Complications
See the section on simultaneous block of the tibial and common peroneal (fibular) nerves in the popliteal area, above.

Block of the common peroneal (fibular) nerve

Patient positioning
Supine, with the treated leg positioned at a slight angle. The person carrying out the injection stands on the side being injected.

Landmarks
Head of the fibula, tendon of the biceps femoris muscle. The head of the fibula is palpated. The injection point lies about 2 cm below the head of the fibula.

Injection technique (Fig. 33.9)
The injection needle is advanced perpendicularly until paresthesias are produced at a depth of about 1 cm. When a nerve stimulator is used, plantar dorsiflexion is noted as a motor response. After aspiration at two levels, incremental injection of the local anesthetic is carried out behind the head of the fibula.

Dosage
5–10 mL of local anesthetic - e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.
Complications
See the section on simultaneous block of the tibial and common peroneal (fibular) nerves in the popliteal area, p. 252.

Saphenous nerve block

Patient positioning
Supine, with the treated leg positioned at a slight angle.

Landmarks
Medial condyle of the tibia, tibial tuberosity, gastrocnemius muscle.

Injection technique (Fig. 33.10)
The medial condyle of the tibia is palpated. Distal to this, a continuous subcutaneous infiltration of the following areas is carried out: medial condyle, tibial tuberosity and gastrocnemius muscle.

Dosage
5–10 mL of local anesthetic – e.g. 0.75% ropivacaine, 0.5% bupivacaine (0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

Complications
No specific complications.

The areas of cutaneous innervation of the individual nerves discussed in this Chapter are illustrated in Fig. 33.11.
34 Blocking peripheral nerves in the ankle joint region

Definition
Individual or combined infiltration anesthesia of the following nerves in the ankle joint region:
- Tibial nerve
- Superficial and deep peroneal (fibular) nerves
- Sural nerve
- Saphenous nerve

Anatomy

Tibial nerve (Fig. 34.1)
The tibial nerve reaches the distal lower leg posterior to the medial malleolus. It gives off medial calcaneal branches to the heel and divides into its two end branches, the medial and lateral plantar nerves, which pass to the sole of the foot and provide it with its sensory supply.

Superficial peroneal (fibular) nerve
(Figs. 34.2, 34.3)
This nerve runs through the peroneus longus muscle, extends between the peroneus longus and brevis muscles, and penetrates the crural fascia in the distal third of the lower leg. Subcutaneously, or still at the subfascial level, it divides into the thicker medial dorsal cutaneous nerve and the smaller intermediate dorsal cutaneous nerve, providing the sensory supply for the skin on the back of the foot and the toes.

Fig. 34.1a Tibial nerve.
(1) Tibial nerve, (2) medial plantar nerve, (3) lateral plantar nerve, (4) calcaneal branches

Fig. 34.1b Tibial nerve – sole of the foot.
(1) Medial plantar nerve, (2) lateral plantar nerve, (3) medial calcaneal branches, (4) posterior tibial artery
Deep peroneal (fibular) nerve (Figs. 34.2, 34.3)
This nerve runs between the tibialis anterior muscle and the extensor hallucis longus muscle in the direction of the ankle, where it divides into a medial and a lateral end branch. The medial end branch continues in the same direction as the nerve trunk, and passes with the dorsalis pedis artery to the first interosseous space, crossing under the tendon of the extensor hallucis brevis muscle to the distal end of the interosseous space. Here it joins with a strand of the superficial peroneal nerve and divides into the end branches for the facing sides of the dorsal surfaces of the first and second toes. The lateral end branch turns laterally and supplies the extensor digitorum brevis muscle, sending off three interosseous nerves.

Sural nerve (Figs. 34.2, 34.3)
The medial sural cutaneous nerve arises in the proximal part of the popliteal fossa, runs down between the two heads of the gastrocnemius muscle, and joins the peroneal communicating branch to form the sural nerve. Accompanied by the small saphenous vein, the sural nerve runs behind the lateral malleolus and passes as the lateral dorsal cutaneous nerve along the lateral side of the foot, where it gives off a connecting branch to the intermediate dorsal cutaneous nerve and ends as the dorsalis digitii minimi nerve on the lateral edge of the dorsum of the small toe.

Behind the lateral malleolus it sends off branches (the lateral calcaneal branches) to the skin there and at the heel. The branches for the lateral side of the ankle, for the anterior capsular wall, and for the tarsal sinus originate proximal to the malleolus.
Saphenous nerve (Fig. 34.3)
The saphenous nerve courses along the medial side of the lower leg and anterior to the medial malleolus, and sends off branches to the skin of the medial side of the foot. It usually ends in the metatarsal area, without reaching the big toe.

Indications
- Surgical procedures in the foot area.
- Outpatient surgery.
- Postoperative pain therapy.
- Supplementing incomplete epidural anesthesia or an incomplete sciatic nerve or femoral nerve block.

Contraindications
- Anticoagulant therapy.
- Infections in the injection area.

Procedure
Full prior information for the patient is mandatory.

Preparations
Check that the emergency equipment is complete and in working order; sterile precautions.

Materials (Fig. 34.4)
- 25-G needle 30 mm long.
- Syringes: 2, 5, 10 mL.
- Local anesthetics, disinfectant, swabs, sterile gloves, drape.

Skin prep, subcutaneous local anesthesia, drawing up the local anesthetic.

Posterior tibial nerve

Patient positioning
Prone, with a pillow under the ankle (or the patient may be seated).

Landmarks
Medial malleolus, posterior tibial artery.

Injection technique (Figs. 34.5, 34.7)
Lateral to the palpated pulse of the posterior tibial artery, a fine 25-G needle, 30 mm long, is introduced at a right angle to the posterior side of the tibia and just posterior to the posterior tibial artery. After paresthesias are elicited and after a negative aspiration test, 5 mL of local anesthetic is injected. If paresthesias cannot be elicited, then after reaching the posterior tibia, the needle is withdrawn for about 1 cm, and 5–10 mL of local anesthetic is injected. Another technique is to carry out perpendicular puncture of the skin at the level of the medial malleolus, dorsal and then ventral to the posterior tibial artery, and to distribute the total dose of local anesthetic in two equal halves on each side [8].
Deep peroneal nerve

Patient positioning
Supine, or sitting.

Landmarks
Dorsalis pedis artery, proximal back of the foot.

Injection technique (Fig. 34.6)
A fine 25-G injection needle, 30 mm long, is introduced perpendicular to the skin surface; 5 mL of the local anesthetic is injected on each side, first lateral to the artery and then medial to it [8].

Sural nerve and superficial peroneal nerve

Patient positioning
Supine, or sitting.

Landmarks
Lateral malleolus.

Injection technique (Fig. 34.8)
About 10 cm above the lateral malleolus, parallel to the upper ankle, fan-shaped subcutaneous infiltration of the Achilles tendon is carried out as far as the edge of the tibia, using about 10 mL of local anesthetic.

Saphenous nerve

Patient positioning
Supine, or sitting.

Landmarks
Medial malleolus.

Injection technique (Fig. 34.5)
About 10 cm above the medial malleolus, 5–10 mL of local anesthetic is injected subcutaneously around the long saphenous vein and, in a fan-shaped fashion, in a mediolateral direction.

Fig. 34.5 Posterior tibial nerve (1) (red needle) and posterior tibial artery (red), (2) saphenous nerve (black needle)

Fig. 34.6 Deep peroneal (fibular) nerve. (1) Dorsalis pedis artery
Chapter 34

The cutaneous innervation areas of the individual nerves are shown in Fig. 34.9.

**Dosage**

*Tibial nerve and deep peroneal nerve*

5–10 mL of local anesthetic.

*Sural nerve, superficial peroneal nerve, saphenous nerve*

10 (15)–20 mL of local anesthetic (subcutaneous fan-shaped infiltration).

**Local anesthetics**

0.5–0.75% ropivacaine, 0.25–0.5% bupivacaine (0.25–0.5% levobupivacaine), 1% prilocaine, 1% mepivacaine.

**Complications**

No specific complications.

---

**Fig. 34.7** Posterior tibial nerve (1) (red needle) and (2) sural nerve (green needle)

**Fig. 34.8** (1) Superficial peroneal (fibular) nerve (blue needle) and (2) sural nerve (green needle)

**Fig. 34.9** Cutaneous innervation areas in the region of the sole of the foot
### Blocking peripheral nerves – knee and foot

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<td>☐ Increased pain</td>
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**VISUAL ANALOG SCALE**

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Special notes:

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
35 Neuraxial anatomy

Spine and sacrum

Spine

The spinal column consists of 33 vertebrae – seven cervical vertebrae; 12 thoracic vertebrae; five lumbar vertebrae; the sacrum, consisting of five fused sacral vertebrae; and the coccyx, consisting of four fused coccygeal segments (Fig. 35.1).

The average length of the spine in adult men is about 72 cm, while in women it is 7–10 cm shorter.

All of the vertebrae have the same basic shape, which is subject to certain variations in the individual sections of the spine. The basic shape consists of an anterior body (the body of the vertebra) and a dorsal arch (the vertebral arch), which consists of pedicles and laminae (Fig. 35.2).

The laminae of the vertebral arch join dorsally to form the spinous process. A transverse process branches off on each side of the vertebral arch, as well as a superior and an inferior articular process.

The vertebrae in the cervical region are smaller, but their size increases from cranial to caudal. The angle of

Fig. 35.1a–c Spine.
 a Lateral, b Ventral, c Dorsal
Chapter 35

inclination of the spinous processes – important topographic signposts for neuraxial injections – varies at different levels of the spine.

The cervical spinous processes, the first two thoracic spinous processes and the lumbar spinous processes lie at the same level as their vertebrae. From T3 to L1, the spinous processes are angled caudally (particularly in the T4–T9 area) (Fig. 35.3a–c).

The vertebral canal (which provides excellent protection for the spinal cord) and the spinal cord, with its meningeal covering, extend throughout the whole length of the spine terminating in the cauda equina.

The spinal vessels and nerves emerge laterally through openings at the upper and lower margins of the roots of the arches of the adjoining vertebrae (the intervertebral foramina).

Fig. 35.2 Basic shape of a vertebra. (1) Vertebral body, (2) vertebral arch, (3) pedicle of the vertebral arch, (4) vertebral foramen, (5) spinous process, (6) transverse process

Fig. 35.3a–c Cervical, thoracic and lumbar spinous processes. a C7 cervical vertebra (vertebra prominens, nuchal tubercle). b T8 thoracic vertebra. c L3 lumbar vertebra

Fig. 35.4 Sacrum (dorsal view). (1) Median sacral crest, (2) sacral horn, (3) sacral hiatus, (4) sacral canal, (5) posterior sacral foramina

Fig. 35.5 Sacrum (ventral view). (1) Transverse lines, (2) anterior pelvic sacral foramina

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Sacrum

The sacrum is wedge-shaped and consists of five vertebrae fused together. It lies distal to the fifth lumbar vertebra and is connected distally, at its apex, to the coccyx.

Dorsally, the sacrum has a convex surface, in the middle of which the median sacral crest stands out (Fig. 35.4).

The crest is produced by the fusion of the rudimentary spinous processes of the upper third or fourth sacral vertebrae. Normally, the arch of the fifth and occasionally also of the fourth sacral vertebra is absent, so that there is a sacral hiatus at this point.

The hiatus is bounded by the sacral horn as a remnant of the caudal articular process, and it is used as a passage by the five small sacral nerves and by the coccygeal nerves.

Between the median sacral crest and the lateral sacral crest lie the four sacral openings (the posterior sacral foramina), through which the dorsal branches of the sacral spinal nerves emerge.

The anterior view shows a concave aspect. Alongside the transverse lines (fused vertebrae), there are large anterior openings (the anterior pelvic sacral foramina), through which the primary anterior parts of the sacral nerves emerge (Fig. 35.5).

Spinal ligaments

The vertebrae are supported from the axis to the cranial sacrum by intervertebral disks and by various ligaments (Fig. 35.6).

The intervertebral disks lie between neighboring vertebrae and function as fixed connecting elements and pressure-absorbing buffers. The disks are at their thinnest in the area of T3–T7 and thickest in the lumbar area.

The anterior longitudinal ligament is attached at the anterior edge of the vertebral bodies and intervertebral disks and is at its thickest in the thoracic area. The posterior longitudinal ligament is wider cranially than it is caudally and it lies behind the vertebral bodies in the medullary canal. The supraspinous ligaments extend as far as the sacrum along the tips of the spinous processes, with which they are connected, and continue cranially in the nuchal ligament and caudally in the interspinous ligament. They become thicker from cranial to caudal. The interspinous ligaments connect the roots and tips of the spinous processes.

The intertransverse ligaments serve to connect the transverse processes (Fig. 35.7).
The ligamentum flavum largely consists of yellow, elastic fibers and it connects the neighboring laminae (Fig. 35.8). It is at its thinnest in the midline (small fissure spaces exist for the veins running from the internal vertebral venous plexus to the external vertebral venous plexus), and its thickness increases laterally. The size and shape of the ligamentum flavum vary at the various levels of the spine. Caudally, for example, it is thicker than in the cranial direction.

Iliolumbosacral ligaments

The stability of the iliolumbosacral region is ensured by lumbosacral and sacroiliac connections that transfer the entire weight of the trunk via the hip bones to the lower extremities. These ligamentous connections serve to connect the vertebrae with one another and to stabilize the sacrum.

Clinically important ligaments: interspinous, supraspinous, iliolumbar, interosseous sacroiliac, sacrospinous and sacrotuberous ligaments (Figs. 35.9, 35.10).

Spinal cord

The spinal cord is about 46 cm long and is the caudal continuation of the medulla oblongata, which extends from the atlas to the conus medullaris (the lower edge of the first lumbar vertebra). The conus medullaris continues in the threadlike median filum terminale as far as the posterior side of the coccyx (Fig. 35.11). The dura mater and arachnoid, and consequently the subarachnoid space as well, extend downward as far as the level of the second sacral vertebra.

Meninges

The spinal cord is surrounded and protected by the meninges (the dura mater, arachnoid mater and pia mater) and by cerebrospinal fluid, epidural fatty tissue and veins (Fig. 35.12). The dura mater of the spinal cord, a fibroelastic membrane, extends as far as the second sacral vertebra, where it ends in a blind sac. It encloses the anterior and posterior spinal nerve roots.
Fig. 35.10 Iliolumbosacral ligaments (ventral view).
(1) iliolumbar ligament, (2) ventral sacroiliac ligament,
(3) sacrospinous ligament, (4) sacrotuberous ligament,
(5) ventral sacrococcygeal ligament

Fig. 35.11a Anatomy.
(1) Spinal cord, (2) dura mater, (3) cauda equina,
(4) ligamentum flavum, (5) epidural space, (6) subarachnoid
space, (7) sacral hiatus

Fig. 35.11b Spinal cord (lower half).
(1) Conus medullaris, (2) cauda equina, (3) filum of spinal dura
mater (filum terminale), (4) sacral nerves, (5) lumbar nerves,
(6) thoracic nerves, (7) dura mater
Between the dura mater and the arachnoid, there is a space, the subdural space, in which a small amount of lymph-like fluid is located. The arachnoid mater, a non-vascularized membrane, also ends at the level of the second sacral vertebra. Between the arachnoid mater and the pia mater lies the subarachnoid space, which is filled with cerebrospinal fluid.

The spinal pia mater is a thin, very well vascularized membrane that tightly encloses the spinal cord. Caudal to the medullary cone, it develops into the thin filum terminale, which descends medial to the cauda equina, penetrates the final part of the dural sac and arachnoid, and fuses with the connective tissue posterior to the first coccygeal segment.

The pia mater sends off 22 denticulate ligaments on each side, which attach to the dura mater and thus stabilize the spinal cord.

**Spinal nerves**

There are 31 pairs of spinal nerves in the human: eight cervical pairs, twelve thoracic pairs, five lumbar pairs, five sacral pairs and one coccygeal pair. These are connected to the spinal cord by a series of ventral and dorsal radicular filaments, which combine to form the nerve roots (Fig. 35.12).

The thicker dorsal (posterior) root is responsible for conducting afferent impulses (pain, temperature, touch, position). Each of the dorsal spinal nerve roots has a sensory spinal ganglion incorporated in it.

The ventral (anterior) root is responsible for conducting efferent impulses (muscles, glands). The nerve roots in the lower segments of the spinal cord descend...
in the horsetail-like cauda equina to their exit openings. After exiting from the subarachnoid space, the ventral and dorsal roots cross the epidural space. In spinal anesthesia, the nerve roots are the principal targets for local anesthesia.

### Spinal dermatomes

Via its branching spinal nerves, each segment of the spinal cord provides the sensory supply for a specific area of skin, known as the dermatome. These areas of skin, which often overlap, are very important for checking and verifying the spread of anesthesia (Figs. 35.13, 35.14).

---

**Arteries of the spinal cord**

The spinal cord is supplied by numerous radicular arteries, which form the anterior spinal artery and twin posterior spinal arteries. The radicular arteries branch off from the cervical vertebral artery, the thoracic intercostal arteries and the abdominal lumbar arteries (Figs. 35.15, 35.16).

The anterior spinal artery, which arises from the fourth segment of the vertebral arteries, accompanies the spinal cord in the midline (anterior median fissure) along its entire course. Via the central branches and small branches of the arterial pial network, the anterior spinal artery supplies the anterior two-thirds of the spinal cord.

The cervical and first two thoracic spinal cord segments receive blood from the radicular branches of subclavian artery branches. In the mediothoracic spinal cord region (T3-T7), there is a radicular branch at the level of T4 or T5.

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**Fig. 35.14** Cutaneous innervation areas (detailed descriptions are given in the relevant chapters)

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**Fig. 35.15a-c** Spinal cord.  
\(a\) Ventral view: (1) anterior spinal artery and vein, (2) spinal branch, (3) anterior median fissure, (4) spinal nerve.  
\(b\) Dorsal view: (1) posterior spinal vein, (2) dorsal branch of the posterior intercostal artery, (3) spinal ganglion.  
\(c\) Cross-section
Chapter 35

The thoracolumbar segment of the spinal cord (T8 to the medullary cone) draws its arterial supply mainly from the large-caliber arteria radicularis magnus (the artery of Adamkiewicz), which arises from an intercostal artery on the left side.

The cauda equina is supplied by branches of the lumbar, iliolumbar and lateral or median sacral arteries. These also supply the medullary cone.

The paired posterior spinal arteries arise from the fourth segment of the vertebral artery, receiving flow from 10–23 posterior radicular branches, and supply the dorsal third of the spinal cord.

Thin pial branches run from the spinal arteries, forming a network on the surface of the spinal cord known as the arterial pial network.

Veins of the spinal cord and vertebrae

The entire spinal canal is traversed by two venous plexuses, the internal and external vertebral venous plexuses (Figs. 35.17, 35.18).

Together, these form a ring around each vertebra, freely anastomosing with one another and receiving flow from the vertebrae, ligaments and spinal cord. They are largely avalvular. Pressure changes in the thoracic or cerebrospinal fluid (CSF) spaces consequently affect the blood volume in the venous plexuses.

The plexuses are most strongly developed in the anterolateral area of the epidural space. They drain not only the spinal cord and its canal, but also part of the CSF.

Cerebrospinal fluid

The production of CSF is mainly achieved by active secretion and diffusion through the epithelial cells of the choroid plexus, but also to a small extent in the subarachnoid space and perivascularly.

The main tasks of the cerebrospinal fluid are:
- To function as a hemodynamic buffer and physical protection against forces affecting the spinal cord and brain.
- To substitute for the function of the lymphatic vessels, which are absent in the central nervous system.
- To allow metabolic exchange between blood and neural tissue.

Fig. 35.16 Arteries of the spinal cord (side view).
(1) Vertebral artery, (2) deep cervical artery, (3) intercostal artery, (4) anterior and posterior spinal artery, (5) arteria radicularis magnus (artery of Adamkiewicz)
There is a selective barrier between the blood and the CSF, the **blood-brain barrier**, which is formed by capillary endothelial cells and the choroid plexus. This barrier is clinically significant, as it is impermeable to many drugs.

The total quantity of the CSF in the adult is about 120–150 mL (with about 20–35 mL below the foramen ovale and about 15 mL below T5).

Approximately 400–450 mL of CSF is produced every day, and complete exchange of the fluid takes place every 10–12 hours.

Lumbar **CSF pressure** in a supine position is about 6–10 cmH₂O, while in a seated position it is about 20–25 cmH₂O.

The **specific gravity** of the CSF is 1.007 (1.003 to 1.009), and this must be taken into account in relation to the local anesthetic being used.

The **osmolarity** of CSF is comparable with that of the blood plasma (300 osmol/L), and the pH value is approximately the same as the physiological value.

Injected drugs mainly spread by diffusion, since CSF in the spinal canal circulates very little, if at all.

**Resorption** of CSF into the blood takes place via the **arachnoid granulations** and through the walls of the capillary vessels in the central nervous system and pia mater.

The liquid in the CSF sheaths of the cranial nerves and in the root pockets of the spinal nerves is an exception to the above rule. This liquid can enter the extradural lymphatic vessels directly.

**Fig. 35.17** Veins of the spinal cord.
(1) Vertebral veins, (2) deep cervical vein, (3) internal vertebral venous plexus, (4) spinal veins

**Fig. 35.18** Veins of the spinal cord (lumbar region).
(1) Arachnoid, (2) dura mater, (3) cauda equina, (4) inferior vena cava, (5) internal vertebral venous plexus, (6) lumbar vein
Spinal anesthesia

Spinal anesthesia is one of the oldest, most valuable and most frequently used regional anesthesia techniques.
The injection of a local anesthetic into the subarachnoid space leads to temporary blocking of nerve conduction in the spinal nerve roots and paralysis of the autonomic, sensory and motor nerve fibers. Spinal anesthesia has the following characteristics:
- It is easy to perform.
- The onset is fast.
- Excellent anesthesia is produced.
- There is no systemic toxicity.

The application of spinal anesthesia depends on the following factors:
- The area of surgery.
- The type and expected duration of the procedure.
- The degree of muscle relaxation required.
- The presence of concomitant disease.
- The expected blood loss.

Indications

Surgical
Spinal anesthesia is particularly advantageous for all types of surgical procedures below the level of the umbilicus.
- Surgical procedures in the area of the lower extremities, hip joint and inguinal region.
- Vascular surgery.
- Prostate and bladder surgery.
- Gynecological and obstetric procedures.
- Surgery in the perineal and perianal region.
- Lumbar surgery – e.g. intervertebral disk operations [96].

Pain therapy

Chemical intraspinal neurolysis with phenol in glycerol or alcohol (in advanced stages of malignant disease).

The use of spinal anesthesia has proved particularly valuable in:
- Patients with a full stomach.
- When tracheal intubation difficulties are expected.
- When there is a history of malignant hyperthermia, or a suspicion of malignant hyperthermia.
- Muscular disease.
- Cardiopulmonary disease.
- Metabolic disease.
- Renal and hepatic disease.
- Stable neurological diseases.
- After high spinal cord injury.
- Elderly patients.

Advantages

Very good muscle relaxation.
- Very good postoperative analgesia.
- Increased bowel motility.
- Prophylaxis against thromboembolism caused by sympathetic block.
- Suitable for outpatient procedures.
- Highly cost-effective, with easy and safe monitoring.

Disadvantages

Unsuitable for upper abdominal procedures (high spinal anesthesia – e.g. T4–T6, is necessary).
- Lack of block of the vagus and phrenic nerves (leads to adverse effects such as nausea, vomiting, hiccup, pain and hypotension).

Contraindications

There are only a few contraindications to carrying out spinal anesthesia.

Specific
- Patient refusal.
- Coagulation disorders, anticoagulant therapy.
- Sepsis.
Local infections at the injection site.
Immune deficiency.
Severe decompensated hypovolemia, shock.
Specific cardiovascular diseases of myocardial, ischemic or valvular origin if the procedure being carried out requires sensory distribution of the anesthesia as far as T6.
Acute cerebral or spinal cord diseases.
Raised intracranial pressure.
A history of hypersensitivity to local anesthetic agents, without a prior subcutaneous test dose.

Specific injection-related
CSF mixed with blood (which does not clear even after repeated aspiration).
No free CSF flow (even after rotating the needle at various levels and repeated attempts at aspiration).

Relative
These contraindications always require a risk–benefit assessment and are more medicolegal in nature.
Severe spinal deformities, arthritis, osteoporosis, intervertebral disk prolapse or post intervertebral disk surgery. Following spinal fusion, spinal metastases.
Spinal canal stenosis [84].
Repetition of spinal anesthesia with hyperbaric solutions if the block originally carried out is ineffective [36, 601 (see Chapter 37 on neurological complications, p. 291). At least 10–15 minutes should be waited; attention should be given to possible mistakes with the initial injection procedure and a maximum of half of the original dose with no adjuncts should be administered.

Relative injection-related
Further attempts after three unsuccessful injections.
Inexperienced anesthetist without supervision.
No anesthetic expertise.

Procedure
Full prior information for the patient is mandatory.

Preparation and materials
Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs); sterile precautions, intravenous access, anesthetic machine.
Start an intravenous infusion and ensure adequate volume loading (250–500 mL of a balanced electrolyte solution).
Careful monitoring: ECG monitoring, BP, pulse oximetry.
Skin prep.
Local anesthetic.
The use of a ready-supplied spinal anesthesia kit – e.g. from B. Braun Melsungen, is recommended (Fig. 36.1).

Spinal needles (Fig. 36.2)
There are two possibilities here:
- 25–27 (29)-G spinal needles with conical tips (pencil-point) – e.g. Pencan, Sprotte, Whitacre – in current standard use.
When the dura is penetrated with these needles, the dural fibers are separated and then close together again. This means that the most troublesome complication – postdural puncture headache – hardly ever occurs when the dural puncture is carried out correctly.
- Spinal needles with Quincke tip, 25–27 G
The needle bevel should be directed laterally during the puncture in order to pass through the dura in a

Head and back pain in the patient’s history does not today represent a contraindication to spinal anesthesia, provided that small-caliber (>25 G) pencil-point injection needles are used and provided only one dural puncture is performed.

Fig. 36.1 Materials
longitudinal direction. A 22-G needle is only used in exceptional cases – e.g. in older patients or when there are difficulties with positioning.

**Patient positioning**

Optimal patient positioning during puncture and during the fixation phase of the local anesthetic is a prerequisite for successful spinal anesthesia.

The following positions are possible:
- Lateral decubitus position.
- Sitting.
- Prone.

In all three positions, it is important to locate the **midline** and to follow it during the entire injection procedure. Lumbar lordosis must be minimised.

**Lateral decubitus position**

The assistant stands in front of the patient. If the anesthetist is right-handed, the patient is placed in the left lateral position. The patient is asked to adopt a “hunchback” position (legs flexed up against the abdomen and chin flexed down onto the chest) in order to bend the spine and allow optimal expansion of the intervertebral spaces.

It is important here for the spine to be parallel and for the intercristal line and the line connecting the two scapular tips to be perpendicular to the operating table (Fig. 36.3).

Advantages:
- More comfortable for the patient and thus particularly suitable for frail patients (risk of collapse).
- The reduction in blood pressure is less marked.
- When hyperbaric solutions are used, anesthesia concentrating on one side or unilateral anesthesia is possible.
- Can be used in pregnant patients (note the left lateral decubitus position).

**Sitting**

The patient is seated on the edge of the operating table and is supported by an assistant standing in front of him or her (Fig. 36.4).
Advantages:
When palpation of the spinous processes is difficult (e.g. in obese patients or those with spinal deformities), it is easier to locate the midline.
The position is less painful for patients with fractures of the hip or lower extremities. Particularly in older patients with femoral neck fractures, we additionally administer 4–6 mg Hypnomidate (etomidate) before the injection, to make the short sitting phase easier.
When anesthesia in the perineal or perianal region is required.
The CSF flows more quickly.

Disadvantages:
This position may lead to a hypotension (risk of collapse) and should be avoided in frail and heavily sedated patients, as well as in pregnant patients (aorticaval compression).
An assistant is always required to support the patient.

Prone jackknife
This position is only used in the very rarely practiced hyperbaric technique for spinal anesthesia (procedures in the rectum, perineum, sacrum, lower spine). An assistant and subsequent repositioning of the patient are not required (Fig. 36.5).
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Injection technique

Median approach (midline)

Landmarks
The injection is carried out in the midline below the L2 segment (conus medullaris), usually between the spinous processes of L2/3 or L3/4 (depending on the desired level of anesthesia).

The patient is asked to draw the legs tightly up to the abdomen and to place the chin on the chest. A line is drawn from one iliac crest to the other. This connection (Tuffier's line) crosses either the spinous process of L4 (50%) or the intervertebral space of segments L4/L5.

The intervertebral space is palpated, the midline is located as the most important signpost, and the injection site is marked with the thumbnail. As this is done, the palpating fingers move in a craniocaudal direction, or side to side (Fig. 36.6).

Strict asepsis
Thorough, repeated and wide skin prep and drying and covering of the injection site with a drape.

Local anesthesia
The skin and supraspinous and interspinous ligaments are anesthetized with 1–1.5 mL of a local anesthetic (e.g., 1% prilocaine).

The injection is carried out between the spread index and middle fingers of the left hand (Fig. 36.7).

Injection

Advancing the introducer
Without moving the spread index and middle finger of the left hand away from the intervertebral space, the introducer is grasped between the thumb and index finger of the right hand and advanced parallel to the operating table and slightly cranially (10°) far enough for it to lie firmly in the interspinous ligament (Fig. 36.8). It should be ensured that the midline position is maintained.

After this, the introducer is fixed with the thumb and index finger of the left hand, with the dorsum of the hand lying firmly on the patient’s back.

Introducing the spinal needle, puncture of the subarachnoid space
The spinal needle, held between the thumb and index finger (or middle finger) of the right hand, is introduced through the interspinous ligament, ligamentum flavum, epidural space and dura/arachnoid as far as the subarachnoid space. The characteristic “dural click” occurs when the subarachnoid space is reached (Fig. 36.9).
When a Quincke needle is used, it should be ensured that the needle bevel is directed laterally, so that the dura is punctured in a longitudinal direction.

**Removing the stylet**
The following may occur here:

- **CSF flows freely**
  With the single-injection technique, aspiration of CSF (0.1 mL) should be attempted immediately before and after injection of local anesthetic. The subarachnoid injection is made at the rate of 1 mL per 5 s.

- **Blood in the CSF**
  Slightly bloody CSF, which clears quickly (spontaneously, or after aspiration) usually occurs after penetration of an epidural vein, on the way into the subarachnoid space. The local anesthetic can be injected.
  However, when pure blood flows, it indicates that the injection needle is positioned within a vein. A new attempt at puncture must be made in a different intervertebral space.

- **No CSF flow**
  Rotation of the needle to all four quadrants and careful aspiration. After replacing the trochar, the needle is advanced slightly.
  If no CSF flows in spite of all these measures, the needle should be removed and the procedure repeated with a different needle direction.
  Unexpectedly deep bone contact suggests that the posterior side of the vertebra or an intervertebral disk has been reached. CSF appears in most cases after the needle has been slightly withdrawn and aspiration has been repeated.

- **Paresthesias during puncture** (Fig. 36.11)
  These occur if the spinal needle touches a nerve root or the periosteum on its path. The needle direction needs to be altered.
  When paresthesias are produced at the subarachnoid level, the needle must be withdrawn slightly. When paresthesias occur during the injection, the needle must be repositioned before any further drug is injected.
The local anesthetic must never be injected without evidence of CSF! The location and distribution of paresthesias arising during the puncture procedure must be recorded.

Experience shows that failure is usually due to the following causes:
- The needle has deviated from the midline.
- The needle is angled too cranially.

Alternative techniques

Paramedian approach
(Figs. 36.12, 36.14) (lateral, paraspinal)
In this technique, the supraspinous and interspinous ligaments are avoided, so that the ligamentum flavum is the primary target on the way to the subarachnoid space.

Procedure
This technique can be used in all the patient positions mentioned above. Flexion of the spine is not required. The caudal edge of the spinous process is marked. The injection site is located 1–1.5 cm lateral and caudal to this. The puncture is carried out in a craniomedial direction, at an angle of about 10–15°. The dura is reached after about 4–6 cm.

Most mistakes arise when the needle is angled too cranially.

This technique can be used in:
- Degenerative changes in the spine.
- Older patients with marked calcification of the supraspinous and interspinous ligaments.
- Obesity.
- Fractures or other pathological conditions in which pain makes it impossible to flex the spine.

Taylor’s approach (Figs. 36.13, 36.14)
This lumbosacral approach is a paramedian injection via the intervertebral space of L5 and S1, the largest interlaminar space in the spinal region.

Procedure
Lateral decubitus position, or sitting. The injection site is located about 1 cm medial and about 1 cm caudal to the posterior superior iliac crest. The injection needle is advanced in a craniomedial direction and at an angle of about 55°. If it touches the periosteum (sacrum), the needle must be withdrawn and its direction must be corrected.

The rare indications for this access route include procedures in the perineal and perianal region.

Positioning of the patient after the injection
The level of the anesthetic spread is controlled by patient positioning measures and checked with cold tests at intervals of 2–5 minutes.

Hyperbaric spinal anesthesia
*Lateral decubitus position*
The patient remains on the side of surgery for 10–15 minutes if unilateral anesthesia is desired.
The patient is laid supine if bilateral anesthesia is required.

*Sitting position*
The patient is immediately laid down to allow the anesthetic to spread. The patient remains sitting if sacral spread is desired.

Isobaric spinal anesthesia
Horizontal positioning is adequate; other positions have no significant influence on the spread of the anesthesia.

Hypobaric technique
Hypobaric spinal anesthesia is not suitable for everyday routine and is rarely used. It is mainly used for operations requiring a prone “jackknife” position, so that the patient does not need to be repositioned (Fig. 36.5).

Fixation phase
The phase immediately after injection of the local anesthetic is particularly critical and requires precise monitoring. The fixation phase lasts about 10–15 minutes.

Properties of local anesthetics in the subarachnoid space
Injecting a local anesthetic into the subarachnoid space blocks sensory and motor function. The main targets of local anesthesia are the posterior roots with the ganglia and anterior roots of the spinal nerves, the autonomic nerve fibers and mixed neural trunks.
The spread of the anesthesia should be checked at short intervals (2–5 min) and confirmed (with a cold spray) shortly before the start of the operation. The first sign of an effect on the spinal nerve roots is a subjective sensation of warmth in the feet. The further development of the block encompasses touch, deep pres-
Spinal anesthesia

Sure, motor function, vibration sensitivity and positional sense.

**Motor function** is completely blocked at the site of the greatest concentration of the local anesthetic. **Sensory** block covers two to four segments and **sympathetic** block extends for a further two to four segments cranially. Subsidence of the block is marked by a return of motor function.

Elimination of local anesthetic that has been injected into the subarachnoid space takes place by subarachnoid vascular resorption (through the vessels of the pia mater and spinal cord), or epidurally [14].
### Chapter 36

#### Table 36.1 Dosage of hyperbaric local anesthetics*

<table>
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<th>Local anesthetic</th>
<th>0.5% bupivacaine</th>
<th>5% lidocaine</th>
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<td></td>
<td>5–8% glucose</td>
<td>7.5% glucose</td>
<td>9.5% glucose</td>
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<tr>
<td></td>
<td>mL</td>
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<td>10.0–12.5</td>
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<td>L1</td>
<td>Deep</td>
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<td>7.5</td>
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<td>S1–S5</td>
<td>Saddle block</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Onset of effect (min)</td>
<td></td>
<td></td>
<td>10–20</td>
<td></td>
</tr>
<tr>
<td>Duration of effect (min)</td>
<td></td>
<td></td>
<td>Up to 160</td>
<td></td>
</tr>
<tr>
<td>Prolongation of effect with vasopressors</td>
<td></td>
<td></td>
<td>No clinically significant effect with bupivacaine, lidocaine, or mepivacaine</td>
<td></td>
</tr>
</tbody>
</table>

* Note the dose reduction (20–30 %) in obese patients and pregnant patients.

---

### Local anesthetics

The following local anesthetics are the main ones used as hyperbaric and isobaric solutions:

- **0.5% bupivacaine** and **0.5% ropivacaine** as long-acting local anesthetics.
- **2–4% mepivacaine** or **2% prilocaine** or **2–5% lidocaine** as medium-duration local anesthetics.

The local anesthetic of the ester group, **0.5–1% tetracaine** (pantocaine), is mainly used in the USA.

Local anesthetics administered into the subarachnoid space reach body temperature in about 60 s.

### Hyperbaric technique

This is the most frequently used and preferred technique for spinal anesthesia. Mixing a local anesthetic with glucose (5–10%) increases its baricity in comparison with CSF and the level of anesthesia can be determined by patient positioning (Table 36.1).

### Isobaric technique

In the isobaric technique, the position of the patient does not have a significant effect on the spread of the anesthesia. With a slow injection, the local anesthetic remains in the vicinity of the injection site and with a fast injection or barbotage, higher levels of anesthesia can be achieved.

The most important parameter for the spread of the anesthesia is the volume of local anesthetic injected (Table 36.2).

---

### Table 36.2 Dosage with isobaric local anesthetic*

<table>
<thead>
<tr>
<th>Local anesthetic</th>
<th>Prilocaine</th>
<th>Mepivacaine</th>
<th>Lidocaine</th>
<th>Bupivacaine</th>
<th>Ropivacaine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td></td>
<td>3–4 ml (60–80 mg), duration of effect: 60–120 min</td>
<td>3–5 ml (60–100 mg), duration of effect: 30–90 min</td>
<td>3–5 ml (60–100 mg), duration of effect: 30–90 min</td>
<td>3–4 ml (15–20 mg), duration of effect: bis 160 min</td>
<td>3–5 ml (15–25 mg), duration of effect: 120–180 min</td>
</tr>
</tbody>
</table>

* Note the dose reduction (20–30 %) in obese patients and pregnant patients.

### Unilateral spinal anesthesia

#### Definition

Unilateral spinal anesthesia is always intended to block only the anterior and posterior roots on the side being operated on, while the contralateral side – and particularly its sympathetic fibers – remains unblocked. This leads to a reduced incidence of hypotension.

#### Indications

Surgical and orthopedic procedures on the lower extremities.

#### Advantages

Reduction in the extent of the sympathetic block (by about 70%), since small volumes and slower injection of the local anesthetic mean that fewer spinal segments are involved [40, 95].
Hemodynamic stability (hypotension is only observed in ca. 5% of patients) [20, 61].
Faster recovery from anesthesia.
Suitable for outpatient procedures.
Greater acceptance by patients.

**Disadvantages**
Strict unilateral anesthesia is only rarely achieved.
The procedure requires considerable patience (time factor).

**Contraindications**
See p. 272.

**Procedure**

**Preparations and materials**
See p. 273.

**Patient positioning**
Lateral decubitus position, lying on the side that is to be operated on.

**Injection technique**
This is the same as for conventional spinal anesthesia. The opening of the pencil-point needle is rotated to the operating side, and the desired amount of local anesthetic is slowly injected [41].

**Patient position after the injection**
The patient remains lying on the side that is to be operated on for ca. 20 min.

**Dosage**
0.5% bupivacaine, hyperbaric injection: 1.2–1.6 mL (6–8 mg)
Injection speed: 2.5 mL/min [77]
1.2 mL/min [21, 22]

**Complications**
See Chapter 37.

---

**Factors affecting the spread and duration of spinal anesthesia** [66]

**Spread**
The following factors are very important:
- The dose and volume of local anesthetic solution injected.
- The speed of injection of the anesthetic solution.
- The position of the patient during and immediately after the injection.

Important factors are:
- The patient’s age, weight and height.
- The anatomic configuration of the spinal column.
- The volume of cerebrospinal fluid.
- The level of the injection site.
- The speed and barbotage of the injection.
- The direction of the injection needle’s beveled tip.
- Intra-abdominal pressure.
- The diameter of the needle.

Less important factors are:
- CSF pressure.
- The concentration of the local anesthetic.

**Duration**
- Type and dosage of the local anesthetic.
- Anesthetic level achieved.
- Patient’s age.
- Vasopressor addition: only with tetracaine; no clinical significance with bupivacaine or lidocaine [24, 25, 91].
Fig. 36.15a Location of the procedure and required sensory spread of local anesthesia
Fig. 36.15b Landmarks for testing the spread of a local anesthetic after neuraxial anesthesia
## Spinal anesthesia

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis:</td>
<td></td>
</tr>
<tr>
<td>Premedication:</td>
<td>☐ No ☐ Yes</td>
</tr>
<tr>
<td>Neurological abnormalities:</td>
<td>☐ No ☐ Yes</td>
</tr>
</tbody>
</table>

**Purpose of block:** ☐ Surgical

**Needle:** ☐ Pencil-Point ☐ Quincke ☐ Other

**i.v. access, infusion:** ☐ Yes

**Monitoring:** ☐ ECG ☐ Pulse oximetry

**Ventilation facilities:** ☐ Yes (equipment checked)

**Emergency equipment (drugs):** ☐ Checked

**Patient:** ☐ Informed (behavior after block)

| Position: | ☐ Lateral recumbent ☐ Sitting |
| Access: | ☐ Median ☐ Paramedian ☐ Taylor |
| Injection level: | ☐ L3/4 ☐ Other |
| CSF: | ☐ Clear ☐ Slightly bloody ☐ Bloody |
| Abnormalities: | ☐ No ☐ Yes |

**Injection:**
- **Local anesthetic:** ___________% __________mg
- **Addition to LA:** ___________% __________μg/ml

**Patient’s remarks during injection:**
- ☐ None ☐ Pain ☐ Paresthesias ☐ Warmth

**Duration and area:**

**Objective block effect after 15 min:**
- ☐ Cold test ☐ Temperature measurement before __________°C after __________°C
- ☐ Sensory: L __________ T __________
- ☐ Motor

**Complications:**
- ☐ None ☐ Pain
- ☐ Radicular symptoms ☐ Vasovagal reactions
- ☐ BP drop ☐ Total spinal anesthesia
- ☐ Subdural spread ☐ Respiratory disturbance
- ☐ Drop in body temperature ☐ Muscle tremor
- ☐ Bladder emptying disturbances ☐ Back pain
- ☐ Postdural puncture headache ☐ Neurological complications

**Special notes:**

© Copyright ABW Wissenschaftsverlag 2004, Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Complications of spinal anesthesia

Complications during the injection

Collapse (vasovagal syncope)

This is a harmless complication, which often occurs in young, nervous and anxious patients during injections in the sitting position. It involves a “neurogenic,” nor-movolemic shock state, which requires no treatment other than lying the patient supine.

Prophylaxis

Injection in lateral decubitus position, mild sedation.

Complications immediately after the injection and during the fixation phase

Hypotension

This is the most frequent complication of spinal anes-thesia. It arises due to blockade of sympathetic fibers and is usually accompanied by bradycardia (pregan-glionic block of the sympathetic nerves to the heart, T1–4) and nausea.

Mechanism

Vasodilation, postarteriolar pooling of blood, reduction in the effective circulating blood volume and venous return to the heart [11, 14].

The higher the spread of the spinal anesthesia or sympathetic block, the greater the reduction in arterial blood pressure.

A drop in blood pressure is also possible after the fixation period of the local anesthetic and it is often exac-erbated by acute blood loss, repositioning maneuvers or quick release of a pneumatic tourniquet.

Treatment

The aim is to increase venous return to the heart and to raise cardiac output, using the following physiological and pharmacological measures:

Volume infusion.
Oxygen administration.
Raising the legs.
Place the patient in a slight Trendelenburg position (10°). This does not produce significant spread of the anesthetic.
Atropine when there is bradycardia.
Small intravenous doses of a vasopressor may also be needed (e.g. epinephrine 10–20 mg).

Prophylaxis

Before spinal anesthesia is administered, any deficits in intravascular volume should be corrected and an additional volume of at least 500 mL of a balanced electrolyte solution should be infused.

Accurate assessment of the patient’s degree of cardio-vascular risk.
In pregnant patients, as well as older or obese pa-tients: reduced dose of the local anesthetic, opioid, or combination.

Prophylactic administration of a vasopressor is not rec-ommended.

High and total spinal anesthesia

Causes

Overdosage of the local anesthetic.
Positioning error.
Inadvertent spinal anesthesia when attempting epidural anesthesia (most frequent cause!)

The clinical picture has a dramatic course, character-ized by restlessness, breathing difficulties, a severe drop in blood pressure and loss of consciousness. It is life-threatening and requires immediate treatment.
Chapter 37

**Therapy**

Immediate tracheal intubation (thiopental 1–2 mg/kg b.w. routinely ca. 150 mg i.v.; succinylcholine if appropriate, since the muscles of mastication are not affected [66].

Ventilation with 100% oxygen.

Raising the legs.

Rapid volume administration.

Atropine.

Vasopressor.

Dopamine infusion.

Careful cardiovascular monitoring.

**Subdural spread of the local anesthetic**

Subdural injection can never be excluded with certainty. It may occur slightly more frequently after spinal anesthesia or myelography than after epidural anesthesia.

The subdural space is at its widest in the cervical region, particularly dorsolaterally. It does not end at the great foramen as does the epidural space, but continues cranially.

**Warning signs**

An unusually high sensory block, which develops very slowly (even after 20 minutes) and a much less marked motor block.

The clinical picture resembles that of total spinal anesthesia and is characterized by moderate hypotonia, breathing difficulties with retained consciousness and often involvement of the cranial and cervical nerves:

**Trigeminal nerve:** trigeminal nerve palsy, with accompanying paresthesias in the area supplied by the nerve and transient weakness of the muscles of mastication with simultaneous Horner’s syndrome, has been observed after high epidural anesthesia or subdural spread [31, 45, 89, 92].

**Horner’s syndrome:** Horner’s syndrome is produced after neuraxial anesthesia with a high spread of the injected local anesthetic and block of very sensitive sympathetic nerve fibers in the areas of segments T4–C8 [54, 83]. Most often, Horner’s syndrome is seen after high spinal or epidural anesthesia in obstetrics and when there is subdural spread of the local anesthetic [28, 34].

Relatively rapid resolution of the symptoms is characteristic.

**Differential diagnosis**

Total spinal anesthesia: dramatic course, blood pressure unrecordable, respiratory arrest, longer time required for symptoms to resolve.

**Prophylaxis**

Individual dosage and dose reduction in older patients, pregnant patients, obese patients and those with diabetes mellitus or arteriosclerosis.

Incremental injection in epidural anesthesia.

**Respiratory disturbances**

These only arise after spread of the local anesthetic above segment T8. They result from block of the intercostal nerves and accompanying paralysis of the intercostal muscles. Resting ventilation is largely unaffected, thanks to a compensatory increase in diaphragmatic movement.

**Therapy**

Mild sedation.

Oxygen administration.

Reassure the patient.

**Gastrointestinal tract disturbances**

Due to blocking of sympathetic inhibition, disturbances of bowel tone and motility may occur, becoming manifest as nausea or, more rarely, as vomiting. These disturbances are very often associated with a drop in blood pressure and bradycardia.

**Reduced body temperature**

Particularly in cool surroundings and when there is intraoperative blood loss, sympathetic block and the associated vasodilatation can lead to a drop in body temperature.

**Complications in the early postoperative phase**

**Urinary retention**

This affects 14–56% of patients, mainly older ones, and results from autonomic dysfunction caused by block of the parasympathetic segments from S2 to S4, which recovers last after spinal anesthesia.
Clinical symptoms

Patients complain of severe lower abdominal and back pain; this is often accompanied by an increase in blood pressure.

Therapy

If physical measures, early mobilization or administration of carbachol (Miostat, Carbastat; i.m.) are not successful, urinary catheterization can lead to a rapid improvement in the symptoms.

Late complications

Late complications are usually caused by the technique of spinal anesthesia. They manifest as:
- Postdural puncture headache.
- Back pain.
- Neurological complications.

Postdural puncture headache (PDPH)

This is a very unpleasant complication after spinal anesthesia, diagnostic lumbar puncture, myelography or diagnostic or therapeutic sympathetic block [63]. It usually develops after 24-48 hours or even later.

Frequency

0.2-24% [14] up to 76.5% [31, 35, 101] after puncture with large-diameter needles.

Mechanism

PDPH is thought to represent a multistep phenomenon initiated by dural puncture and resultant CSF leakage. Two proposed mechanisms for PDPH pain have been discussed in the literature. The first theory proposes that a decrease in CSF pressure produces traction on structures within the cranium, resulting in the generation of pain. The second hypothesis suggests that decreased CSF pressure leads to intrathecal hypotension and painful vasodilatation of the intracranial blood vessels (known as the "intracranial vascular response" [17, 101]). Mainly when the patient is in a standing position, painful areas dilate (meninges, tentorium, vessels) and there is further pain transmission via the cerebral nerves and upper cervical nerves.

Etiology

Postdural puncture headache occurs most frequently in younger patients and women, particularly during pregnancy. Repeated dural perforation, puncture with large-diameter needles, and in particular accidental spinal anesthesia when attempting to carry out epidural anesthesia, are liable to lead to postdural puncture headache.

Location

Usually occipitofrontal (occipital: 25%, frontal: 22% or occipitofrontal: 25%) [13, 101].

Clinical symptoms

Position-dependent headache, which is more severe when sitting and standing, coughing or straining, with marked relief when lying down.

Associated symptoms

Pain in the nape of the neck, stiffness in the neck, nausea, vomiting, sensitivity to light, smells and noise, auditory disturbances, tinnitus, loss of appetite, depressive mood.

CSF hypotension syndrome and involvement of the cranial and cervical nerves

All of the cranial nerves, with the exception of the olfactory nerve, glossopharyngeal nerve and vagus nerve, can be affected by low CSF pressure. The abducent nerve and vestibulocochlear nerve are most frequently affected (Fig. 37.1).

Abducent nerve:
The long intracranial course of this nerve leads to traction and consequent irritation of the nerve when there are changes in intracranial pressure. The patient complains of double vision, with parallel horizontal images and difficulties in focusing on objects [7, 34, 97].

Vestibulocochlear nerve
When precise audiometric examinations are carried out, unilateral or bilateral hypacusis can be observed in 0.4-40% of patients with CSF hypotension syndrome [34]. The prognosis is good.
Differential diagnosis

Migraine.
Tension headache.
Cervical myofascial pain, particularly in the sternocleidomastoid muscle, with what is known as "pseudospinal headache" [39].
CNS infections (bacterial meningitis).
Sinus thrombosis (in the second half of pregnancy or in the puerperium, frequently in preeclampsia).
Pneumocephalus (after accidental dural perforation in attempted epidural anesthesia when using the loss-of-resistance technique with air [51]).

Therapy

When there is a diagnosis of postdural puncture headache, various treatment approaches are possible.

Noninvasive conservative therapy

This is used initially and includes traditional symptomatic measures such as:
- Bed rest (compulsory).
- Analgesics.
- Sedatives.
- Antiemetics.

The majority of patients experience marked improvement in the symptoms or complete recovery after 5–7 days with this form of treatment [101]. In ca. 80% of patients, the symptoms improve spontaneously within 2 weeks without any treatment ("tincture of time" [23]).

Treatment measures recommended in the past, such as massive fluid intake or obligatory 24-hour bed rest after the injection, are unnecessary.

Caffeine sodium benzoate is often used as part of noninvasive conservative treatment, with considerable success (> 85%) [13, 17, 43, 52, 88, 89]. The substance leads to cerebral vasoconstriction and a reduction in cerebral blood flow [87].

Caffeine sodium benzoate can be administered orally or intramuscularly [17, 51]. The following infusion is used most frequently: 2 liters of liquid are administered over 2 hours, with the first liter containing 500 mg caffeine sodium benzoate. When there is residual pain, the treatment can be repeated after 4 hours [58].

Fig. 37.1 Cranial nerves.
(1) Optic nerve, (2) oculomotor nerve, (3) trochlear nerve, (4) trigeminal nerve, (5) vestibulocochlear nerve, (6) glossopharyngeal nerve, (7) vagus nerve, (8) hypoglossal nerve, (9) abducent nerve

Mild CNS stimulation and dizziness have been observed as side effects.

Hypertonus, a history of epilepsy, and pre-eclampsia are contraindications.

This form of treatment is particularly indicated in immune-suppressed patients, when there is a risk of infection, when there are difficulties in performing epidural puncture ("blood patch") and in postdural puncture headache after thoracic or cervical injections.

Other alternatives that have been reported in the area of noninvasive conservative treatment of postdural puncture headache include administering adrenocorticotropic hormone (ACTH) [6] or sumatriptan (a serotonin type 1d receptor agonist) [18].

None of the conservative treatment approaches removes the cause of postdural puncture headache; they merely bridge the period until the dural leak closes naturally.
Complications of spinal anesthesia

Invasive therapy

The method of choice in treatment-resistant postdural puncture headache is administration of a "blood patch" at the dural perforation site.

Prerequisites

Correct diagnosis.
Exclusion of all contraindications.
Informing the patient.
Experienced anesthetist.

This procedure should never be carried out without a correct diagnosis!

Procedure

10–20 mL of blood, taken from the patient in sterile conditions (Fig. 37.2), is reinjected epidurally. The injection is carried out at the same level as the original spinal anesthesia procedure or one segment caudally (Fig. 37.3).

The injection is carried out slowly (1 mL in 3–4 s). After the injection, the patient lies supine for ca. 30–60 min. This procedure can be repeated after 24 hours. The patient is recommended to maintain bedrest for ca. 24 hours.

Using magnetic resonance imaging, Beards et al. [10] traced the spread of the extradurally injected homologous blood. The maximum compression effect on the dura was seen after an interval of 30 min–3 hours, encompassing four to five neighboring segments. After about 7 hours, this effect subsided.

Other authors [19] have observed a spread over six segments above and three segments below the puncture site after extradural injection of radioactively marked blood.

Extradurally injected blood also spreads in the subarachnoid space [90] and particularly in the subcutaneous fatty tissue in the region of the lumbar spine. It has been suggested that this is a possible cause of postinjection back pain.

Complications

Back pain (35.9%), pain in the nape of the neck (0.9%), increased temperature (5%) and dizziness are temporary phenomena and do not require treatment [14]. The treatment has a 95% success rate.
Chapter 37

Potential complications
Inadvertent subarachnoid injection.
Hematoma formation, with compression of the spinal cord.
Risk of infection.
Persistent back pain.
Radicular pain.
Facial palsy [76].
Nerve injury [13, 58].
Cramps [93].

Alternative methods
Epidural dextran patch [98, 101].
Initially, a test dose of 20 mL Promit (dextran 1) is injected intravenously, to avoid potential allergic reactions.
Then, at the level of the dural perforation site, a slow epidural injection of 20-25 mL dextran 40 is carried out. The viscosity and high molecular weight of dextran 40 lead to very slow resorption from the epidural space, so that a longer period of compression of the dural defect is achieved.
Epidural patch with fibrin glue [32, 46, 48].
Infusion of isotonic saline via an epidural catheter: 150-200 mL/day [8, 31, 53]. This method represents a temporary solution for the problem.
Intrathecal injection of 10 mL saline 0.9% immediately after dural puncture, using an epidural needle.

Prophylaxis against postdural puncture headache
Use thin pencil-point spinal needles: 25–29 G – e.g. Pencan, Sprotte, Whitacre.
If needles with a Quincke tip are being used, the bevel should be positioned so as to be parallel to the mainly longitudinal dural fibers.
Atraumatic technique: avoid multiple perforations of the dura.
Experienced anesthetist.

When these prerequisites are observed, spinal anesthesia can also be carried out in patients with a history of headache and in young patients.

Back pain
This complication is a frequent occurrence after spinal anesthesia (2–25%), but it is no more frequent than after general anesthesia. Diseases of the spine make this complication more likely.

Mechanism
Tissue trauma after multiple attempts at puncture. Position-dependent pressure during surgery on bones, joints and ligaments in the lumbar region.

Treatment
Symptomatic.

Transient neurologic symptoms (TNS)
[3, 42, 79, 86, 99]

Definition
Transient occurrence of neurological symptoms, usually caused by spinal anesthesia (rarely after epidural techniques). Neurological findings are lacking (absence of motor, sensory, or sphincter disturbances). The symptoms develop within 24 hours, after complete disappearance of neuraxial anesthesia and 2–4 hours after the patient has been mobilized. In most cases, the symptoms resolve completely after a few hours or days, and at the latest after a week.

Clinical symptoms
Severe back pain, pain and dysesthesia in the area of the buttocks, radiating to the legs. These are bilateral symptoms. Muscle spasms are often present.
Etiology

The etiology of TNS is not known. Possible causes of this strange phenomenon that have been proposed include the following:

Specific local anesthetic toxicity – primarily with hyperbaric lidocaine and mepivacaine (the frequency of the condition after spinal anesthesia has been administered with hyperbaric lidocaine is reported to be 0-40% in the literature).

Extremely slow injection using narrow-lumen pencil-point spinal needles, creating “sacral pooling” of the local anesthetic.

Intrathecal pethidine administration.

Intraoperative patient positioning. In this case, the symptoms – particularly after procedures conducted with the patient in what is known as the “lithotomy” position (dorsosacral position; 30-36%) and after knee arthroscopy (18-22%) are seen much more frequently than in procedures conducted using a supine position during surgery (4-8%). Mechanical stretching of the spinal nerve roots probably promotes the development of TNS.

Early mobilization after outpatient procedures.

Injection trauma and obesity may also play a role.

It is regarded as proven that the following factors do not promote the development of TNS: sex, age, ethnic group, ASA physical status, weight, a history of back pain, type of injection needle used, position during the injection, and the addition of opioids such as fentanyl and sufentanil, or glucose.

What to do for suspected TNS

Neurological complications should be excluded on an urgent basis (epidural/spinal abscess, anterior spinal artery syndrome, cauda equina syndrome (CES)). It is necessary to maintain constant verbal contact with the patient, particularly after outpatient procedures.

Treatment

The most effective form of treatment is symptomatic – particularly the administration of nonsteroidal anti-inflammatory drugs, muscle-relaxing agents and injections at the affected trigger points.

Prophylaxis

The only way of providing absolute protection against the development of TNS is to avoid administering neuraxial anesthesia. Caution is advisable when selecting the local anesthetic. Local anesthetics such as bupivacaine or prilocaine should be used at the lowest possible dosages and concentrations (e.g. 7.5–10 mg bupivacaine, possibly with the addition of fentanyl or sufentanil). Vasopressors should not be added. Particular caution is needed in outpatients undergoing operations in the lithotomy position or knee arthroscopy.

Neurological complications

See also Chapter 41, p. 325.
Neurological complications occur extremely rarely after spinal anesthesia.

If there is the slightest suspicion, an immediate neurological consultation should be requested!

Etiology [62]

Traumatic nerve lesions due to direct trauma by the needle or catheter, or due to intraneural injection of the local anesthetic.

Toxic effects of the injected local anesthetic (see the section on cauda equina syndrome, below).

Hemorrhage into the spinal canal, particularly in patients with coagulation disorders (subarachnoid or subdural hemorrhage, epidural hematoma).

Vascular causes (thrombosis and spasm in the anterior spinal artery).

Infection in the form of bacterial meningitis, which may be caused by inadequate asepsis or bacterial transmission via blood or lymph.

Chemical irritation by substances used for skin prep at the puncture site.

Introduction of foreign bodies.

Exacerbation of latent neurological diseases (e.g. multiple sclerosis, tabes, tumor, viral infections).

Injury due to poor surgical positioning.

Psychogenic causes – e.g. as the initiating factor in paraplegic symptoms [27, 49].
Neurological complications can become manifest as arachnoiditis, myelitis, spinal or epidural abscess, cauda equina syndrome, or anterior spinal artery syndrome.

**Cauda equina syndrome (CES)**

Cauda equina syndrome is an extremely rare complication [33], which can occur after both intrathecal and epidural injections (single-shot or continuous techniques).

**Clinical symptoms**

Peripheral paralysis, often asymmetric, of both legs, “saddle-like” sensory disturbances of all types in the lumbar and sacral segments, pain, absence of spontaneous bladder or rectal emptying, impotence.

**Diagnosis**

MRI, CT and/or myelography [57, 78].

**Nerves of the cauda equina**

The nerves of the cauda equina, located in a poorly vascularized distal area of the dural sac, possess only a weak protective layer [57, 59, 60].

Consequently, they react particularly sensitively to:

- The effects of local anesthetics [60, 74], depending on the type, dose, baricity and duration of exposure, particularly when an epidural dose is inadvertently administered intrathecally.
- Harmful effects of various local anesthetics (chloroprocaine [80] and hexylcaine [98]) have been reported in the past. Since the 1990s, there have also been reports that hyperbaric lidocaine can damage the nerves of the cauda equina [85], particularly after intrathecal administration via microcatheters [60, 84, 85].

Bupivacaine has proved to be safe, although there have also been individual reports of CES after intrathecal administration of hyperbaric solutions or after continuous epidural administration [60].

Direct trauma caused by the needle or by a catheter, particularly microcatheters (see Chapter 38, p. 293).

Chemical irritation due to bacterial contamination.

**Risks**

**Repetition** of spinal anesthesia with a hyperbaric solution when the original block is incomplete represents a potential risk (see Chapter 36, section on relative contraindications, p. 273). In patients with spinal canal stenosis, caution should be exercised due to potential accumulation or incorrect spread of the local anesthetic [36, 37, 60, 84].

Most important prophylactic measures [56]

- Always choose the lowest possible concentration of the local anesthetic and inject it on an incremental basis.
- Caution should be exercised when using hyperbaric solutions (5% lidocaine in particular should be avoided).
- Advance the spinal catheter a maximum of 2–3 cm beyond the needle tip (see Chapter 38, p. 293).

**Anterior spinal artery syndrome**

This syndrome can be caused by direct trauma to the vessel or by ischemia in the anterior two-thirds of the distal spinal cord [62].

Injury to the artery produces a clearly definable clinical syndrome: motor disturbances and loss of pain and temperature sensitivity below the level of the lesion, with preserved positional sense and vibration sensitivity [74].
Continuous spinal anesthesia requires placement of a catheter in the subarachnoid space. Continuous administration of a local anesthetic or opioid, or a combination of the two, is carried out via the catheter to produce adequate intraoperative and postoperative analgesia.

History of continuous spinal anesthesia

1907  H.P. Dean reported the first use of CSA via an intrathecal spinal needle during surgery.

1944  E. Tuohy: a urethral catheter was introduced through a 15-G needle (PDPH > 30%).


1989  Introduction of the microcatheter technique (by Boom in the USA), 28-G spinal microcatheter through a 22-G needle.

1992  Reports on cauda equina syndrome (14 per 50,000). The Food and Drug Administration (FDA) banned the use of the spinal microcatheter in the USA. Suspected causes:
- Overdose with hyperbaric 5% lidocaine or 1% tetracaine.
- Extremely slow injection through the small diameter catheter, leading to "sacral pooling" of the local anesthetic.
- Caudal migration of the spinal microcatheter.

1993  In Germany, the BGA confirmed the above causes, but the continued use of spinal microcatheters for CSA was allowed.

1994  Development of a new "over-the-needle" CSA macrocatheter system (analogous to indwelling venous cannulas): lower risk of PDPH.

CSA is characterized [9, 56, 66] by:
- Rapid onset.
- Lowest possible dose of the local anesthetic or opioid by careful titration.
- Low incidence of cardiovascular and respiratory complications.

- Allows anesthesia to be prolonged as long as required.
- Shorter recovery times.
- Postoperative pain therapy.

Advantages over "single-shot" spinal anesthesia
- Injection of a local anesthetic only after placing the patient in the surgical position, with a consequent reduction in cardiopulmonary risk.
- Better checking and control of the spread of anesthesia due to careful titration.
- Prolongation of anesthesia for as long as required.
- Precise control and short recovery time, due to injection of medium-duration local anesthetics.
- At the end of the operation, the transition to opioid administration for postoperative pain therapy is made easier.

Advantages over continuous epidural anesthesia
- Easier identification of the subarachnoid space, and thus higher success rates, particularly when there are anatomical difficulties.
- Easy preoperative confirmation of subarachnoid positioning of the catheter.
- Only about 10% of the usual epidural dose is needed, so that the risk of toxicity is very low.
- Faster onset.
- Reliable block.
- Shorter recovery time.
- Lower risk of catheter migration.

Advantages over combined spinal and epidural anesthesia (CSE)
- Easy preoperative confirmation of subarachnoid positioning of the catheter.
- Reliable implementation of the anesthesia and postoperative pain therapy using only a single technique ("all-in-one system").
- Continuity and better control with rapidly-acting subarachnoid top-ups.
- Test dose to check the catheter position is unnecessary.
Indications
Long surgical procedures with subsequent postoperative pain therapy.
Older patients and high-risk patients.
Anatomical difficulties.
Use in vascular surgery, orthopedics, urology, gynecology and obstetrics, and in postoperative pain therapy.

Contraindications
These are the same as the general contraindications for neuraxial anesthesia (see Chapter 36).

Procedure
Full prior information for the patient is mandatory.

Continuous spinal anesthesia (CSA) should only be carried out by experienced anesthetists.

Preparations and materials
Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs).
Strict asepsis.
Intravenous access, anesthesia machine.
Ensure adequate intravenous volume loading with a balanced electrolyte solution (250–500 mL).
Careful monitoring: ECG monitoring, BP, pulse oximetry.

The use of a specific CSA set is recommended (Fig. 38.1).

Injection technique – through-the-needle system
Classical technique 
Standard 18-G epidural Tuohy needle, with a 20-G epidural catheter (e.g. Perifix®, B. Braun Melsungen) or a standard spinal needle (25–26 G), with a 32-G microcatheter or 22-G pencil-point spinal needle with a 28-G microcatheter.

Over-the-needle system (spinal needle lying in the catheter)
22-G or 24-G Spincath, epidural guiding needle with a 30° beveled tip, smoothly moving; catheter connector, flat epidural filter (0.2 mm, antibacterial), B. Braun Melsungen.

Patient positioning
The lateral decubitus position is preferred, but the paramedian approach, which offers the best angle for catheter placement, is also often used.

Injection technique – through-the-needle system
The needle bevel (Quincke, Tuohy or pencil-point) is first directed cranially. Shortly before the ligamentum flavum is reached, the needle is rotated 90° or directed laterally (Quincke, Tuohy), in order to puncture the dura after penetrating the ligamentum flavum. When the subarachnoid space has been reached, the bevel is rotated so as to face cranially. After removal of the stylet and free flow of CSF, the injection needle is advanced by 1–2 mm. The catheter is then carefully advanced into the subarachnoid space up to a maximum of 2–3 cm beyond the needle tip, to avoid neural irritation or vascular puncture. Once the catheter has been placed in the desired position, the needle is slowly withdrawn over the catheter. The catheter connector and bacterial filter are then attached, with the catheter being fixed in the same way as an epidural catheter. Careful aspiration of CSF (in microcatheters, aspiration can be very difficult or even impossible).

If there are technical difficulties, the catheter and injection needle are always removed together. A catheter must never be withdrawn through the needle.

The patient is then placed in the position required for the operation, and the drugs for subarachnoid administration are prepared (diluted with 0.9% saline when appropriate).
Continuous spinal anesthesia (CSA)

Over-the-needle system

Epidural puncture is carried out using the loss-of-resistance technique, with a needle that has a 30° bevel. This serves as the guiding needle for the Spinocath catheter system. The stylet is withdrawn (Fig. 38.2).

The catheter and internal spinal needle are grasped with the thumb, index finger, and middle finger at the end of the needle, ensuring secure fixation of the spinal needle in the catheter for the dural puncture (Fig. 38.3).

Dural puncture with the spinal needle and catheter tip (advance about 5 mm). The dural click and dilation of the hole in the dura by the catheter tip are usually easily felt.

CSF appears at the end of the spinal needle (lateral eye of the spinal needle) within about 3–6 s (22 G) or 6–10 s (24 G).

The catheter is grasped with one hand about 3 cm behind the guiding needle, and the pull-out wire is grasped at its end and stretched with the other hand (Fig. 38.4).

Advance the catheter over the spinal needle 2–3 cm at most into the spinal space (technique analogous to indwelling venous catheters).

Withdraw the spinal needle from the catheter completely with the withdrawal wire (Fig. 38.5).

Remove the epidural guiding needle, fixing the spinal catheter in the usual way.

The connector and flat filter are then attached.

Advantages

Easy puncture, secure positioning, little trauma, gentle dilation with the cone-shaped catheter tip, immediate sealing, no initial CSF loss and thus a reduced risk of postdural puncture headache.

Problem situation with the two techniques

Intrathecal positioning of the catheter – cranial or caudal?

Dosage

The lowest possible dose and concentration of local anesthetic or opioid must be selected. Always carry out injections in small, incremental doses (careful titration).

Surgical

Local anesthetic

0.5% bupivacaine (isobaric): 1–1.5 mL = 5–7.5 mg (± 0.2 mL) after careful titration.

0.5% bupivacaine (hyperbaric) for unilaterally accentuated anesthesia [71].

Combination

0.5% bupivacaine 2.5–5 mg and sufentanil 7.5–10 μg.
0.5% bupivacaine 2.5–5 mg and fentanyl 25 μg.

Repeat doses should be 30–50% of the initial dose.
Fig. 38.4 Advance the catheter about 2–3 cm over the spinal needle (keeping the catheter stretched with the other hand on the pull-out wire as this is done)

Fig. 38.5 Fix the catheter in position with one hand. Using the other hand, the spinal needle is withdrawn on the pull-out wire.
Postoperative pain therapy [70]
Interruption intrathecal administration:
0.25% bupivacaine (isobaric) – 1 mL every 4 h.
When there is inadequate analgesia, an additional injection of 0.5 mL 0.25% bupivacaine is given every 30 minutes (maximum dose 2.5 mL/4 h).

Continuous intrathecal infusion:
0.25% bupivacaine (isobaric) – 10 mL/24 h.
When there is inadequate analgesia, an additional injection of 1 mL 0.25% bupivacaine is administered initially; a maximum of 1 mL 0.5% bupivacaine can be given subsequently.

Disadvantages and complications
(see also Chapter 37)
Postdural puncture headache (PDPH)
The aim is to reduce the incidence of postdural puncture headache through the use of microcatheters (e.g. a 32-G microcatheter through a 26-G injection needle or a 28-G catheter through a 22-G pencil-point injection needle) or the Spinocath catheter system. It is assumed that an inflammatory reaction occurs in the area of the puncture site, which allows sealing of the dural perforation site and thus reduces or prevents CSF loss [56]. The initial CSF loss after catheter placement is in theory avoided when the Spinocath system is used.

Cauda equina syndrome (CES)
The etiology of the cauda equina syndrome is probably multifactorial. The microcatheter technique and subarachnoid injection of hyperbaric lidocaine or tetracaine have been linked to the development of CES [37, 85].

The causes are thought to be high doses and sacral pooling of the injected local anesthetic, due to the high injection resistance in the microcatheter. It is still unclear whether the neurological damage is caused by direct toxic effects of the local anesthetic or by indirect ischemic effects in the cauda equina area, which has a poor blood supply [56, 59].
It should also be emphasized that the subarachnoid space is very sensitive to any accidental injection of unintended medications – in contrast to the epidural space, which is very robust and more “forgiving” [12].

Shearing of the catheter
This rare complication can occur during catheter placement and catheter removal (particularly with the microcatheter technique).

Prophylaxis
When technical difficulties arise, never withdraw a spinal catheter through the needle.
A catheter should always be removed with extreme care. The patient is placed in the lateral position, with the back flexed in order to stretch the ligamentum flavum [4].
Never use force to pull the catheter, particularly against elastic resistance.
If difficulties arise, wait until the patient is able to stand.
Subsequent inspection of the catheter after removal to check that it is complete, and keeping a record of the removal, are obligatory.

Opioid side effects
See Chapter 50, additions to local anesthetics, section on opioids, p. 393.
Continuous spinal anesthesia

Name: __________________________ Date: __________________________

Diagnosis: __________________________

Premedication: □ No □ Yes

Neurological abnormalities: □ No □ Yes

Purpose of block: □ Surgical □ Therapeutic (postoperative)

Needle: □ G __ Tip: __ Spinal catheter G ____ (micro, macro) ____

i.v. access, infusion: □ Yes

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

Position: □ Lateral recumbent □ Sitting

Access: □ Median □ Paramedian

Injection level: □ L3/4 □ Other _______

Technique: □ Through-the-needle □ Over the-needle

Subarachnoid space: □ Identified

Catheter: □ Advanced 2–3 cm

Aspiration test: □ No □ Yes

Bacterial filter: □ No □ Yes

Abnormalities: □ No □ Yes _______

Injection:

Local anesthetic (isobaric, hyperbaric): ___________ mg ______ %

(incremental)

□ Opioid ___________ (µg) □ Other ___________ µg/mg/mL

□ Subsequent injection of ___________ mL ______ %

Patient’s remarks during injection:

□ None □ Pain □ Paresthesias □ Warmth

Duration and area: __________________________

Objective block effect after 15 min:

□ Cold test □ Temperature measurement before _____°C after _____°C

□ Sensory: L _______ T _______

□ Motor

Complications:

□ None □ Pain

□ Radicular symptoms □ Vasovagal reactions

□ BP drop □ Total spinal anesthesia

□ Subdural spread □ Respiratory disturbance

□ Drop in body temperature □ Muscle tremor

□ Bladder emptying disturbances □ Back pain

□ Postdural puncture headache □ Neurological complications

Special notes:

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The first reports on the use of CSA in obstetrics were published in 1951. However, due to the high incidence of postdural puncture headache, use of the procedure was very limited until the 1980s. The development of improved equipment, as well as the introduction of opioids for subarachnoid and epidural applications (particularly lipid-soluble sufentanil, fentanyl and pethidine), encouraged the wider use of this method.

Furthermore, further experience is still needed before this valuable method can be used routinely in obstetric anesthesia [4].

**Patient selection**
Candidates for continuous epidural anesthesia in obstetrics are also suitable for continuous spinal anesthesia.

**Advantages**
- Easy identification of the subarachnoid space.
- Higher success rate.
- Lowest possible dosage of local anesthetic, opioids or a combination of the two and thus low incidence of cardiotoxic effects.
- Faster onset of anesthesia and analgesia.
- Bilateral spread.
- Particularly suitable in high-risk patients [1, 15, 55].

**Procedure**
Full prior information for the patient is mandatory.

**Preparation and materials**
- Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs). Intravenous access, anesthetic machine.
- Strict asepsis.
- Ensure adequate intravenous volume loading with a balanced electrolyte solution (250–500 mL).
- Careful monitoring: ECG, BP, pulse oximetry.
- Antacid administration (see Chapter 43, p. 334).
- Prepare the drugs, diluting them with 0.9% saline when appropriate.

**Patient positioning and injection**
Puncture is carried out with the patient in the left lateral decubitus position, followed by placement of the spinal catheter, fixing of the catheter in position and placement of a bacterial filter.

Injection of a local anesthetic or opioid is always carried out on a incremental basis and at the lowest possible dosage, with careful monitoring (ECG, pulse oximetry; blood pressure monitoring; every 3 minutes during the first 30 minutes).

In obstetrics, it is recommended that the spinal catheter should not be left in place for more than 24 hours (risk of an increased PDPH rate).

**Dosages** (Table 39.1) [4, 73]

<table>
<thead>
<tr>
<th>Local anesthetics for vaginal delivery</th>
<th>Initial dose: 1 mL 0.25% bupivacaine. If this dose is inadequate, it can be supplemented with 0.5% bupivacaine, titrated with small boluses of 0.25 mL each [4].</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opioids for vaginal delivery</td>
<td>Sufentanil: 7.5–10 µg. Fentanyl: 25 µg. In contrast to fentanyl, sufentanil (10 µg) has a faster onset and is more effective [64].</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>Local anesthetics: 0.5% bupivacaine (isobaric or hyperbaric), 2 mL increments = 10 mg (the maximum dose of 20 mg is rarely necessary) [4, 71].</td>
</tr>
</tbody>
</table>
Table 39.1  Vaginal delivery: dosage and duration of effect of subarachnoidally administered drugs [4, 73]

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose</th>
<th>Onset of effect</th>
<th>Duration of effect</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufentanil</td>
<td>10 µg</td>
<td>2–10 min</td>
<td>60–180 min</td>
<td>Better analgesia than with fentanyl</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>25–50 µg</td>
<td>2–10 min</td>
<td>30–120 min</td>
<td></td>
</tr>
<tr>
<td>Pethidine</td>
<td>10–20 mg</td>
<td>2–10 min</td>
<td>60–180 min</td>
<td>Has sedative effects (higher dosage),</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>more frequent vomiting</td>
</tr>
<tr>
<td>Morphine*</td>
<td>0.2–2 mg</td>
<td>30–60 min</td>
<td>8–24 h</td>
<td>Respiratory depression</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>2.5–5 mg</td>
<td>15–20 min</td>
<td>30–60 min</td>
<td>Frequent tachyphylaxis</td>
</tr>
</tbody>
</table>

* Doses ≥ 2.5 mg are often accompanied by itching, nausea and vomiting.

Combination of opioids and local anesthetics

Initial dose: 1.5 ± 0.2 ml, 0.5% bupivacaine, hyperbaric, with the addition of 10 µg sufentanil.

Sufentanil and pethidine are more effective than fentanyl. All three opioids can lead to a slight decrease in blood pressure (not greater than 15% of the baseline). The Apgar score in neonates remains normal [4].

Opioid side effects [4]

See Chapter 50, section on opioids, p. 393.

Other complications

When CSA is used in obstetrics, the same complications must be expected as described earlier for continuous spinal anesthesia (see Chapter 38, p. 297) and continuous epidural anesthesia in the obstetric field. The occurrence of cauda equina syndrome after CSA in obstetrics has not yet been reported [4]. Various postpartum neuropathies (e.g. of the femoral nerve or obturator nerve), the duration of which is limited, must not be confused with cauda equina syndrome.
40 Chemical intraspinal neurolysis with phenol in glycerol

Chemical intraspinal neurolysis of the posterior spinal cord roots allows transient selective blocking of pain without any significant effect on cutaneous sensation or proprioception [47, 66, 69]. Neurolytic substances at appropriate concentrations (phenol in glycerol, alcohol and chlorocresol) are used to destroy the thin C fibers, A-delta fibers and A-gamma fibers, while only having a slight effect on the larger motor fibers [47] (Fig. 40.1).

At low doses of phenol, there is neither permanent motor weakness nor long-term loss of sensibility. Glycerol is used as the carrier substance for phenol. Phenol not only has destructive neurolytic effects, but also acts as a local anesthetic.

Indications
Pain in the advanced stages of malignant disease (e.g. rectum, prostate, bladder, gynecological tumors). This method is particularly valuable for tumor-related pain in the rectal area.

When opioids are ineffective in the terminal stages (method of choice in poor prognoses and poor general condition).

When the patient declines neurosurgical pain-relieving procedures.

Spastic paraplegia with no hope of functional recovery (spasticity, hyperreflexia and pain).

Contraindications
The general contraindications for spinal anesthesia apply (see Chapter 36, p. 272f).
No anesthetic expertise.

Procedure
Full prior information for the patient is mandatory.

Preparations and materials
Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs); sterile precautions, intravenous access, anesthetic machine.

Commence intravenous infusion and ensure adequate volume loading (250–500 mL of a balanced electrolyte solution).

Careful monitoring: ECG, BP control, pulse oximetry.

Spinal needle with Quincke tip, 22 G (due to the high viscosity).

1-mL tuberculin syringe.

2-mL syringe with 1–2 mL 0.9% saline.

Ampoule with 5% or 10% phenol in glycerol (Fig. 40.2).

Fig. 40.1 Saddle-like spread of the phenol
Warm the phenol ampoule to body temperature to reduce the viscosity [66] and then draw it up into the tuberculin syringe.

**Prerequisites**

Prerequisites for a neurolytic injection are:

- A prior prognostic spinal block with a local anesthetic (e.g., with hyperbaric 4% mepivacaine). This is the only way to identify the correct dose and avoid giving patients with central pain an injection that is not indicated.
- Very experienced anesthetist.
- No analgesics and no premedication on the day of the block, so that the effect of the neurolytic can be more easily assessed.

**Positioning and injection technique**

The patient is placed in a sitting position, since the aim is to achieve saddle-block anesthesia. In cases of rectal carcinoma, sitting is almost impossible due to severe “fireball” pain in the anal region. A rubber ring is very helpful in such cases (Fig. 40.3).

Puncture with a 22-G spinal needle in the region of the L5/S1 segment.

Free CSF flow must be demonstrated in all four quadrants (rotate the needle and bevel) (Fig. 40.4). There is a risk of necrosis if phenol is inadvertently injected into neighboring tissues.

Very slow injection of phenol (0.5 mL over 30 min) (Fig. 40.5). The correct dosage is based on the test block with local anesthetic. Normally, symptoms improve quickly after the administration of 0.1–0.2 mL phenol, so that the patient ceases to feel any pain while sitting. If this improvement does not occur, it is usually because the phenol concentration selected was too low.

A 10% solution is preferred by the author.

Constant checking of sensation by the assistant during the injection: pin-prick method (Fig. 40.6).

After injecting the required amount of neurolytic (the authors recommend 0.5–0.6 mL per session), the spinal needle is cleared of residual phenol by the injection of 1 mL 0.9% saline and withdrawn (Fig. 40.7).

The patient remains seated for the following 2–3 hours. After this, only 5% of the phenol is still bound to the glycerol and an optimal saddle block is achieved.
To minimize the risks and achieve better distribution of the phenol, spread the total dose of 1–1.2 mL over two successive days.

**Observations after the block**

Transient numbness in the calf region often occurs on the day of the injection. The first injection rarely produces adequate pain reduction. A repeat block is possible when the pain recurs. The average duration of pain reduction is about two to three months, although in the author’s experience the duration of effect is difficult to assess in advance. It can range from 1–2 days to 6 months.

---

**Complications**

Complications are rare and transient [69]. The sensory and motor supply to the urinary bladder and rectum originates in the lumbosacral segments. If the procedure is not carried out carefully, there is therefore a possibility of loss of sphincter function in the bladder and rectum. In the extensive literature over the last 40 years, the frequency of this complication is reported to be 3–5%.

The loss of function is transient and usually limited to 4–6 weeks, depending on the recovery period required by the nerve fibers affected by the neurolytic. The patient must be made aware of this potential complication.
Record and checklist

Neurolysis with phenol in glycerol

Name: __________________________ Date: __________________________

Diagnosis: __________________________

Premedication: □ No □ Yes

Neurological abnormalities: □ No □ Yes

Purpose of block: □ Therapeutic

Needle: □ Quincke 22 G

i.v. access, infusion: □ Yes

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed □ Consent

□ Prognostic spinal anesthesia carried out

Position: □ Sitting

Access: □ Median

Injection level: □ L5–S1 □ Other

Free CSF flow: □ At all 4 levels

CSF: □ Clear □ Slightly bloody □ Bloody

Abnormalities: □ No □ Yes

Injection:

Phenol in glycerol: _____ mL □ 5% _____ mL □ 10%

Injection time: _____ min

□ Sensory and motor function checked during injection

Patient’s remarks:

□ During the injection: __________________________

After phenol administration:

Injection of 1 mL 0.9% NaCl through the spinal needle:

□ Yes □ No

Complications:

□ None □ Bladder emptying disturbances

□ Bowel emptying disturbances □ Postdural puncture headache

□ Back pain □ Neurological complications

Subjective effects of block:

□ None □ Increased pain

□ Reduced pain □ No pain

VISUAL ANALOG SCALE

0 10 20 30 40 50 60 70 80 90 100

Special notes:

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In epidural anesthesia, drugs are injected into the extradural space in order to interrupt conduction in the somatic and autonomic nerve fibers. In addition to local anesthetics, opioids, steroids and homologous blood, other substances can also be used, mainly as adjuvants – e.g. the alpha-2-adrenoceptor agonist clonidine, vasopressors, or ketamine.

The epidural space (cavum epidurale) lies between the widely separated laminae of the meninges: the thin periosteal lamina (lamina externa, endorrhachis), which covers the spinal cord; and the lamina interna – the spinal dura mater.

Laterally, the epidural space is bounded by peristeum and by the intervertebral foramina. Ventral and dorsally, it is enclosed by the anterior longitudinal ligament of the vertebrae and the ligamentum flavum (Fig. 41.1). In the cervical region, the ligamentum flavum is much thinner and not very elastic. The ligamentum flavum is thickest in the midline in the lumbar region. The distance between the skin and the epidural space is about 4 cm in approximately 50% of patients and between 4 cm and 6 cm in 80%.

Fig. 41.1 Cross-section of the epidural space. (1) Ligamentum flavum, (2) epidural space with venous plexus, (3) spinal ganglion, (4) spinous process, (5) body of vertebra, (6) dorsal branch of spinal nerve, (7) ventral branch of spinal nerve
of patients. The range extends from less than 3 cm (in slim individuals) to more than 8 cm (in obese patients).

The distance between the ligamentum flavum and the dura mater varies from 2-3 mm in the cervical area to up to 5-6 mm in the mid-lumbar region [23]. The epidural space extends from the foramen magnum to the sacrococcygeal ligament. It is connected via the intervertebral foramina with the paravertebral space. It has an indirect transdural link to the CSF. The substantial epidural venous network is connected to the azygos vein and to the pelvic, abdominal and thoracic veins [11, 23].

In addition to fat and connective tissue, the epidural space contains lymph, the internal and external vertebral venous plexuses and the roots of the spinal nerves. The width of the epidural space is 4-7 mm in the lumbar region, 3-5 mm in the thoracic region and 3-4 mm in the cervical region (C7-T1). The dura mater is 0.3-0.7 mm thick in the lumbar region, 1 mm thick in the central thoracic region, and 1-1.5 mm thick in the cervical region. There is negative pressure in the epidural space in some 80-90% of patients. However, the negative pressure is not the same at all levels and it varies according to intrathoracic respiratory pressure variations, as well as to posture. The negative pressure increases in the sitting position, while in the supine position it is reduced. It is also reduced in pulmonary diseases (emphysema, asthma) and during heavy coughing or straining.

**Indications**

The use of epidural anesthesia has proved particularly valuable in the following groups of patients:

- Those with a full stomach.
- Those in whom tracheal intubation difficulties are expected.
- Those with a history or suspicion of malignant hyperthermia.
- Muscle disease.
- Cardiopulmonary disease.
- Metabolic disease.
- Renal and hepatic disease.
- Stable neurological diseases.
- Elderly patients.

**Surgical indications**

- Procedures in the area of the lower extremities, hip joints and inguinal region.
- Vascular surgery.
- Upper abdominal and thoracic procedures, in combination with general anesthesia.
- Urological procedures (prostate, bladder).
- Gynecological and obstetric procedures.
- Procedures in the perineal and perianal region.
- Interventional radiology.

**Postoperative and post-traumatic pain therapy**

Usually in combination with local anesthetics and opioids.

**Therapeutic block with injection of depot corticoids**

Caudal, lumbar or cervical.

**Epidural injection of homologous blood or dextran, or fibrin glue patch in postdural puncture headache**

**Contraindications**

**Specific**

- Patient refusal.
- Patients under general anesthesia.
- Coagulation disorders, anticoagulant therapy.
- Sepsis.
- Local infections at the injection site.
- Immune deficiency.
- Severe decompensated hypovolemia, shock.
- Specific cardiovascular diseases of myocardial, ischemic or valvular origin, if the procedure being carried out requires sensory spread up to or beyond T6.
- Acute diseases of the brain and spinal cord.
- Raised intracranial pressure.
- A history of hypersensitivity to local anesthetics, without a prior intradermal test dose.

**Relative**

- These contraindications always require a risk–benefit analysis and are more medicolegal in nature:
  - Chronic disorders of the brain and spinal cord.
  - Severe spinal deformities, arthritis, osteoporosis, intervertebral disk prolapse or pain after intervertebral disk surgery.
  - After spinal fusion, spinal metastases.

**Injection-related**

- Additional attempts after three unsuccessful punctures.
- Inexperienced anesthetist without supervision.
- No anesthetic expertise.
Lumbar epidural anesthesia

- Insertion should always be carried out below the level of L2 (conus medullaris). Insertion above the L2 segment must only be carried out by a technically highly skilled anesthetist and should have specific indications [13].
- Any severely radiating pain occurring during the insertion is a warning signal. The needle must not be advanced any further.
- Epidural insertion in patients under general anesthesia, particularly above the L2 segment, should generally be avoided, except in the hands of the most skilled anesthesiologists. One exception to this rule is epidural insertion in children, which must be left to experienced pediatric anesthesiologists [13, 54].

Procedure

Full prior information for the patient is mandatory.

Preparations and materials

Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs); sterile precautions, intravenous access, anesthetic machine.

Insert an intravenous cannula and give a volume load (250–500 mL of a balanced electrolyte solution).

Precise monitoring: ECG, BP, pulse oximetry.

The use of purpose-designed kit for epidural anesthesia is recommended (e.g. from B. Braun Melsungen) (Fig. 41.2).

Disinfectant.

Local anesthetic.

Epidural needles

Tuohy, Hustead, Crawford, or Weiss (Fig. 41.3).

Fig. 41.2 Materials

Fig. 41.3a–d Epidural needles.

a Tuohy, b Hustead, c Crawford, d Weiss
**Chapter 41**

**Single-shot technique**

**Patient positioning**
Optimal positioning of the patient during the injection and fixation phase of the local anesthetic is the prerequisite for success. Lumbar epidural anesthesia can be carried out with the patient in the lateral decubitus position (preferred) or sitting.

It is important with both positions to minimise lumbar lordosis and to identify the midline.

**Injection technique**

**Median approach**

**Landmarks**
The injection is carried out in the midline below the L2 segment (conus medullaris), usually between the spinous processes of L2/L3 or L3/L4. The intervertebral space is palpated and the midline is located to serve as the most important signpost. In the midline, the ligamentum flavum is at its thickest, the epidural space is widest and the blood vessels are at their smallest. The injection site is marked with the thumbnail (Fig. 41.4).

**Strict asepsis**
Thorough, repeated and wide skin prep, drying and covering of the injection site with a drape.

**Local anesthesia**
Local infiltration of the skin and supraspinous and interspinous ligaments is carried out between the spread index and middle fingers of the left hand, using 1–1.5 mL of a local anesthetic (e.g. 1% prilocaine) (Fig. 41.5).

**Skin incision**
Using a stylet or a large needle (Fig. 41.6).

**Puncture of the supraspinous and interspinous ligaments and ligamentum flavum**
Without moving the spread index and middle fingers of the left hand from the intervertebral space, an epidural needle is fixed between the thumb of the right hand (hub) and the index and middle finger (shaft) and advanced through the skin incision (Fig. 41.7). After passing the supraspinous ligament, which is about 1 cm thick, the needle, with its bevel directed laterally, is advanced a further 2–3 cm (depending on the anatomy), until it rests firmly in the interspinous ligament.

The trochar is removed and a low friction syringe is attached (Fig. 41.8).

![Fig. 41.4 Conus medullaris (lower edge of the first lumbar vertebra), (1) Conus medullaris, (2) cauda equina, (3) dural sac, (4) L1 segment](image)

Care should be taken to ensure that the needle is kept in the midline.

Inadvertent deviation from the midline leads to the needle passing the supraspinous ligament, with a angled entry into the interspinous ligament with only brief resistance and a subsequent false loss of resistance. This type of puncture ends in the paravertebral musculature and is accompanied by local pain. The laminae and superior and inferior articular processes of the vertebrae may also be affected. As the articular processes are innervated, puncture trauma is accompanied by severe localized ipsilateral back pain, spasm of the paravertebral muscles and pain radiating into the leg. This type of pain is often confused with radicular pain.
After passing the interspinous ligament, the needle must be advanced carefully, millimeter by millimeter, in the direction of the ligamentum flavum.
Chapter 41

**Advantage**

When the epidural space has been reached, no fluid should emerge from the needle. Any CSF that emerges is therefore more easily identified.

**Disadvantages**

The loss of resistance is not as clear and the dura is not pushed aside from the needle tip in the same way as it is using the saline injection. Complications have been reported [6, 80, 88] – e.g. pneumocephalus, compression of the spinal cord and nerve roots by air collecting in the epidural space, air embolism, air collecting retroperitoneally, subcutaneous emphysema.

After air has been injected into the epidural space, irregular spread of the epidural anesthesia may occur, as the air bubbles act as a mechanical barrier. However, an even more important aspect is that when epidural anesthesia is combined with general anesthesia, the injected air may pose a danger to the patient. If nitrous oxide is used, it may diffuse quickly into the air bubbles and substantially expand them. Like large hematomas, large gas bubbles can compress the spinal cord and thereby cause transient or permanent neurological injury.

**Fig. 41.9 Identifying the epidural space (loss of resistance)**

**Puncturing the epidural space**

The thumb and index finger of the left hand, which is resting with the back of the hand firmly against the patient’s back, secure the needle, advance it millimeter by millimeter and at the same exercise a braking function. The thumb of the right hand applies pressure on the syringe plunger. Loss of resistance indicates that the epidural space has been reached. The contents of the syringe are easily injected. Identification of the epidural space is carried out using the **loss-of-resistance technique** (Fig. 41.9).

The following variations on this technique can be applied:

**Technique using saline or air**

**Saline:** after the interspinous ligament has been reached, the stylet is removed and a low-friction syringe filled with a saline solution and with a small air bubble in it, serving as a visual indicator, is attached. When the ligamentum flavum is encountered, the air bubble is compressed by pressure on the syringe plunger (Fig. 41.10a); when the epidural space is reached, the bubble returns to its normal, larger shape (Fig. 41.10b).

**Air:** this technique is not suitable for inexperienced anesthetists or in insertions likely to be associated with technical difficulties [80, 82].

"**Hanging drop**" technique

After the interspinous ligament has been reached, a drop of saline is placed within the hub of the needle (Fig. 41.11a). After the ligamentum flavum has been passed and the epidural space has been reached, the drop is "sucked in" by the vacuum that is usually present during the inspiration phase (Fig. 41.11b).
Fig. 41.10a Loss-of-resistance technique with saline. The air bubble is compressed by pressure on the syringe plunger.

Fig. 41.10b Loss-of-resistance technique with saline. The epidural space has been reached. The air bubble has returned to its normal, loose shape.
Fig. 41.11a “Hanging drop” technique. The epidural needle is positioned in the ligamentum flavum.

Fig. 41.11b “Hanging drop” technique. The epidural space has been reached. The drop is sucked back in.
Aspiration and injection of a test dose
Careful aspiration is carried out (Fig. 41.12). The needle continues to be secured by the thumb and index finger of the left hand, resting with the back of the hand firmly against the patient’s back. After negative aspiration, a test dose of 3–4 mL of local anesthetic, usually with epinephrine added, can be injected. This allows easier detection of possible intravascular injection if tachycardia occurs (Fig. 41.13).

The addition of epinephrine can lead to unreliable results in the following groups of patients [63]:
- Patients taking beta-blockers [42, 62].
- Patients under general anesthesia [29, 58, 95].
- Older patients [43].
- Pregnant patients [19].

Caution when adding epinephrine is required in:
- Pregnant patients (transient fetal bradycardia due to reduced uterine blood flow [57]).
- Older patients with coronary heart disease.
- Arteriosclerosis, hypertonia, diabetes.

Contraindications to the addition of epinephrine are:
- Glaucoma (with closed iridocorneal angle).
- Paroxysmal tachycardia, high-frequency absolute arrhythmia.

The test dose should be allowed 5 minutes to take effect. During this period, the needle should be rotated at 1-minute intervals (Fig. 41.14). Five minutes after administration of the test dose, the spread of the anesthesia is checked to exclude inadvertent subarachnoid injection. The patient is asked whether there is a sensation of warmth or numbness in the lower extremities. The following points are important in this phase:
- Maintaining constant verbal contact with the patient.
- Careful cardiovascular monitoring.

If all is well, a local anesthetic can be injected.
Injection of a local anesthetic (Fig. 41.15)

After aspiration has been repeated, incremental administration of a local anesthetic is carried out. In a "single-shot" injection, half of the planned dose is initially injected at a speed of 0.3–0.5 mL/s; the syringe is disconnected again, a check is made for any escaping fluid and only then is the remainder of the dose administered. After aspiration has been repeated shortly before the end of the injection, the needle is withdrawn and the patient is placed in the desired position.

Problem situations

Escaping fluid

After the epidural space has been identified or after administration of the test dose, a few drops of fluid may still drip from the positioned needle. This phenomenon often worries inexperienced anesthetists.

Procedure:

During an attempt at aspiration, the viscosity of the fluid should be noted.

The patient is asked to breathe in and out deeply. If the needle is positioned epidurally, there is synchronous movement of the fluid drop.

A few drops of fluid can be tested on the back of the hand to check whether they are cold or warm: colder and slowly dripping fluid suggests saline, whereas warmer and quickly dripping fluid suggests CSF (Fig. 41.16).

Test the glucose content of the fluid.

Escaping blood (Fig. 41.17)

The following steps are possible:

Another attempt at insertion, one segment higher or lower.

Administer general anesthesia.

In all other indications – e.g. therapeutic blocks – it is advisable to abandon the procedure.
Escaping CSF

The method of choice in surgical procedures is to carry out spinal anesthesia when the CSF is clear. Another attempt at insertion. It should be taken into account that an epidural dose of local anesthetic can spread intrathecally through the existing dural leak (larger puncture needles, 16–18 G) and can lead to total spinal anesthesia. Administer general anesthesia. In all other indications – e.g. therapeutic blocks – it is again advisable to abandon the procedure. Patients must be informed about the possibility of postdural puncture headache.

The following measures have proved valuable for reducing the risk of complications: aspiration, test dose of a local anesthetic containing epinephrine and incremental administration of the local anesthetic.

Paramedian (paraspinal) approach (Fig. 41.18)

This technique, which is independent of lumbar lordosis or the ability of the spine to flex, avoids puncture of the supraspinous ligament and the frequently ossified interspinous ligament. The puncture site is located in the selected intervertebral space, about 1.5–2 cm lateral from the upper edge of the lower spinous process. Fan-shaped local anesthesia identifies the depth of the vertebral arches (laminae), which are marked (4–6 cm). The epidural needle (usually 18-G Crawford) is introduced in a craniomedial direction at an angle of about 15° to the sagittal level and about 35° to the skin surface, so that it passes the laminae and slides into the interlaminar fissure. The only ligament that needs to be penetrated on the way to the epidural space is the ligamentum flavum. Reaching this is characterized by a “leathery” resistance. The most important step in this technique is to identify the depth of the ligamentum flavum. The trochar is then removed from the puncture needle and identification of the epidural space is carried out in the same way as described for the single-shot technique.
**Lumbar epidural anesthesia**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis:</td>
<td></td>
</tr>
<tr>
<td>Premedication:</td>
<td>No Yes</td>
</tr>
<tr>
<td>Neurological abnormalities:</td>
<td>No Yes</td>
</tr>
</tbody>
</table>

**Purpose of block:**
- Surgical
- Therapeutic
- Diagnostic

**Needle:**
- Tuohy G
- Other

**i.v. access, infusion:**
- Yes

**Monitoring:**
- ECG
- Pulse oximetry

**Ventilation facilities:**
- Yes (equipment checked)

**Emergency equipment (drugs):**
- Checked

**Patient:**
- Informed

**Position:**
- Lateral decubitus
- Sitting

**Access:**
- Median
- Paramedian

**Injection level:**
- L3/L4
- Other

**Injection technique:**
- Loss of resistance
- Other

**Epidural space:**
- Identified

**Aspiration test:**
- Carried out

**Test dose:**
- Epinephrine added: Yes No

**Check on sensorimotor function after 5 min:**
- Carried out

**Abnormalities:**
- No Yes

**Injection:**
- Local anesthetic:
  - mL % (incremental)
- Addition: pg/mg

**Patient's remarks during injection:**
- None Pain Paresthesias Warmth

**Duration and area:**

**Objective block effect after 20 min:**
- Cold test
- Temperature measurement before after °C
- Sensory L T
- Motor

**Complications:**
- None
- Radicular symptoms
- BP drop
- Vascular puncture
- Massive epidural anesthesia
- Subdural spread
- Drop in body temperature
- Bladder emptying disturbances
- Back pain
- Pain
- Vasovagal reactions
- Dural puncture
- Intravascular injection
- Total spinal anesthesia
- Respiratory disturbance
- Muscle tremor
- Postdural puncture headache
- Neurological complications

**Special notes:**

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Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Continuous epidural anesthesia*

Procedure

The identification of the epidural space is carried out in the same way as in the single-shot injection. After the epidural space has been reached and loss of resistance has been confirmed, the aspiration test is carried out. Before the catheter is introduced, the needle bevel should be directed cranially.

The thumb and index finger of the left hand secure the epidural needle, with the back of the hand lying firmly on the patient’s back. The catheter is advanced cranially, using the thumb and index finger of the right hand, to a maximum of 3–4 cm (Fig. 41.19). Advancing it further than this can lead to lateral deviation of the catheter, with accompanying paresthesias. After placement of the catheter in the desired position, the needle is slowly withdrawn (Fig. 41.20a), while at the same time the thumb and index finger of the left hand secure the catheter at the injection site (Fig. 41.20b).

* If technical difficulties are experienced, the catheter and puncture needle must always be removed simultaneously. The catheter must never be withdrawn through the positioned puncture needle.
An adapter is attached to the end of the catheter. The patency of the catheter is tested by injecting 1–2 mL saline (Fig. 41.21). After aspiration, the syringe is disconnected and the open end of the catheter is placed on a sterile drape below the puncture site. Attention must be given to any escaping fluid (CSF or blood) (Fig. 41.22).

A bacterial filter is then attached (Fig. 41.23a) and the catheter is secured with a skin suture and a dressing (Fig. 41.23b). The patient is placed in the desired position and a test dose is administered, as with the single-shot injection. During the waiting period, it is important to maintain verbal contact with the patient and to check the spread of the anesthesia, to exclude the ever-present risk of inadvertent subarachnoid injection.
A subdural injection cannot always be excluded with absolute certainty, in spite of all precautions. After 5 minutes, the remainder of the dose, adjusted for the individual patient, can be administered on an incremental basis (max. 5 mL each injection) until the desired level of anesthesia is reached (Fig. 41.24).

**Problem situations**
Blood in the catheter (Fig. 41.25).
The catheter is withdrawn 0.5–1 cm and rinsed with 2–3 mL saline. After waiting and subsequent aspiration, a test dose can be given if no further blood is observed. If blood is still present, the catheter must be withdrawn.

**Escaping CSF**
When subarachnoid positioning of the catheter is demonstrated, the following steps are possible:
- Inject a spinal dose and then remove the catheter.
- Carry on with continuous spinal anesthesia.
- Remove the catheter and administer general anesthesia.

The patient must be informed about the possibility of postdural puncture headache.

**Monitoring an epidural catheter**
Continuous pain therapy using an epidural catheter also requires continuous monitoring and checking of efficacy. This includes the following points in particular:
- Daily checking of the catheter position, so that intravascular or subarachnoid migration can be recognized early.
- Changing the bacterial filter and dressing every 2 days, with careful checking of the puncture site, to minimize the risk of bacterial colonization and associated infection.
- Continuous monitoring of efficacy and – if necessary – adjustment of the dose of local anesthetic, opioid, or other adjuvant substance.
- Records must be kept.
Lumbar catheter epidural anesthesia

Name: ___________________ Date: ____________

Diagnosis: ___________________

Premedication: □ No □ Yes

Neurological abnormalities: □ No □ Yes

Purpose of block: □ Surgical □ Therapeutic

Needle: □ Tuohy G □ Other

i.v. access, infusion: □ Yes

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

Position: □ Lateral decubitus □ Sitting

Access: □ Median □ Paramedian

Injection level: □ L3/L4 □ Other

Injection technique: □ Loss of resistance □ Other

Epidural space: □ Identified

Catheter: □ Advanced 3–4 cm cranially

Aspiration test: □ Carried out

Catheter end: □ Placed deeper than the puncture site

Bacterial filter: □

Test dose: ____________ Epinephrine added: □ Yes □ No

Check on sensorimotor function after 5 min: □ Carried out

Abnormalities: □ No □ Yes

Injection:

□ Local anesthetic: ____________ ml ____________ % (incremental)

□ Addition: ____________ µg/ml

□ Subsequent injection (incremental): ____________ ml ____________ %

Patient’s remarks during injection:

□ None □ Pain □ Paresthesias □ Warmth

Duration and area:

Objective block effect after 20 min:

□ Cold test □ Temperature measurement before _____ °C after _____ °C

□ Sensory: L _____ T _____ □ Motor

Complications:

□ None □ Radicular symptoms □ BP drop □ Vascular puncture

□ Massive epidural anesthesia □ Subdural spread □ Drop in body temperature

□ Bladder emptying disturbances □ Back pain □ Pain □ Vasovagal reactions

□ Dural puncture □ Intravascular injection □ Total spinal anesthesia

□ Respiratory disturbance □ Muscle tremor □ Postdural puncture headache

□ Neurological complications

Special notes:

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Local anesthetic in the epidural space may take three routes.
- Resorption into the circulation via the epidural venous plexus.
- Transdural diffusion into the cerebrospinal fluid.
- Lateral spread through the intervertebral foramina and associated paravertebral block of the spinal nerves.

The targets of epidural injection of local anesthetic are the intradurally located roots of the spinal nerves, which are reached by diffusion through the dura. The spread of the injected local anesthetic is influenced by the following factors:
- Volume and concentration have the greatest influence.
- The speed of injection has a minimal influence on the quality of the anesthesia. Too fast an injection can lead to dangerous cerebrospinal and cardiotoxic complications.
- The positioning of the patient is much less important than in spinal anesthesia.
- Location of the injection and diameter of the nerve roots:
  - In injections in the lumbar region, the local anesthetic tends to spread more cranially, so that (particularly when injecting lipophilic local anesthetics such as etidocaine) block of segments L5–S2 is markedly delayed and they are incompletely blocked – probably due to the larger diameter of the nerve roots (S1 about 3.8 mm, S2 about 3.4 mm).
  - For the same reasons, the upper thoracic and lower cervical segments show resistance to the effect of local anesthetics.
- Injection level: the closer the injection site, the shorter is the latency.
- Anatomic relationships: Spinal deformities or operations near the spinal cord often lead to alterations of relationships in the epidural space and consequently affect the spread of local anesthetics.

Dosages

Surgical anesthesia

Medium-duration amide local anesthetics
(Table 41.1)

These local anesthetics are characterized by their low molecular weight, low lipophilia, moderate protein binding and high dissociation constant. At concentrations of 1.5–2%, they produce rapid and good analgesia and a low motor block.
Table 41.1 Medium-duration amide local anesthetics

<table>
<thead>
<tr>
<th>Local anesthetic</th>
<th>Epidural dose</th>
<th>Onset of effect</th>
<th>Maximum dose</th>
<th>Duration of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5–2% lidocaine</td>
<td>15–30 ml</td>
<td>10–30 min</td>
<td>300 mg</td>
<td>80–120 min</td>
</tr>
<tr>
<td>with epinephrine</td>
<td></td>
<td></td>
<td>500 mg</td>
<td>120–180 min</td>
</tr>
<tr>
<td>1.5–2% mepivacaine</td>
<td>15–30 ml</td>
<td>10–30 min</td>
<td>300 mg</td>
<td>90–140 min</td>
</tr>
<tr>
<td>with epinephrine</td>
<td></td>
<td></td>
<td>500 mg</td>
<td>140–200 min</td>
</tr>
<tr>
<td>1.5–2% prilocaine</td>
<td>15–30 ml</td>
<td>12–16 min</td>
<td>400 mg</td>
<td>ca. 100 min</td>
</tr>
<tr>
<td>with epinephrine</td>
<td></td>
<td></td>
<td>600 mg</td>
<td>ca. 140 min</td>
</tr>
</tbody>
</table>

Long-duration amide local anesthetics (Table 41.2)

<table>
<thead>
<tr>
<th>Local anesthetic</th>
<th>Epidural dose</th>
<th>Onset of effect</th>
<th>Maximum dose</th>
<th>Duration of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75% ropivacaine</td>
<td>15–25 ml</td>
<td>10–20 min</td>
<td>250 mg (300)</td>
<td>180–300 min</td>
</tr>
<tr>
<td>1% ropivacaine</td>
<td>15–20 ml</td>
<td>10–20 min</td>
<td>250 mg (300)</td>
<td>240–360 min</td>
</tr>
<tr>
<td>0.5% levobupivacaine</td>
<td>15–20 ml</td>
<td>18–30 min</td>
<td>150 mg</td>
<td>160–210 min</td>
</tr>
<tr>
<td>0.5–0.75% bupivacaine</td>
<td>15–30 ml</td>
<td>18–30 min</td>
<td>150 mg</td>
<td>165–240 min</td>
</tr>
<tr>
<td>1% etidocaine</td>
<td>15–30 ml</td>
<td>10–15 min</td>
<td>300 mg</td>
<td>150–280 min</td>
</tr>
</tbody>
</table>

Incomplete epidural anesthesia

In incomplete epidural anesthesia (failure to spread to specific segments or inadequate motor block), it is recommended that an additional injection be carried out after a delay of about 30 minutes for safety. The additional injection into the epidural catheter should be half of the initial dose – e.g. 2% lidocaine with added epinephrine.

Diagnostic and therapeutic blocks

Medium-duration amide local anesthetics (Table 41.3)

<table>
<thead>
<tr>
<th>Block</th>
<th>Sympathetic</th>
<th>Sensory</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidocaine</td>
<td>0.5%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Mepivacaine</td>
<td>0.5%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Prilocaine</td>
<td>0.5%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Long-duration amide local anesthetics (Table 41.4)

<table>
<thead>
<tr>
<th>Block</th>
<th>Sympathetic</th>
<th>Sensory</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ropivacaine</td>
<td>0.2%</td>
<td>0.375%</td>
<td>0.75–1%</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>0.125%</td>
<td>0.25%</td>
<td>0.5–0.75%</td>
</tr>
<tr>
<td>Levo-bupivacaine</td>
<td>0.125%</td>
<td>0.25%</td>
<td>0.5–0.75%</td>
</tr>
</tbody>
</table>
Lumbar epidural anesthesia

Postoperative or post-traumatic pain therapy

Continuous epidural infusion

Local anesthetics
- 0.2–0.3% ropivacaine
  Speed: 6–14 mL/h
  (usually 10 mL/h, max. 37.5 mg/h).
- 0.125% bupivacaine
  Speed: 8–18 mL/h (usually 10–14 mL/h).
- 0.25% bupivacaine
  Speed: 4–16 mL/h (usually 8–10 mL/h).
- 0.125–0.25% levobupivacaine
  Speed: 5–8 mL/h
  (bolus 2–4 mL every 15 min).

Individual adjustment of the dosage and duration of treatment is absolutely necessary.

Opioids (see Chapter 50, section on opioids, p. n)
- Sufentanil: 30–50 µg
- Fentanyl: 50–100 µg
- Morphine: 2–5 mg

Combination of local anesthetic and opioid

*Ropivacaine and sufentanil (fentanyl)*

Bolus injection:
- e.g. 15 mL 0.1% ropivacaine + 1–2 µg/mL sufentanil (10–20 µg)
Continuous infusion starting after 30 min:
- 0.1% ropivacaine + 0.2–0.3 µg/mL sufentanil.
  Speed: 6–10 mL/h.

Or

Bolus injection:
- 15 mL 0.1% ropivacaine + 2 µg/mL fentanyl (30 µg).
Continuous infusion starting after 30 min:
- 0.1% ropivacaine + 2 µg/mL fentanyl.
  Speed: 10 mL/h.

*Bupivacaine and sufentanil (fentanyl)*

Bolus injection:
- e.g. 10 mL 0.25% bupivacaine + 1–2 µg/mL sufentanil (10–20 µg)
Continuous infusion starting after 30 min:
- 0.125–0.0625% bupivacaine + 0.2–0.3 µg/mL sufentanil.
  Speed: 6–10 mL/h.

Or

Bolus injection:
- e.g. 10 mL 0.25% bupivacaine + 50 µg/mL fentanyl.
Continuous infusion starting after 30 min:
- 0.125–0.0625% bupivacaine + 1–2 µg/mL fentanyl.
  Speed: 10 mL/h.

Patient-controlled epidural analgesia (PCEA)

*Sufentanil and ropivacaine*
- 0.1% ropivacaine + 1 µg/mL sufentanil
  Speed: 5–10 mL/h
  Bolus injection: 5 mL
  Lockout time: 10–20 min.

*Fentanyl and ropivacaine*
- 0.1% ropivacaine + 2 µg/mL fentanyl
  Speed: 10 mL/h
  Bolus injection: 10 mL (max. 32 mL/h)
  Lockout time: 10–20 min.

Epidural administration of clonidine (see Chapter 50, section on clonidine, p. 394)

Bolus injection:
- 5–10 µg/kg b.w.
Epidural infusion:
- 20–50 µg/h.
Complications (Fig. 41.26)

Early complications

During injection or when introducing the catheter

- Collapse (vasovagal reaction).
- Dural perforation.
- Catheter shearing.
- Spinal cord injury.
- Trauma to a nerve root.

After identifying the epidural space and administering a test dose

- Subarachnoid injection.
- Intravascular injection.

During and after injection of the full dose of a local anesthetic, during the fixation phase

- Massive epidural anesthesia.
- Total spinal anesthesia.
- Subdural spread.
- Intravascular injection, with toxic reactions.

During the surgical procedure

- Drop in blood pressure.
- Respiratory disturbance.
- Drop in body temperature.
- Muscle tremor.

Complications in the early postoperative phase

- Difficulty with micturition.

Late complications

- Postdural puncture headache.
- Back pain.
- Neurological complications.

Complications that can develop at any time with an epidural catheter in position

- Dural perforation.
- Total spinal anesthesia.
- Subdural injection.
- Intravascular injection.
- Urinary retention.
- Infections.

Fig. 41.26 Complications
(1) Intravascular injection, (2) subdural injection, (3) subarachnoid injection, (4) catheter shearing, (5) epidural abscess, (6) epidural hematoma, (7) injury to the spinal cord and nerve roots

- Catheter shearing when removing the catheter.
- Neurological complications.

Inadvertent dural puncture

This is caused by poor technique. As epidural puncture needles have a large lumen (16–18 G), the probability of developing postdural puncture headache is very high (70–80%; see Chapter 37, p. 287). Depending on whether or not the inadvertent dural puncture is noticed, various steps can be taken.

When dural puncture is noted:
- Administer a spinal dose and carry out spinal anesthesia.
- New attempt at insertion.
- Switch to general anesthesia.

When dural perforation is not noticed:
Accidental subarachnoid injection of an epidural dose leads to total spinal anesthesia, with very serious sequelae (see Chapter 37, section on high and total anesthesia, p. 285).

The patient should be informed immediately and made aware of the possible complications.
Lumbar epidural anesthesia

Prophylaxis
Stay in the midline during the insertion procedure. Always advance the needle millimeter by millimeter after passing the ligamentum flavum. Aspiration test. Test dose. At every additional injection into the positioned epidural catheter, observe the same safety measures as with the single-shot injection. Maintain constant verbal contact with the patient. Check the spread of anesthesia frequently. Careful monitoring.

Therapy
See Chapter 37, section on postdural puncture headache, p. 287.

Massive epidural anesthesia
Massive epidural anesthesia arises due to overdose of local anesthetic and its absorption at the injection site. The condition develops more slowly than with an intravascular injection and in extreme cases it can lead to generalized tonic–clonic seizures (see Chapter 6).

Subdural spread of local anesthetic
See Chapter 37, p. 286.

Intravascular injection
This can occur during the administration of a test dose, during a single-shot injection or during the injection of a local anesthetic through the catheter and it can lead to severe toxic reactions (see Chapter 6, p. 66 and Chapter 1, p. 9).

Prophylaxis
Before any single-shot injection or injection through the positioned catheter:
Aspiration test.
Test dose of a local anesthetic containing epinephrine.

Involvement of cranial and cervical nerves
High spread of an epidurally injected local anesthetic or a sudden increase in CSF pressure can lead to the following complications, which are mostly transient: hearing loss caused by transfer to the cochlear perilymph space; visual defects (in the most severe cases, retinal bleeding or even blindness); trigeminal nerve palsy, with weakness in the muscles of mastication; facial palsy (see Chapter 37, blood patch injection, p. 289); the development of Horner’s syndrome.

Catheter shearing
Shearing of the catheter can occur both when it is being introduced and when it is being removed.

Prophylaxis
When placing the catheter:
When technical difficulties occur during insertion, the catheter and the spinal needle are always removed simultaneously. A catheter must never be withdrawn through the needle.

During catheter removal:
When the catheter is being removed, any elastic resistance should be noted. Force should never be used when pulling. If necessary, wait until the patient is able to stand up and pull the catheter during flexion or slight extension of the back. After the catheter has been removed, it should be checked to ensure the tip has not broken off. A record must be kept. If shearing occurs, the patient must be informed immediately. Neurological monitoring is obligatory, but surgery is very rarely indicated.

Transient neurological symptoms (TNS)
See Chapter 37, p. 290.

Neurological complications
Injury to the spinal cord and nerve roots
This is an extremely rare complication, since most insertions are carried out below the conus medullaris. Neurological injuries can occur in all forms of neuraxial regional anesthesia.

Prophylaxis
Advance the puncture needle with the utmost care. Stop the procedure immediately if pain occurs:
- During insertion
- While introducing the catheter
- During the injection (intraneural placement) A catheter should be advanced at most 3–4 cm into the epidural space
Puncture should be avoided at all costs in adult patients under general anesthesia, particularly above the L2 segment.

Bacterial meningitis
Strict asepsis is absolutely necessary when carrying out the block. A block is contraindicated when there is septic disease or infection in the area of the injection site.
Epidural abscess

The main cause of epidural abscess is Staphylococcus aureus [24]. The symptoms, which develop slowly (high fever, significant cervical or cervicothoracic and/or lumbar pain) require urgent investigation (erythrocyte sedimentation rate, blood culture, CSF measurement, myelography, CT, MRI). Immediate surgical treatment (laminectomy, drainage) within 12 hours is important to reduce complications.

Epidural abscesses are extremely rare and usually occur spontaneously. Earlier references to them in the literature involved continuous caudal blocks in which the necessary sterile conditions were ignored. However, numerous studies [1, 2, 12, 24, 40, 76, 92] report evidence of a connection between pre-existing sepsis and the development of abscesses after epidural anesthesia.

Systemic and local infections at the injection site are therefore an absolute contraindication to epidural anesthesia.

Epidural hematoma

This is an extremely rare but feared complication. It is characterized by rapid development of the classic symptoms, although these are not necessarily all evident in the reported occurrences in every patient affected: initial loss of consciousness, severe pain, substantial neurological disturbances, a lucid interval with normalization of the neurological status, headache and increasing clouding of consciousness, simultaneous pupillary dilatation, Cheyne-Stokes respiration, bradycardia, unconsciousness.

Any complaints by the patient regarding pain, fever, or radicular symptoms must be immediately investigated. Maintaining constant contact with the patient, particularly after an outpatient procedure, is mandatory. Immediate diagnostic clarification (myelography, CT, MRI) and immediate neurosurgical treatment within the first 12 hours are important for the prognosis.

The risk factors reported in the literature [44, 91, 101] include trauma, vascular disease, coagulation disturbances and anticoagulant treatment.

Cauda equina syndrome

See Chapter 37, p. 292.
42 Thoracic epidural anesthesia

Epidural injection or placement of a catheter for continuous epidural administration of a local anesthetic, opioid, or combination of the two in the region of the thoracic spine.

Advantages

- Excellent analgesia.
  - The injection of local anesthetic takes place directly into the selected thoracic segment. This allows a lower dose per segment (e.g. 0.5–0.8 mL) and provides more targeted anesthesia of the surgical area – without affecting sensory or motor function in the pelvis or lower extremities, or bladder function.
  - Better postoperative pulmonary function.
  - Early mobilization.
  - Improved blood flow to the area of surgery.
  - Improved peristalsis.
  - In addition, the risk of toxic reactions is lower.

Disadvantage

- Potential traumatic puncture of the spinal cord. A specific and valid indication is therefore necessary.

Prerequisite

- Very experienced, technically skilled anesthetist.

Anatomy (Figs. 42.1, 42.2)

The thoracic spinous processes form varying angles with their vertebral bodies. At the upper and lower boundaries of the thoracic spine with the cervical spine (C7, T1–3) and lumbar spine (T10–12, L1), the spinous processes are almost parallel to the sagittal plane. The angle of puncture when locating the epidural space is thus almost identical to that in the lumbar region. It should also be noted that in the region of the lower thoracic spine (T10–12, L1) the distance from the skin to the spinal canal is slightly less, due to the shorter spinous processes.

In the central area of the thoracic spine (T4–9), the spinous processes have a very caudal angle and the laminae of the vertebral bodies are slanted. The ligamentum flavum becomes thinner over its lumbar to cranial course and the epidural space becomes narrow-
er: 6 mm in the lumbar spine, 3–5 mm in the thoracic spine and 2–3 mm in the cervical spine. In the central thoracic area, the dura mater is ca. 1 mm thick. These anatomic facts determine the puncture technique.

**Indications**

**Surgical indications** (Table 42.1)

Upper abdominal, thoracic and thoraco-abdominal procedures in combination with general anesthesia, with subsequent continuation of continuous postoperative pain therapy with local anesthetics, opioids, or a combination of the two.

Table 42.1 Thoracic epidural anesthesia combined with basic general anesthesia

<table>
<thead>
<tr>
<th>Surgical procedures and injection levels required</th>
<th>Injection level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>T2</td>
</tr>
<tr>
<td>Cardiac surgery</td>
<td></td>
</tr>
<tr>
<td>Pulmonary resection, esophagectomy</td>
<td>T4–6</td>
</tr>
<tr>
<td>Upper abdomen</td>
<td>T6</td>
</tr>
<tr>
<td>Gastrectomy, liver and pancreatic surgery</td>
<td></td>
</tr>
<tr>
<td>Lower abdomen</td>
<td>T10</td>
</tr>
<tr>
<td>Bowel resection, gynecological tumor surgery</td>
<td></td>
</tr>
<tr>
<td>Extraperitoneal and retroperitoneal procedures</td>
<td>T8</td>
</tr>
<tr>
<td>Vascular surgery, retroperitoneal lymphadenectomy, renal surgery, prostatectomy</td>
<td></td>
</tr>
</tbody>
</table>

**Indications for pain therapy**

- Fractures to a series of ribs.
- Post-herpetic neuralgia.
- Acute pancreatitis.
- Cancer pain.

**Contraindications**

The contraindications are the same as those for lumbar epidural anesthesia (see Chapter 41, p. 306). Puncture is absolutely contraindicated in adult patients under general anesthesia.

**Procedure**

Full prior information for the patient is mandatory.

**Preparation and materials**

- Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs); sterile precautions, intravenous access, anesthetic machine.
- Start an intravenous infusion and give a volume load (250–500 mL of a balanced electrolyte solution).
- Careful monitoring: ECG, BP, pulse oximetry.
- Skin prep.
- Local anesthetic.

**Epidural needles**

- 18-G Tuohy or Crawford (see Chapter 41, Fig. 41.3).

**Access routes**

Puncture of the epidural space is carried out on the same principles as for the lumbar region.

**Midline insertion in the sitting position**

The sitting position is helpful, as it increases the negative pressure in the epidural space, particularly during inspiration.

The patient sits relaxed and leaning slightly forward, with the neck flexed and the arms crossed, supported by an assistant. The patient must be aware of the importance of sitting still during the puncture procedure.

**Location, skin prep, local anesthesia, skin incision**

After thorough skin prep (strict asepsis), a sterile drape is placed on the puncture area and the puncture site in the selected intervertebral space is anesthetized with 1.5–2 mL 1% prilocaine. During infiltration with a needle 3 cm long, the insertion angle is assessed. A skin incision with a stylet or lumen needle follows.

**Puncture of the supraspinous and interspinous ligament and ligamentum flavum**

An 18-G Tuohy needle with the bevel directed cranially, or a Crawford needle with a caudally directed bevel, is introduced at an angle of about 45° up to a depth of about 2.5 cm, until it is lying firmly in the interspinous ligament. The trochar is then removed.
Puncturing the epidural space
Identification of the epidural space can be carried out using the loss-of-resistance technique or using the "hanging drop" technique with saline.

Loss-of-resistance technique (Fig. 42.4)
See Chapter 41, Fig. 41.10.

"Hanging drop" technique (Fig. 42.3; see Chapter 41, Fig. 41.11)
With this technique, high negative pressure in the thoracic epidural space during inspiration is helpful. After removal of the trochar from the puncture needle, a drop of the saline or local anesthetic is placed within the hub of the needle and the needle is advanced toward the ligamentum flavum. The thumbs and index fingers of both hands secure the needle and advance it millimeter by millimeter, with both thumbs firmly supported on the patient’s back fulfilling a braking function. The anesthetist’s eyes are fixed on the "hanging drop." When the epidural space is reached, the drop is sucked in during the inspiration phase and a loss of resistance in the tissue is felt.

Paramedian insertion
This access route circumvents the sharply angled spinous processes and the supraspinous and interspinous ligaments.
Local anesthesia is applied about 1.5 cm lateral to the caudal tip of the spinous process in the selected area. This fan-shaped anesthesia allows the depth of the laminae to be measured and marked.
Fig. 42.5a–c Paramedian puncture. Steps for location. 

**a** Step 1: needle position 1.5 cm lateral to the caudal tip of the spinous process.

**b** Step 2: angle of 15° to the sagittal plane.

**c** Step 3: angle of 55–60° to the skin surface.
Thoracic epidural anesthesia

The epidural needle is advanced alongside the spinous process at an angle of 15° to the sagittal plane and 55–60° to the skin surface or long axis of the spine (Fig. 42.5). After the ligamentum flavum has been passed, identification of the epidural space is carried out using the loss-of-resistance technique with saline.

Dosages
The dose of local anesthetic in the thoracic region is 15–30% lower than in the lumbar region, at about 0.5–0.8 mL per segment.

Local anesthetics

Ropivacaine
Incremental bolus injection: 0.75%, 5–15 mL (depending on the injection site).
Epidural infusion: 0.2%, 8–10 mL/h (max. 37.5 mg/h).

Bupivacaine
Incremental bolus injection: 0.25–0.5%, 4–6 mL (for 2–4 thoracic segments).
Epidural infusion: 0.125%, 5–10 mL/h.

Levobupivacaine
Incremental bolus injection: 0.25–0.5%, 4–6 mL (for 2–4 thoracic segments).
Epidural infusion: 0.125%, 5–10 mL/h.

Combination of local anesthetics and opioids

Ropivacaine and sufentanil
Bolus injection: Ropivacaine 0.5% (7–9 mL, puncture site T8–T9), (10–12 mL, puncture site T9–T11) + sufentanil 30 µg.
Epidural infusion: Ropivacaine 0.2% + sufentanil 0.5 µg/mL. Speed: 5–7 mL/h.

Bupivacaine and sufentanil
Bolus injection: Bupivacaine (0.25%), 5 mL + 1 µg/mL sufentanil.
Epidural infusion: Bupivacaine (0.125–0.0625%) + sufentanil 0.2–0.3 µg/mL. Speed: 6–10 mL/h.

Bupivacaine and fentanyl
Bolus injection: Bupivacaine (0.25–0.5%), 5 mL + 50 µg fentanyl.
Epidural infusion: Bupivacaine (0.125%) + 1–2 µg/mL fentanyl. Speed: 6–10 mL/h.

Administration of opioids via the epidural catheter – lumbar or thoracic?

Lipid-soluble opioids
The precise mechanism involved in the action of epidurally administered lipid-soluble opioids is a matter of controversy. According to a number of more recent investigations, the blocking of pain by lipid-soluble opioids after epidural administration is more the result of systemic uptake than a direct effect on spinal opioid receptors. The positioning of the epidural catheter would therefore be of secondary importance.

As some studies have reported [4, 48, 60, 74], opioid infusion via a lumbar epidural catheter has been used successfully for pain relief after thoracotomy.

The authors conclude that the generally less familiar and potentially more dangerous thoracic access route is not justifiable.

Morphine as a hydrophilic substance
Morphine is hydrophilic and spreads quickly in the CSF, and it is therefore able to produce analgesia for thoracic procedures even when it is injected into the caudal epidural space. Several studies have shown that lumbar administration of epidural morphine for pain relief after thoracotomy or after high abdominal surgery is just as effective as thoracic administration [9, 33, 74].

Specific complications
Spinal cord injury is among the extremely rare complications with this procedure (see Chapter 41).

Bupivacaine and fentanyl
Bolus injection: Bupivacaine (0.25–0.5%), 5 mL + 50 µg fentanyl.
Epidural infusion: Bupivacaine (0.125%) + 1–2 µg/mL fentanyl. Speed: 6–10 mL/h.
# Thoracic catheter epidural anesthesia

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis:</td>
<td></td>
</tr>
<tr>
<td>Premedication:</td>
<td>No</td>
</tr>
<tr>
<td>Neurological abnormalities:</td>
<td>No</td>
</tr>
</tbody>
</table>

| Purpose of block: | Surgical | Treatment (postoperative) |
| Needle: | Tuohy G | Other |
| i.v. access, infusion: | Yes |
| Monitoring: | ECG | Pulse oximetry |
| Ventilation facilities: | Yes (equipment checked) |
| Emergency equipment (drugs): | Checked |
| Patient: | Informed |

| Position: | Lateral decubitus | Sitting |
| Access: | Median | Paramedian |
| Injection level: | T | |
| Injection technique: | Loss of resistance | Other |
| Epidural space: | Identified |
| Catheter: | Advanced 3–4 cm cranially |
| Aspiration test: | Carried out |
| Catheter end positioned lower than the injection site: | Check on sensorimotor function after 5 min: | Carried out |
| Bacterial filter: | |
| Test dose: | Epinephrine added: | Yes | No |

| Abnormalities: | No | Yes |
| Injection: | Local anesthetic: | ml | % |
| Addition: | µg/mg |
| Additional injection (incremental): | ml | % |

| Patient’s remarks during injection: | None | Pain | Paresthesias | Warmth |
| Duration and area: | |

| Objective block effect after 20 min: | Cold test | Temperature measurement before ______ C after ______ C |
| Sensory: | T | |
| Motor: | |

| Complications: | None | Radicular symptoms | BP drop | Vascular puncture |
| Massive epidural anesthesia | Subdural spread | Drop in body temperature |
| Bladder emptying disturbances | Back pain | Pain | Vasovagal reactions |
| Dural puncture | Intravascular injection | Total spinal anesthesia |
| Respiratory disturbance | Muscle tremor | Postdural puncture headache |
| Neurological complications |

| Special notes: | |

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43 Epidural anesthesia in obstetrics

The goal of epidural anesthesia in normal deliveries is sensory block of the desired segments (first stage: T10–T11, L1; second stage: L2–S4/S5), with the lowest possible concentrations of a local anesthetic, opioid, or a combination of the two. In Cesarean sections, the aim is to achieve adequate anesthesia (T4–6) with larger doses.

**Gastrointestinal tract**
The stomach shifts cranially, resulting in increased intragastric pressure, with a tendency toward reflux, reduced tone, reduced motility and a resultant delay in gastric emptying. The risk of aspiration is increased during tracheal intubation for anesthesia.

**Blood volume**
Blood volume increases by about 30%.

**Labor pain**
Two types of labor pain are distinguished, depending on the stage of labor (Fig. 43.1).

**First stage**
Pain in the first stage of labor primarily results from dilation of the cervix and lower uterine segment and distension of the body of the uterus (10–12 hours in a primipara, 6–8 hours in a multipara). It is characterized by painful uterine contractions. Visceral dilation pain is caused by uterine contractions and dilation of the cervix and lower segment of the uterus.

**Physiological changes**

**Respiratory tract**
Movement of the diaphragm in the cranial direction increases minute volume by 40%. This causes hyperventilation, with increased oxygen consumption (+ 20%), with peak values during birth (+ 40% in the first stage, up to + 100% during the second stage).

**Cardiovascular system**
The increase in heart rate and the resulting rise in cardiac output reach a maximum of up to 40% by the 34th gestational week. This increase is marked in the utero-placental unit and kidneys. By contrast, arterial blood pressure does not increase.

---

**Fig. 43.1 Segmental spread of labor pain**
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This pain is conducted via unmyelinated C-fibers, which enter the spinal cord through the posterior roots of the spinal nerves – in the early stage at T11–T12 and in the later stage at T10 and L1. The pain radiates to the lower abdomen, groin, inside of the thighs and dorsally into the lumbar region, hip region and sacrum.

Second stage
This pain covers the period between full dilatation of the cervix (10 cm) and birth of the child. This period lasts 30–40 minutes in a primipara and 20–30 minutes in a multipara. The pain is caused by dilation of the vagina, vulva and pelvic floor.

Somatic perineal pain in the area innervated by the pudendal nerve is conducted via myelinated A-delta fibers and also includes segments T10 to L1 and L2 to S4–S5 (Fig. 43.1).

Compensatory mechanism
A collateral circulation occurs via the azygos vein system and sympathetic tone is increased to stimulate venous return to the heart. If the collateral circulation is not sufficient, or if sympathetic tone is canceled out by epidural anesthesia, a dangerous drop in cardiac output and/or arterial blood pressure may occur, with symptoms of shock. The critical threshold for a drop in blood pressure is 70–80 mmHg, but values between 90 and 100 mmHg over a period of 10–15 minutes can also threaten the fetus if not treated.

Clinical symptoms
Nausea, faintness, pallor, sweating, breathing difficulty.

Prophylaxis
Left lateral position or at a 15° angle to the left (with a wedge-shaped cushion under the right hip (Fig. 43.2), or using the palm of the hand to displace the uterus to the left (Fig. 43.3).

Adequate volume load before anesthesia (1000 mL in vaginal delivery, 1500–2000 mL of a balanced electrolyte solution in Cesarean section).

Give oxygen.

Vasopressor administration – provided intravascular volume is adequate. The drug of choice is ephedrine 10–20 mg i. v.

Increased risk of aspiration during intubation for anesthesia

All patients in late pregnancy are regarded having a full stomach.

Prophylaxis
30 mL sodium citrate (0.3 mol/L) about 30 minutes before the start of anesthesia.
400 mg cimetidine p.o. (200 mg i.v.) or ranitidine.
10 mg metoclopramide i.v.

Aortocaval compression syndrome
At the end of pregnancy, there is pressure from the dilated uterus on the inferior vena cava and lower abdominal aorta when the patient is in the supine position.

Mechanism
A reduction in venous return to the heart, with a decrease in cardiac output and a drop in arterial blood pressure caudal to the compression area. Since the perfusion of the uterine vessels is directly correlated with arterial blood pressure, in untreated cases there may be a risk to the mother or a risk of fetal asphyxia due to reduced blood flow to the uteroplacental unit.
Hypotension

A drop in maternal blood pressure is the most frequent complication of epidural anesthesia. In untreated cases, it leads to reduced blood flow to the uteroplacental unit and fetal asphyxia.

Prophylaxis

Infusion of a balanced electrolyte solution 20 minutes before the start of anesthesia.
Prevention of the aortocaval compression syndrome.

Treatment

Increase in fluid administration.
Slight Trendelenburg position (10°).
Give oxygen.
Vasopressor.

Indications [81]

Maternal
Labor pain.
Pulmonary disease (e.g. asthma, upper airway infection).
Cardiovascular disease.
Metabolic disease (e.g. diabetes mellitus).
Neurological diseases (e.g. epilepsy, aneurysms of the cerebral vessels, arteriovenous malformations).
Pre-eclampsia.

Fetal
Premature birth.
Growth retardation.
Breech presentation.
Multiple pregnancy.

Obstetric
Prolonged labor or arrested labor.
High-risk birth.
Induction of birth with oxytocin.
Uncoordinated uterine activity (dystocia).

Anesthesiological
Anticipated tracheal intubation difficulties.
Obesity.
Suspicion or history of malignant hyperthermia.

Contraindications

General
See Chapter 41, p. 306.

Specific
Placenta previa.
Prolapse of the umbilical cord.
Acute fetal asphyxia.

Relative
Prior Cesarean section (unnoticed uterine rupture).
Placental abruption (absence of pain).

Procedure

Full prior information for the patient is mandatory.

- Insertion should only be carried out during a pause in labor (the negative epidural pressure is lost during uterine contractions and there is therefore a risk of dural perforation).
- The oxytocin drip should be interrupted during administration of a local anesthetic. Oxytocin administration can only be resumed 15 minutes after the last major dose of a local anesthetic and when the cardiotocogram is normal.
- The membranes should not be ruptured within 30 minutes before or after administration of a major dose of local anesthetic.
- Insertion of an epidural catheter and administration of a local anesthetic can only be carried out if the cervix has opened 5–6 cm in a primipara or 3–4 cm in a multipara.

Preparation and materials

Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs).
Strict asepsis.
Intravenous access, anesthetic machine.
Ensure adequate intravenous volume load with a balanced electrolyte solution (500–1000 mL).
Careful monitoring: ECG, BP, pulse oximetry.
Monitoring of bladder function (atonic bladder during epidural anesthesia!)
Continuous fetal monitoring.

The use of a purpose-made kit for epidural anesthesia is recommended (e.g. from B. Braun Melsungen).

Patient positioning

The patient is usually placed on the left side; more rarely, a sitting position is adopted – e.g. in obese patients or in those with severe spinal deformities.
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Location, skin prep, local anesthesia, skin incision
Location and marking of the puncture site (L2/3 or L3/4) is followed by thorough skin prep, covering with a drape, local anesthesia and skin incision using a hemostylet.

Puncturing the epidural space
Puncture is carried out in the midline using a Tuohy needle (16–18 G) with the bevel directed cranially. The loss-of-resistance technique is used to identify the epidural space (low-friction 10-mL syringe, filled with saline and with a small air bubble; advance with constant pressure on the plunger as far as the epidural space). The catheter is advanced a maximum of 3–4 cm into the epidural space.

After aspiration, the open end of the catheter is placed below the puncture site on the sterile drape and any escaping fluid (CSF or blood) is noted.

Administration of a test dose
3–4 mL 0.5% ropivacaine, or 0.25% bupivacaine, or 1% mepivacaine with epinephrine added.

The addition of epinephrine in obstetrics is controversial, as it can lead to false-positive reactions and reduced uteroplacental perfusion in about 27% of pregnant patients.

In patients who are receiving beta-blockers, there may be an increase in blood pressure without an increase in the pulse frequency. As increases in pulse rate and blood pressure often occur spontaneously during birth, a false-positive response is possible. Many authors therefore recommend using epinephrine-containing test doses only if the situation is uncertain [19, 57, 63].

During the waiting period of 5 minutes, verbal contact with the patient must always be maintained and the spread of the anesthesia must be monitored.

Incremental administration of local anesthetic
If there is no evidence of intravascular or subarachnoid injection, incremental administration of a local anesthetic is now carried out (5 mL each in several test doses), until anesthesia has reached the desired level. During this phase, particular attention should be given to the patient’s position (not supine). During the following 20–30 minutes, the spread of the sensory block must be monitored.

- Repeated aspiration.
- Use a test dose.
- Select the lowest possible dosage.
- Always inject on an incremental basis (with several test doses).
- Maintain verbal contact.
- Careful monitoring.

Local anesthetic and opioids in obstetrics

Local anesthetics
Due to their physicochemical properties, local anesthetics cross the placenta easily. Independent of the site of injection, amide local anesthetics appear very quickly in the maternal and fetal circulation and produce higher plasma levels.

Concentrations in the umbilical blood after the injection of ropivacaine, bupivacaine, or etidocaine are lower (high protein binding of over 90% in maternal blood) than those of lidocaine and mepivacaine (50–70% binds to plasma proteins).

The elimination half-lives in the newborn are 3 hours for lidocaine, 9 hours for mepivacaine, 8 hours for bupivacaine and 6.5 hours for etidocaine.

Most important local anesthetic in obstetrics
Ropivacaine
Ropivacaine is structurally similar to bupivacaine and it has a similar profile of activity, but it has a much lower cardiotoxic potential.

According to plasma studies in neonates and their mothers, it has a stable and high level of maternal protein binding (94%), so that placental transmission is limited.

In relation to analgesia and motor block, ropivacaine is equivalent to bupivacaine. The onset of effect, duration of effect and anesthetic quality are also comparable to those of bupivacaine [3, 30].

The concentrations used vary from 0.5% to 0.75% (cesarean section) up to 0.2% (vaginal delivery).

Ropivacaine produces a very good differential sensory-motor block (good analgesic quality with largely preserved motor function – up to 80% of patients have no measurable motor block on the Bromage scale).

At a concentration of 2 mg/mL, ropivacaine is thus the agent of choice for epidural obstetric and postoperative analgesia.

Single-shot injection
Five minutes after administration of the test dose, 10–20 mL 0.2% ropivacaine (20–40 mg) is injected on an incremental basis.

Onset of effect after 10–15 min, duration of effect 30–90 min.

Intermittent epidural analgesia
10–15 mL 0.2% ropivacaine (20–30 mg).
Continuous-infusion epidural analgesia (CIEA)

0.2% ropivacaine, speed 6–10 mL (12–20 mg/h) (max. 37.5 mg/h).

**Bupivacaine**

Bupivacaine has been used successfully in obstetrics for many years as a long-acting amide local anesthetic. The concentrations used vary from 0.5% (Cesarean section) to 0.25% (vaginal delivery) up to 0.125–0.0625%, usually in combination with opioids. Low-dose bupivacaine (0.125%) leads to effective analgesia in some 70% of mothers giving birth. Higher concentrations (0.5%) are often associated with a motor block, which is not desirable in a normal delivery. Higher concentrations (0.75%) should be avoided in obstetrics. The cardiotoxicity of bupivacaine must be regarded as a considerable disadvantage [81].

**Single-shot injection**

After a test dose of 3–4 mL 0.25–0.5% bupivacaine (or 3 mL of a 1% epinephrine-containing mepivacaine solution), 15 mL 0.5% or 20 mL 0.375% bupivacaine (3–5 mL) are injected on an incremental basis.

**Intermittent epidural analgesia**

After a test dose of 3–4 mL 0.25–0.5% bupivacaine (or 3 mL of a 1% epinephrine-containing mepivacaine solution), injection of an initial dose of 5–8 mL 0.25% (or 0.125%) bupivacaine (titrated in smaller portions) is given until a segmental level of T10 is reached.

**Additional injections**

Intermittent administration is continued with additional injections of 0.125% (8–16 mL) or 0.25% (5–8 mL) bupivacaine at intervals of 60–90 minutes, or as required. During the first stage of labor, the local anesthetic dose is injected with one half in the right and left lateral positions, or the full dose with the patient supine (persistent leftward displacement of the uterus). During the second stage, the patient’s trunk should be raised by about 30–60° in order to reach lower segments.

Every new bolus of a drug involves the same risks as the initial bolus. It is possible to confuse overdose with underdose.

Continuous-infusion epidural analgesia (CIEA)

Five minutes after the administration of the test dose, 5–8 mL 0.25% bupivacaine is injected in smaller increments. After 30 minutes, if all is well, the continuous infusion can be started: 6 mL 0.25% or 10–15 mL 0.125% bupivacaine per hour. Careful monitoring of the circulation and checking of the anesthetic spread must be carried out.

**Lidocaine**

Lidocaine is rarely used for epidural anesthesia in obstetrics, as it produces a marked motor block even at relatively low doses. The duration of effect is 60–90 minutes. Due to its rapid onset, lidocaine is very suitable for short-term augmentation of epidural anesthesia (10–15 mL of a 1.5–2% solution; see also p. 248).

2–3% 2-chloroprocaine

Chloroprocaine is a fast-acting local anesthetic that is toxicologically one of the safest of the ester type, and it has proved its value particularly in emergency situations [81]. It is hydrolyzed to inactive metabolites very quickly even at high dosages (short duration of effect of about 30–60 minutes) and has hardly any effect on the neonate’s condition. Chloroprocaine is a very good supplement to bupivacaine, particularly if large amounts of bupivacaine have already been used during a Cesarean section.

**Single-shot injection**

2% 2-chloroprocaine: 10–15 mL, onset of effect after 4–6 minutes, duration of effect 30–45 minutes.

3% 2-chloroprocaine: 10 mL, onset of effect after 4–6 minutes, duration of effect 45–60 minutes.

The analgesic effect of an opioid injected subsequently (fentanyl) is reduced by antagonism caused by chloroprocaine at the opiate receptor [22]. This local anesthetic is mainly used in the USA, but has recently also been adopted in Switzerland.

**Opioids**

When opioids alone are used in obstetric anesthesia, adequate analgesia is only achieved in the treatment of visceral pain in the first stage of labor. Somatic pain in the second stage is more difficult to manage [74, 81]. The rapidly-acting lipophilic opioids sufentanil and fentanyl, which have a duration of effect of 2–3 hours, have replaced the more hydrophilic morphine (duration of effect 8–24 hours). The agents of choice are low-dose sufentanil or fentanyl in combination with low-dose bupivacaine in the form of an epidural infusion.
Chapter 43

Advantages
Faster onset.
Longer duration of analgesia.
Lower total dose of local anesthetic and opioid (about 20–25%).
Reduced motor block.
No significant side effects for the mother or child.

Continuous-infusion epidural analgesia (CIEA) [34, 74, 98, 99]

Sufentanil and ropivacaine
After administering a test dose and incremental bolus administration of 15 mL 0.1% ropivacaine and 1–2 μg/mL sufentanil (10–20 μg), the continuous infusion can be started:
0.1% ropivacaine and 0.2–0.3 μg/mL sufentanil.
Speed: 10 mL/h.

Fentanyl and ropivacaine
After administering a test dose and incremental bolus administration of 15 mL 0.1% ropivacaine and 30 μg fentanyl, the continuous infusion can be started:
0.1% ropivacaine and 2 μg/mL sufentanil.
Speed: 10–12 mL/h.

Sufentanil and bupivacaine (levobupivacaine)
After administering a test dose and bolus administration of 10 mL 0.125–0.0625% bupivacaine (0.125–0.0625% levobupivacaine) and 1–2 μg/mL sufentanil (10–20 μg), the continuous infusion can be started after about 30 minutes:
0.0625–0.125% bupivacaine (0.0625–0.125% levobupivacaine) and 0.2–0.3 μg/mL sufentanil.
Speed: 6–10 mL/h.

Fentanyl and bupivacaine (levobupivacaine)
After administering a test dose and bolus administration of 10 mL 0.25% bupivacaine (0.25% levobupivacaine) and 50 μg fentanyl, the continuous infusion can be started after about 30 minutes:
0.0625% bupivacaine (0.0625% levobupivacaine) and 1–2 μg/mL fentanyl.
Speed: 10 mL/h.

Patient-controlled epidural analgesia (PCEA) [34, 74]

Sufentanil and ropivacaine
0.1% ropivacaine and 1 μg/mL sufentanil.
Speed: 5–10 mL/h.
Bolus dose: 5 mL.
Lockout period: 10–20 min.

Fentanyl and ropivacaine
0.1% ropivacaine and 2 μg/mL sufentanil.
Speed: 10 mL/h.
Bolus dose: 10 mL.
Lockout period: 10–20 min.

Sufentanil and bupivacaine (levobupivacaine)
After administering a test dose and bolus administration of 5–10 mL 0.125% bupivacaine (0.125% levobupivacaine) and 10–30 μg/mL sufentanil, the continuous infusion can be started:
0.0625% bupivacaine (0.0625% levobupivacaine) and 1 μg/mL sufentanil.
Basic setting: Speed 5 mL/h (5 μg sufentanil)
Bolus dose 5 mL (5 μg sufentanil)
Lockout period: 20 min.

Epinephrine addition in obstetrics
Epinephrine has both alpha-adrenergic and beta-adrenergic effects. Adding epinephrine causes a dose-dependent reduction in uterine activity and leads to a delay in delivery. If there is inadvertent intravascular injection of a local anesthetic with epinephrine, adverse circulatory reactions can occur both in the mother (hypertonia, cardiac arrhythmia) and in the child (reduced placental perfusion due to vasoconstriction).
Any addition of epinephrine in obstetrics must therefore be strictly indicated.

Lumbar catheter epidural anesthesia in Cesarean section
When a Cesarean section is to be performed, the spread of the injected local anesthetic must reach segments T4 to T6. The higher the spread of the anesthesia, the greater the risk of severe hypotension. Segments L5, S1 and S2 are not always adequately anesthetized and there is often a delay in anesthesia in this area.
Procedure

Preparation, materials, prerequisites
See Chapter 41, p. 307.

Patient positioning
Left lateral decubitus for L2/3 or L3/4, or sitting (e.g., in obese patients or those with spinal deformities).

Puncture of the epidural space, test dose, incremental administration of local anesthetic
After identification of the epidural space and aspiration, a catheter is placed (see Chapter 41, section on continuous catheter epidural anesthesia, p. 317) and a test dose is administered. After about 5 minutes, incremental injection of a local anesthetic can be carried out in small increments of up to 5 mL each (several test doses), until adequate anesthesia reaches the desired segmental level of T4 to T6. If the catheter is already in position, there is the following choice: if there has been no injection within the previous 30 minutes, then after testing of the spread of the anesthesia about 12–15 mL 0.75% ropivacaine or 0.5% bupivacaine can be injected on an incremental basis. Alternatively, if an injection has been given shortly before, then initially only 5–10 mL 0.75% ropivacaine or 0.5% bupivacaine is injected.

In a protracted birth with a large total dose of local anesthetic and subsequent Cesarean section or marked fetal acidosis, 2–3% 2-chloroprocaine should be used, due to its fast onset and short half-life in both mother and child.

Additional safety measures
Supine positioning, with left lateral displacement of the uterus until birth of the child (slight Trendelenburg 10° if appropriate). Oxygen administration. Careful circulatory monitoring. Thorough checking of the spread of anesthesia shortly before the start of surgery.

Local anesthetics for Cesarean section
About 15–30 mL of local anesthetic is necessary for adequate anesthesia up to T4–T6 (Table 43.1).

Adjuvant opioids
The addition of sufentanil or fentanyl to bupivacaine or lidocaine improves analgesia significantly. The following doses can be used:
Sufentanyl: 30–50 µg.
Fentanyl: 50–100 µg.

<table>
<thead>
<tr>
<th>Local anesthetic</th>
<th>Volume (mL)</th>
<th>Onset of effect (min)</th>
<th>Duration of effect (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75% ropivacaine</td>
<td>15–20</td>
<td>10–20</td>
<td>180–300</td>
</tr>
<tr>
<td>0.5% ropivacaine</td>
<td>25–30</td>
<td>10–15</td>
<td>120–150</td>
</tr>
<tr>
<td>0.5% bupivacaine</td>
<td>15–30</td>
<td>10–15</td>
<td>120–180</td>
</tr>
<tr>
<td>0.5% levobupivacaine</td>
<td>15–30</td>
<td>10–15</td>
<td>120–180</td>
</tr>
<tr>
<td>1.5–2% lidocaine</td>
<td>15–25</td>
<td>10–15</td>
<td>45–60</td>
</tr>
<tr>
<td>(with the addition of epinephrine 1: 400 000; 0.05 mL in 20 mL of local anesthetic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2–3% 2-Chloroprocain</td>
<td>15–25</td>
<td>ca. 10</td>
<td>45–60</td>
</tr>
</tbody>
</table>
Record and checklist

Obstetric catheter epidural anesthesia

Name: ___________________ Date: ___________________

Diagnosis: ___________________

Premedication: □ No □ Yes

Neurological abnormalities: □ No □ Yes

Purpose of block: □ Vaginal delivery □ Cesarean section

Needle: □ Tuohy □ Other ______

i.v. access, infusion: □ Yes

Monitoring: □ ECG □ Pulse oximetry

Ventilation facilities: □ Yes (equipment checked)

Emergency equipment (drugs): □ Checked

Patient: □ Informed

Prerequisites met: □ Adequate volume supplementation

□ Fetal monitoring □ No oxytocin drip □ No amniotomy

□ Monitoring of bladder function □ Cervix 5-6 cm (primipara)

□ Cervix 3-4 cm (multipara)

Position: □ Left lateral □ Sitting

Access: □ Median □ Paramedian

Injection level: □ L3/4 □ Other ______

Injection technique: □ Loss of resistance □ Other ______

Epidural space: □ Identified

Catheter: □ Advanced 3-4 cm cranially

Aspiration test: □ Carried out

Catheter end: □ Positioned lower than the injection site

Bacterial filter: □

Test dose: ______________ Epinephrine added: □ Yes □ No

Check on sensorimotor function after 5 min: □ Carried out

Abnormalities: □ No □ Yes

Injection:

□ Local anesthetic: __________________________ ml %

□ Addition: __________________________ μg/mg

□ Additional injection (incremental): __________________________ ml %

Patient's remarks during injection:

□ None □ Pain □ Paresthesias □ Warmth

Duration and area:

Objective block effect after 20 min:

□ Cold test □ Temperature measurement before ______°C after ______°C

□ Sensory: L ______ T ______ □ Motor

Complications:

□ None □ Radicular symptoms □ BP drop □ Vascular puncture

□ Massive epidural anesthesia □ Subdural spread □ Drop in body temperature

□ Bladder emptying disturbances □ Back pain □ Aortocaval compression syndrome □ Pain □ Vasovagal reactions □ Dural puncture □ Intravascular injection □ Total spinal anesthesia □ Respiratory disturbance □ Muscle tremor □ Postdural puncture headache □ Neurological complications

Special notes:

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44 Lumbar epidural anesthesia in children

Advantages
Better anatomic relationships and thus easier orientation and less time required for puncture.
Better distribution of the injected local anesthetic than in adults.
Highly effective anesthesia and analgesia with smaller amounts of local anesthetic.
Easier passage of the epidural catheter than in the adult.
Due to immaturity of the sympathetic nervous system, circulatory problems are very rare, particularly in children under eight.
Very fast recovery phase due to light basic general anesthesia and lack of need for muscle relaxants.
Stable postoperative phase and sparing of opioids and thus fewer side effects such as nausea, vomiting or urinary retention.
The need for subsequent postoperative intensive care is reduced.

Disadvantages
Light general anesthesia is recommended, so that testing of the spread of anesthesia is not possible.

Characteristics of the pediatric epidural space
See Chapter 48, p. 376.

Indications
Single-shot technique
All surgical procedures in the region of dermatomes T5–S5 involving operating times of up to 90 minutes – e.g. perineal and perianal procedures, orchiopexy (including undescended testis), hypospadias, inguinal hernia, incarcerated hernia, umbilical hernia, superficial surgical procedures in the lower extremities – e.g. skin grafting, etc.

Continuous technique
In combination with general anesthesia in more prolonged operations in the upper and lower abdomen, as well as urogenital and orthopedic procedures (dermatomes T5–S5) [28].

Distinctive features of pediatric anatomy
[37, 49]

The following anatomic characteristics must be noted before carrying out epidural puncture in children (Fig. 44.1):

In the neonate, the spinal cord ends in the area of the L3 segment; at the end of the first year of life, it reaches the L1 segment.
In the one-year-old child, the dural sac ends in the area of S2 and in the neonate it can even reach as far as the sacral foramina of S3 or S4.
In infants, the iliac crest line crosses the midline in the area of L5 and at about L5/S1 in neonates.
Lumbar lordosis has not yet developed in neonates and infants.
The distance from the skin to the epidural space correlates with the child’s age. According to Busoni, measured in millimeters in the L2/L3 segment it is equivalent to 10 mm + (age in years × 2) mm [37].
Chapter 44

Advantages

- Shorter recovery time due to sparing of intraoperative drugs.
- Postoperative pain therapy.

Disadvantage

- The dosage is not as reliable as with caudal application.

Contraindications

See Chapter 41, p. 306.

Procedure

Full prior information for the patient and parents is mandatory.

Preparation and materials

These are the same as for epidural anesthesia in adults. Light general anesthesia or more rarely sedation combined with topical application of Emla cream is used for both the single-shot technique and for continuous epidural anesthesia.

- Strict asepsis: Thorough, repeated and wide skin prep, drying and covering of the puncture site with a drape.
- Local anesthesia or application of Emla cream.
- Preparation of the drugs: Syringe with 1 mL epinephrine-containing local anesthetic (test dose). Syringe with the calculated dose of local anesthetic. In the continuous technique, the length of the needle should be compared with the marking points on the catheter for better identification of the depth of the catheter after it has been introduced. The ability of the catheter to pass through the needle is tested at the same time.
- Skin incision with a stylet or large needle.

A precordial stethoscope is also required. The use of a purpose-designed kit is recommended.

Epidural needles in pediatric patients

Single-shot technique

Up to four years of age: Tuohy needle with a metal trochar and 0.5 cm calibration marks, 22 G (0.73 x 50 mm) or 20 G (0.9 x 50 mm) – e.g. Perican Paed®, B. Braun Melsungen.

Over four years of age: Tuohy needle with a plastic trochar and 0.5 cm calibration marks, 18 G (1.3 x 50 mm) – e.g. Perican Paed®, B. Braun Melsungen.

Continuous technique

Up to four years of age: Tuohy needle with a metal trochar and 0.5 cm calibration marks, 20 G (0.9 x 50 mm), epidural catheter (0.6 mm–75 cm long) with central opening.

Over four years of age: Tuohy needle with a plastic trochar and 0.5 cm calibration marks, 18 G (1.3 x 50 mm), epidural catheter (0.85 mm–100 cm long) with central opening (e.g. Perifix Paed®, B. Braun Melsungen).

Single-shot technique

Patient positioning

Lateral decubitus, with legs bent.

Finding the epidural space

The insertion is carried out in the midline, usually between the spinous processes of L2/3 or L3/4 (Fig. 44.2). A Tuohy needle, with its bevel directed cranially, is advanced through the skin incision at an angle of 90° in neonates or 70° in infants, until it is lying in the interspinous ligament (Fig. 44.3).

Removal of the trochar and attachment of a low-friction syringe with saline (injection of a maximum of 0.5 mL in the neonate or 3 mL in older children).

Advancing the catheter further after leaving the interspinous ligament must be carried out gradually and gently, in the direction of the ligamentum flavum.

Identification of the epidural space is carried out using the loss-of-resistance technique. Any fluid escaping from the end of the needle (CSF, blood) should be noted.

Aspiration test.

Test dose of 1 mL of an epinephrine-containing local anesthetic.

During the subsequent waiting period: careful cardiovascular monitoring (plus precordial stethoscope) in order to recognize the development of tachycardia or arrhythmia. However, this test may
lead to unreliable results in anesthetized children [29].
Incremental injection of local anesthetic: after a negative result with the test dose, the calculated dose of local anesthetic is administered on an incremental basis.

Checking the spread of anesthesia
In children who are not under light general anesthesia, the spread of the anesthesia should always be checked.

Since correct checking of the spread of anesthesia is not possible in anesthetized children, this method should only be used by highly experienced pediatric anesthetists.

Detailed testing of sensory and motor function is conducted postoperatively in the recovery room. The child should only be moved to the ward when he or she can move the legs freely.

Continuous lumbar epidural anesthesia

Comparison with continuous caudal anesthesia

**Advantage**
Since the risk of contamination of the lumbar epidural catheter is lower (4%) than with a caudally placed catheter (22%) [49], a lumbar epidural catheter is preferable when there is a need for postoperative pain therapy.

**Disadvantage**
The dosage scheme is less reliable than with the caudal application.

**Insertion technique***
A midline insertion in the region of the L5/S1 segment has proved particularly favorable for placing a catheter in the lumbar area (modified Taylor access) [49]. Identification of the epidural space is carried out as described above. After the epidural space has been reached and loss of resistance has been confirmed, an aspiration test is carried out. Before the introduction of a catheter, the needle bevel should be directed cranially.

After the catheter has been placed in the desired position, the needle is very carefully withdrawn, with the thumb and index finger of the left hand simultaneously securing the catheter at the injection site. An adapter is attached to the end of the catheter. The patency of the catheter is tested by injecting 1 mL of saline.

After aspiration, the syringe is disconnected and the open end of the catheter is placed on a sterile drape below the level of the puncture site. Any escaping fluid (CSF, blood) should be noted.

* If technical difficulties arise, the catheter and injection needle are always withdrawn simultaneously. A catheter must never be withdrawn through the injection needle.
these diagrams are less reliable for lumbar epidural administration (in which there is both cranial and caudal spread; Fig. 44.6b) [37]. Another formula was tested with 0.25% bupivacaine: 0.75 mL/kg b.w. (children under eight years of age and under 25 kg) [37]. Yet another [50] is recommended for children under eight years of age: 0.7 mL/kg 1% mepivacaine, 0.25% bupivacaine, or 0.2% ropivacaine. In children over eight years of age, higher concentrations are used at a reduced dosage, based on height and weight as in adults.

A bacterial filter is then placed and the catheter is secured (Fig. 44.5). An epinephrine-containing test dose is administered, followed by incremental injection of local anesthetic. After a risk–benefit assessment, a catheter for postoperative pain therapy is usually left in place for 48–72 hours. After this period, the risk of infection and migration of the catheter increases.

**Local anesthetic and dosage**

Age-dependent doses as proposed by Bromage [10] for lumbar epidural administration in adults also apply to pediatric patients. For testing, 2% lidocaine is used (see Chapter 41). This dosage guideline is not suitable for children under the age of four. Busoni used 2% mepivacaine for testing, and after statistical evaluation developed valuable diagrams that became very popular with anesthetists. However, in comparison with caudal epidural administration (where the local anesthetic only spreads cranially; Fig. 44.6a),

**Concentration of local anesthetic**

- 0.2% ropivacaine
- 0.25–0.5% bupivacaine
- 0.25% levobupivacaine
- 1–1.5% (2%) mepivacaine
- 1–1.5% (2%) lidocaine

The concentration of the local anesthetic is based on the location and severity of the procedure. For more extensive abdominal procedures, slightly higher concentrations are required (2% lidocaine, 0.5% bupivacaine and 2% mepivacaine with epinephrine added [37]).

**Dosage [51]**

**Lumbar:**

- 0.2% ropivacaine 1.4 mg/kg b.w.
- 0.25% bupivacaine 2 mg/kg b.w.
- 1% mepivacaine 5–7 mg/kg b.w.

**Thoracic:**

- 0.2% ropivacaine 0.8–1 mg/kg b.w.
- 0.25% bupivacaine 1–1.2 mg/kg b.w.
- 1% mepivacaine 3–5 mg/kg b.w.

**Practical recommendations for postoperative pain therapy [49, 51]**

**Local anesthetics**

**Initial dose:**

- 0.2% ropivacaine 2 mg/kg b.w.
- 0.25% bupivacaine 2–2.5 mg/kg b.w.
Continuous epidural infusion with 0.1% ropivacaine or 0.125% bupivacaine

- Neonates and infants: 0.2 mg/kg/h
- Small children: 0.3–0.4 mg/kg/h
- Older children: 0.4–0.5 mg/kg/h

Opioids
- Morphine: 33 µg/kg/every 8–12 h
- Fentanyl: 0.5 µg/kg/h
- Clonidine: 2–3 µg/kg/24 h

Complications
See Chapter 41, section on complications in adults, p. 324.
Neuraxial techniques are recognized procedures in diagnostic and therapeutic pain treatment. The first report in Europe describing the administration of steroids in the epidural space was published in 1952 [77]. Since 1961, authors in the United States and the United Kingdom in particular have regularly described lumbar [35, 38] and thoracic [32] epidural administration of methylprednisolone, and since 1986, cervical epidural steroid injections have increasingly been used in treatment-resistant cervical pain conditions [67, 78, 89]. The indications for epidural and intrathecal administration of methylprednisolone in anesthesia, orthopedics, neurology, neurosurgery, and rheumatology have included lumbosacral arachnoiditis, lumbar spine syndrome, multiple sclerosis, brachialgia, cluster headache, diabetic neuritis, post-herpetic neuralgia and causalgia, and Guillain–Barré syndrome.

The focus in neurology has been on intrathecal administration, and the success rates in arachnoiditis, lumbar spine syndrome, cluster headache, multiple sclerosis, and cervicobrachialgia have been estimated at 65% (Cleveland Clinic, 1963: assessment of intrathecal hydrocortisone administration in over 1000 patients [83–86]). In 1970, a critical study by Goldstein et al. [39] for the first time pointed out the risks of intrathecal administration of methylprednisolone. Experimental studies on the neurotoxic effects of polyethylene glycol, the preservative used in the methylprednisolone preparation Depo-Medrol [59, 87] followed, using animal models. After reports from Australia describing increasing numbers of complications with intrathecal injections, but very rare complications with epidural applications, a reaction set in that led to the withdrawal in 1990 of approval for Depo-Medrol for intrathecal – and consequently also epidural – applications. This decision was criticized by numerous experienced specialists throughout the world, since epidural administration of methylprednisolone in carefully selected patients had established itself as an effective and safe component of multidisciplinary pain therapy [1, 2, 6, 8, 20, 45, 93, 94, 105].

Even in large groups of patients – both Abram [1, 2] and Delaney et al. [27] reported more than 6000 applications – epidural administration of methylprednisolone was not associated with neurotoxic or meningeal reactions. In our own experience (more than 3000 epidural injections of Depo-Medrol, two-thirds of which were lumbar and one-third cervical), complications were rare and confined to technical problems such as dural puncture. According to the Australian and British Pain Societies, no evidence has been found that epidural steroid injections are injurious to the patient [41, 101]. “However … the Pain Societies of Great Britain and Australia now feel that a) there is good evidence that epidural steroids are helpful and b) no evidence that epidural steroids are harmful” (J.C.D. Wells, personal communication, 1995) [101].

When epidural steroid injection is carried out correctly by an experienced anesthetist, it is an important and useful component of the treatment of cervical and lumbar pain and is well tolerated by the patient.

**Cervical epidural steroid injection**

**Anatomy**

The narrowest sagittal diameter of the epidural space in the cervical region is 1–1.5 mm, but it may enlarge when the neck is flexed [11, 23, 61, 75]. The cervical spinous processes are not angled, and it is therefore advisable to use a midline approach with the patient in a sitting position and with the neck flexed (see also Chapter 41).

**Indications**

- Acute cervical pain, cervical radicular pain (when surgery is not indicated).
- Acute episodes of chronic cervical pain.
- Treatment-resistant cervicobrachial pain, genuine occipital neuralgia [67], post-herpetic neuralgia [67].
- After whiplash trauma [65].
- After cervical intervertebral disk surgery.
- Compressive lesions [78] and spinal stenoses [89].
Contraindications
See Chapter 41, p. 306.

Relative
Diabetes mellitus:
When steroids are administered, regular checking of blood sugar levels must be carried out. The increased risk of infection must be taken into account.

Neurological disease:
In individual cases, a strict risk–benefit assessment must be carried out. Epidural injections for surgical and therapeutic purposes have been safely carried out, and are continuing to be carried out safely, in thousands of patients – e.g. after intervertebral disk surgery with stable neurological deficits.

This block must only be carried out by highly experienced and skilled anesthetists with good training.

Procedure
Full prior information for the patient is mandatory.

Preparation and materials
Availability and knowledge of all anesthetic facilities.
Strict indication (risk–benefit assessment).
Check that the emergency equipment is complete and in working order; sterile precautions, anesthetic machine, intravenous access, BP monitoring, ECG monitoring, pulse oximetry.
Maintain strict asepsis.

The use of purpose-designed kit for epidural anesthesia is recommended (e.g. from B. Braun Melsungen); disinfectant, endotracheal anesthesia set, emergency drugs.

Puncture needles
See Chapter 41, Fig. 41.3.

Tuohy needle:
The needle most widely used throughout the world is the 18-G Tuohy needle (there are also reports in the literature describing 17-G to 20-G Tuohy needles).

Weiss needle:
This needle (18–20 G) with wings and a blunt tip is preferable for use with the "hanging drop" technique [79].

Spinal needle:
Spinal needles (3½, 20 G) are only used for an epidurogram [99].

Patient positioning
Sitting (this increases the negative epidural pressure, particularly during inspiration), with the neck flexed (this relaxes the cervical muscles, and increases the size of the epidural space), if possible supported by an assistant (Fig. 45.1).
The patient must be informed about the importance of sitting still during the insertion procedure.

Skin prep
In all blocks.

Identifying the epidural space
The epidural space can be identified using either the loss-of-resistance technique (see below), with a subsequent epidurogram if appropriate [101], or using the “hanging drop” technique (see Chapter 41, Fig. 41.11).

Injection technique
For puncture in the C7–T1 and T1–T4 regions, the midline approach is recommended.

Local infiltration
After thorough skin prep (strict asepsis), the puncture area is covered with a sterile drape, and local anesthesia with 1.5 ml 1% prilocaine is given.

Fig. 45.1 Patient position: sitting, with the neck flexed and supported by an assistant.
Cutaneous, subcutaneous, and intraligamentous infiltration is carried out up to a depth of 2 cm (Fig. 45.2).

**Reaching the ligamentum flavum**

After palpation of the vertebra prominens (nuchal tubercle), the skin between the two spinous processes selected (C7–T1) is incised with a stylet, to make it easier to introduce the Tuohy needle (Fig. 45.3).

![Fig. 45.2 Cutaneous, subcutaneous, and intraligamentous infiltration of the puncture area](image)

The 18-G Tuohy needle, with its bevel directed cranially, is introduced in the midline. Depending on the flexion of the neck, the angle can be about 30° (Fig. 45.4). After about 1.5 cm, it reaches the interspinous ligament. A low-friction syringe filled with 10 mL isotonic saline, and with a small air bubble, is now attached to the needle.

**Loss-of-resistance technique**

See Chapter 41, Fig. 41.10. The needle is now advanced very slowly, millimeter by millimeter, with simultaneous pressure on the syringe plunger, using the right hand. The left hand is used to apply braking pressure. As CSF pressure in the cervical region is very low and the elasticity of the ligamentum flavum is reduced in this area, aspiration must be carried out very frequently. When the epidural space is entered, the contents of the syringe can be injected easily. During the injection, brief paresthesias in the shoulder and arm region and as far as the fingertips are signs that the needle is positioned correctly.

**Steroid injection into the epidural space**

After this, slow injection of the solution of steroid, saline and local anesthetic can be carried out without a prior test dose [79, 101], as the concentration of local anesthetic in the mixture is very low. A false loss of resistance often occurs in the cervical region, with the epidural space not being reached. Dur-
Epidural steroid injection

During the subsequent saline injection, the patient experiences severe local pain.

**Effects of the block and onset**
The analgesic and anti-inflammatory effects [52, 104] and resultant relaxation of the tensed neck muscles set in after 1–6 days.

**Dosage**

**Local infiltration of the puncture site**
1.5 mL local anesthetic – e.g. 1% prilocaine.

**Identification of the epidural space**
10 mL isotonic saline.

**Injection solution**
10 mL total volume: 1.5 mL (60 mg) soluble Volon A (triamcinolone acetonide), mixed with 2 mL 1% mepivacaine and about 6.5 mL isotonic saline. The mixture with saline and local anesthetic dilutes the steroid's preservative to an acceptable level [10]. The total volume guarantees adequate spread of the steroid. These are the reasons why the author prefers this particular injection mixture.

Immediately after the injection, transient fatigue (for about 20 minutes) and brief paresthesias in the shoulder, arm, and hand region are characteristic signs of a successful block.

After the steroid injection, the patient remains lying down for about 1 hour (ECG, pulse oximetry, BP monitoring).

After a further hour, the patient, who should not drive, can be discharged if escorted. During the following 24–48 hours, pain may occur at the injection site.

The risk of an epidural hematoma or abscess developing is extremely low, but it cannot be excluded. The patient must therefore be aware of the need to contact the hospital at the first sign of any complication.

There is no justification for more than three injections at intervals of 1–2 weeks. If the symptoms deteriorate again, periodic single injections are possible after a careful risk–benefit assessment.

**Complications**

**Dural puncture with postdural puncture headache**
See Chapter 37, p. 287.

**Spinal cord injury**

Neurological injuries may occur in all forms of neuraxial regional anesthesia. Spinal cord injury with paraplegia is caused by poor technique, but is extremely rare. Prophylaxis requires extremely cautious advancing of the needle, as well as frequent aspiration. It should be noted that CSF pressure is very low in the cervical region.

**Bacterial meningitis**

Strict asepsis is always necessary when carrying out this block. In septic diseases and infections in the area of the injection site, the block is contraindicated.

**Epidural abscess**

No connection has yet been identified between epidural steroid administration and the development of epidural abscesses. Numerous studies [1, 2, 12, 20, 40, 76, 92] report that there is rather evidence of a connection between prior septic disease and the development of abscesses after epidural anesthesia (see Chapter 41, p. 326).

**Epidural hematoma**

If the patient reports any symptoms of pain or fever, or radicular symptoms, these must be investigated. Constant contact with the patient is necessary, particularly after outpatient procedures. Immediate investigation (myelography, CT, MRI) and neurosurgical treatment within the first 12 hours are essential to reduce morbidity and mortality (see Chapter 41, p. 326).

During the preliminary examination to exclude contraindications, it should be noted if the patient is receiving any medication that might affect platelet function.

Monotherapy with a platelet aggregation inhibitor does not lead to an increased risk of hemorrhage. In contrast, a combination of different drugs and therapy must be noted.

In connection with anatomic changes or technical difficulties, simultaneous administration of the following preparations can lead to marked risks: Acetylsalicylic acid (ASA, aspirin) or mixed preparations containing ASA, nonsteroidal anti-inflammatory drugs, high-dose antibiotics, propranolol, furosemide, quinidine, heparin, heparinoids, thrombolytics, tricyclic antidepressants...
sants, phenothiazine, antilipemic drugs, chemotherapy drugs, dextrans, etc. An epidural block with steroids should not take place within 5 days of the last intake of acetylsalicylic acid (ASA) and ASA-containing preparations. The last intake of nonsteroidal anti-inflammatory agents should be at least 24 hours previously. There is a lack of controlled studies here, and the topic is a controversial one.

Cushing's syndrome
In extremely rare cases, Cushing's syndrome may manifest as a result of an epidural block with steroids [31]. There is evidence of a reduced plasma cortisol level up to 2 weeks after the injection, even though the usual dosage of 40–80 mg per block is well below the maximum recommended corticosteroid dosage of 3 mg/kg b.w. per injection [96].
### Cervical epidural steroid injection

**Block no.**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis:</td>
<td></td>
</tr>
<tr>
<td>Premedication:</td>
<td>□ No</td>
</tr>
<tr>
<td>Neurological abnormalities:</td>
<td>□ No</td>
</tr>
</tbody>
</table>

**Purpose of block:**
- □ Diagnosis
- □ Pain treatment

**Needle:**
- □ Tuohy G ___
- □ Other ___

**i.v. access, infusion:**
- □ Yes

**Monitoring:**
- □ ECG
- □ Pulse oximetry

**Ventilation facilities:**
- □ Yes (equipment checked)

**Emergency equipment (drugs):**
- □ Checked

**Patient:**
- □ Informed

**Position:**
- □ Sitting
- □ Lateral decubitus

**Access:**
- □ Median
- □ Paramedian

**Injection level:**
- □ C7/T1
- □ Other ___

**Injection technique:**
- □ Loss of resistance
- □ Other ____

**Test dose:**
- □ No
- □ Yes ___ mL ___ %

**Injection mixture:**
- Steroid: ___ mg
- NaCl 0.9%: ___ mL ___ %
- Local anesthetic: ___ mL ___ %

**Patient's remarks during injection:**
- □ None
- □ Pain
- □ Paresthesias
- □ Warmth

**Duration and area:**

**Objective block effect after 15 min:**
- □ Cold test
- □ Temperature measurement before ____ °C after ____ °C
- □ Sensory
- □ Motor

**Monitoring after block:**
- □ < 2 h
- □ > 2 h

**Time of discharge:**

**Abnormalities:**

**Complications:**
- □ None
- □ Vasovagal reactions
- □ Severe pain
- □ Fever
- □ Dural puncture
- □ Radicular symptoms
- □ Neurological complications

**Subjective effects of the block:**
- □ None
- □ Increased pain
- □ Reduced pain
- □ Relief of pain

**VISUAL ANALOG SCALE**

<table>
<thead>
<tr>
<th>Duration:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

**Special notes:**

© Copyright ABW Wissenschaftsverlag 2004,
Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
This method is not effective in:
Deforming spondylopathy, spondylochondrosis, de-
forming spondyloarthropathy, spondylolisthesis,
spondylarthritis, scoliosis, functional back pain, chronic
symptoms.

Indications
Patients with a short history of pain.
Unsuccessful intervertebral disk surgery (post-
laminectomy syndrome).
Inflammatory and compressive radiculopathies.
Intervertebral disk prolapse (not requiring surgery).
Spinal canal stenosis.
Post-herpetic neuralgia in the lumbosacral area
(best results within 3 months after the start of the
disease).

Specific and relative contraindications
See Chapter 41, p. 306 and the section on cervical
epidural steroid injection.

This block must only be carried out by highly ex-
perienced and skilled anesthetists with good training.

Procedure

Full prior information for the patient is mandatory.

Preparation and materials
Strict indication (risk–benefit assessment).
The patient must be fully informed.
Check that the emergency equipment is complete
and in working order.
Observe strict asepsis.
Anesthetic machine, intravenous access, BP moni-
toring, ECG monitoring, pulse oximetry.

The use of purpose-designed kit for epidural anesthesia
is recommended (e.g., from B. Braun Melsungen).

Puncture needles
Tuohy needle, 17 G or 18 G (see Chapter 41, Fig.
41.3).
Spinal needles (3\(^\frac{1}{2}\), 20 G) are only used for an
epidurogram [101].

Patient positioning
Lateral decubitus with the patient lying on the painful
side, or sitting (risk of collapse).

Skin prep, local anesthesia, skin incision,
and identification of the epidural space
See Chapter 41, p. 307.

After intervertebral disk surgery, the puncture is carried
out about 1 cm above the scar. It can be carried out
with a midline or paramedian approach.

Steroid injection into the epidural space
Injection of the steroid, mixed with a local anesthetic,
must be carried out slowly.
After the injection, the patient remains in the lateral
decubitus position for about 20 minutes.

Effects of the block and onset of effect
See also the section on cervical epidural steroid injec-
tion, p. 349.

Immediately after the block, transient fatigue (for
about 20 minutes), brief paresthesias, and a sensation
of warmth in both legs are characteristic signs of a suc-
cessful block.
After an injection of steroid combined with local anes-
thetic, the patient remains recumbent for about 1–2
hours (20 minutes of this lying on the side), until the ef-
fect of the local anesthetic has declined.
Monitoring is obligatory during this period.
After a further hour, the patient, who should not drive,
can be discharged if escorted. It should be checked and
recorded beforehand that the effect of the local anes-
thetic is no longer present.
During the following 24–48 hours, pain may occur at
the injection site. The risk of an epidural hematoma or
abscess developing is extremely low, but it cannot be
excluded. The patient must therefore be aware of the
need to contact the hospital at the first sign of any
complication.

Puncture needles
Tuohy needle, 17 G or 18 G (see Chapter 41, Fig.
41.3).
Spinal needles (3\(^\frac{1}{2}\), 20 G) are only used for an
epidurogram [101].
**Dosage**

*Injection solution*

Test dose: 2 mL 1% lidocaine.

Total volume 10 mL: 2 mL (50 mg) intralesional Aristo-cort (triamcinolone diacetate), mixed with 2 mL 0.9% NaCl and 6 mL 1% lidocaine [79].

Or:

Test dose: 2 mL 1% lidocaine.

Total volume 10 mL: 2 mL (80 mg) soluble Volon A (tri-amcinolone acetonide), mixed with 8 mL local anesthetic consisting of equal halves of 1% lidocaine and 0.25 bupivacaine [101].

**Block series**

See the section on cervical epidural steroid injection, p. 349.

**Complications**

See Chapter 41, p. 324, and the section on cervical epidural steroid injection, p. 349.
### Lumbar Epidural Steroid Injection

**Record and Checklist**

**Block no.**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis:</td>
<td></td>
</tr>
</tbody>
</table>

**Premedication:**
- [ ] No
- [ ] Yes

**Neurological abnormalities:**
- [ ] No
- [ ] Yes

<table>
<thead>
<tr>
<th>Purpose of block:</th>
<th>Diagnosis</th>
<th>Pain treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle:</td>
<td>[ ] Tuohy G</td>
<td>[ ] Other</td>
</tr>
<tr>
<td>i.v. access, infusion:</td>
<td>[ ] Yes</td>
<td>[ ] Pulse oximetry</td>
</tr>
<tr>
<td>Monitoring:</td>
<td>[ ] ECG</td>
<td>[ ] No (equipment checked)</td>
</tr>
<tr>
<td>Emergency equipment (drugs):</td>
<td>[ ] Checked</td>
<td></td>
</tr>
<tr>
<td>Patient:</td>
<td>[ ] Informed</td>
<td></td>
</tr>
</tbody>
</table>

**Position:**
- [ ] Sitting
- [ ] Lateral decubitus

**Access:**
- [ ] Median
- [ ] Paramedian

**Injection level:**
- [ ] L3/L4
- [ ] Other

**Injection technique:**
- [ ] Loss of resistance
- [ ] Other

**Test dose:**
- [ ] No
- [ ] Yes

**Injection mixture:**
- Steroid: [ ] mg
- NaCl 0.9%: [ ] mL
- Local anesthetic: [ ] mL [ ] %

**Patient’s remarks during injection:**
- [ ] None
- [ ] Pain
- [ ] Paresthesias
- [ ] Warmth

**Duration and area:**
- [ ] Cold test
- [ ] Temperature measurement before [ ] °C after [ ] °C
- [ ] Sensory
- [ ] Motor

**Objective block effect after 15 min:**
- [ ] < 2 h
- [ ] > 2 h

**Time of discharge:**
- [ ] Abnormalities:

**Complications:**
- [ ] None
- [ ] Vasovagal reactions
- [ ] Severe pain
- [ ] Fever
- [ ] Dural puncture
- [ ] Radicular symptoms
- [ ] Neurological complications

**Subjective effects of the block:**
- [ ] None
- [ ] Increased pain
- [ ] Reduced pain
- [ ] Relief of pain

**VISUAL ANALOG SCALE**

<table>
<thead>
<tr>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
</table>

**Special notes:**

© Copyright ABW Wissenschaftsverlag 2004, Jankovic, Regional nerve blocks and infiltration therapy, 3rd edition
Introduction

This combined technique was introduced in neuraxial regional anesthesia in order to exploit as many advantages of both procedures as possible and to minimize their disadvantages.

In CSE, the reliability, fast onset of effect, high success rate, excellent muscle relaxation and low toxicity of spinal anesthesia are combined with the advantages of epidural anesthesia: flexibility, good controllability, ability to prolong the anesthesia as required and potential transition to postoperative pain treatment.

CSE allows better titration and a substantial reduction in the dose of local anesthetic, opioid, or combination of the two.

The advantages of this technique can be used particularly effectively in obstetrics, with results showing a substantial reduction in maternal hypotension during birth.

History

In 1937, the New York surgeon Soresi [90] reported that it was possible to inject procaine first epidurally and then intrathecally through the same needle.

In 1979, Curelaru [26] described the use of CSE in abdominal surgery, urology and orthopedics. After placement of an epidural catheter, a subarachnoid injection was carried out one or two segments below the puncture site.

In 1981, Brownridge [14] reported the use of CSE for cesarean section. He used two different segments for puncture.

A modification of this technique with one-segment puncture ("needle through needle") was used in 1982 by Coates [21] and Mumtaz [64] in orthopedic surgery and in 1984 by Carrie [15] in obstetric surgery.

In 1986, Rawal [70] described the sequential (two-stage) CSE technique for cesarean section.

Indications

Surgical procedures:
- General surgery
- Outpatient surgery [97], Vascular surgery [100], Orthopedics [21, 46, 64, 102], Gynecology [17], Obstetrics [15, 70, 71, 72], Urology [26], Pediatric surgery [66], Postoperative pain therapy.

Contraindications

The contraindications are the same as those for spinal anesthesia (see Chapter 36, p. 272) and epidural anesthesia (see Chapter 41, p. 306).

Procedure

Full prior information for the patient is mandatory.

Preparation and materials

Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs), anesthetic machine.

Set up an intravenous infusion and give a volume load (500–1000 mL of a balanced electrolyte solution).


The use of purpose-designed kit is recommended – e.g. Espocan from B. Braun Melsungen (Fig. 46.1).

This procedure must only be carried out by an experienced anesthetist.
Patient positioning
The puncture is carried out below the L2 segment, with the patient either in the lateral decubitus position (preferable) or sitting.

Injection technique
"Needle through needle"
After locating and marking the puncture site (L2/3 or L3/4), thorough skin prep is carried out, followed by local anesthesia and a skin incision using a stylet.
Insertion is carried out in the midline using an 18-G epidural Tuohy needle, with the bevel directed cranially. Identification of the epidural space is carried out using the loss-of-resistance technique (Fig. 46.2).
After identification of the epidural space and injection of a test dose (Fig. 46.3), a thin 27-G pencil-point spinal needle is carefully advanced through the epidural needle in the direction of the subarachnoid space, until dural perforation is confirmed by a click (Fig. 46.4a).
The adapted form of the Tuohy needle tip, which has a central opening positioned in the needle axis ("back eye"), allows the needle to take a direct path, so that the spinal needle does not need to bend. The plastic coating of the spinal needle expands its outer diameter, so that it fits the epidural needle precisely, maintains its central position as it is advanced and easily passes through the axial opening ("back eye") (Fig. 46.4b).
After careful aspiration of CSF, subarachnoid injection of a local anesthetic, opioid, or a combination of the two is carried out (Fig. 46.5). As this is done, the hub of the spinal needle should be secured with the thumb and index finger of the left hand, which rests on the patient’s back. This is the critical phase of the puncture procedure.
The spinal needle is then withdrawn and the epidural catheter is introduced up to a maximum of 3–4 cm (Fig. 46.6).
After aspiration, the open end of the catheter is laid on a sterile surface below the puncture site and any escaping fluid (CSF or blood) is noted (Fig. 46.7).
To test the patency of the catheter, 1–2 mL saline is then injected. The catheter is secured and a bacterial filter is attached (Fig. 46.8).
Fig. 46.4a A 27-G pencil-point spinal needle is introduced through the positioned epidural needle.

Fig. 46.4b Identification of the subarachnoid space with the dural click.

Fig. 46.5 Subarachnoid injection. The spinal needle is then withdrawn.

Fig. 46.6a Introducing the epidural catheter.

Fig. 46.6b The epidural catheter is advanced by a maximum of 3–4 cm cranially.

- Repeated aspiration.
- As low a dose as possible.
- Always use incremental injections (several test doses).
- Maintain verbal contact.
- Check the spread of anesthesia carefully.
- Careful monitoring.
Problem situations
Specific problems during CSE occur in connection with the administration of a test dose to exclude subarachnoid positioning of the catheter. As spinal anesthesia is being given, it is not possible to test for incorrect intrathecal positioning of the catheter, and incorrect positioning usually becomes evident through high or total spinal anesthesia. This technique should therefore only be carried out by experienced anesthetists. Local anesthetics must only be injected in small incremental amounts (test doses), the spread of the anesthesia must be carefully checked and verbal contact with the patient must be maintained.

Two-segment technique
Puncture is carried out in the midline at the level of L2/3 or L3/4. An 18-G Tuohy needle is used. After identification of the epidural space, the epidural catheter is advanced to a maximum of 3–4 cm. A test dose is then administered. One or two segments lower, conventional spinal anesthesia is then carried out using a 27-G pencil-point needle. The remainder of the procedure is the same as in the “needle-through-needle” technique.

Dosages in the “needle-through-needle” and two-segment techniques
[69, 70, 74, 98]
Subarachnoid
- Opioid: 10 µg sufentanil + 1 mL 0.9% saline.
- Local anesthetic:
  0.5% ropivacaine 1–1.5 mL (5–7.5 mg) ± 0.2 mL
  0.5% hyperbaric bupivacaine 1–1.5 mL (5–7.5 mg) ± 0.2 mL
- Local anesthetic + opioid:
  0.5% ropivacaine + sufentanil 7.5–10 µg, or
  0.5% ropivacaine + fentanyl 25 µg.
  0.5% hyperbaric bupivacaine 1–2.5 mg + sufentanil 7.5–10 µg, or:
  0.5% hyperbaric bupivacaine 1–2.5 mg + fentanyl 25 µg.
Combined spinal and epidural anesthesia (CSE)

Epidural
Top-up dose
After the fixation period for the local anesthetic injected intrathecally (ca. 15 min):
0.5% ropivacaine, 1.5–2 mL per unblocked segment, or
0.25–0.5% bupivacaine, 1.5–2 mL per unblocked segment.

Epidural infusion after bolus administration of
10–15 mL 0.1% ropivacaine + 1–2 µg/mL sufentanil (10–20 µg) or 2 µg/mL fentanyl (30 µg), or:
10 mL 0.0625–0.125% bupivacaine + 10–20 µg sufentanil, or:
10 mL 0.125–0.25% bupivacaine + 50 µg fentanyl.
Continuous infusion of:
0.1% ropivacaine + 0.2–0.3 µg/mL sufentanil (2 µg/mL fentanyl) at 10–12 mL/h, or:
0.031–0.0625% bupivacaine + 0.2–0.3 µg/mL sufentanil at 6–10 mL/h, or:
0.0625% bupivacaine + 1–2 µg/mL fentanyl at 10 mL/h.

Sequential (two-stage) CSE in Cesarean section
This technique has proved particularly useful for Cesarean section, reducing the frequency and severity of maternal hypotension [73].

First stage: procedure in sitting position
Identification of the epidural space (18-G Tuohy needle).
Advancing the spinal needle (27-G pencil-point) until dural perforation is achieved (dural click and free CSF flow).
Intrathecal administration of a local anesthetic and/or opioid. The aim is to reach the segmental level of S5–T9 with as low a concentration as possible (e.g. hyperbaric bupivacaine 1.5 mL ± 0.2 mL).
Introduction of the epidural catheter.

Second stage: procedure in the supine position (left lateral decubitus)
5–20 minute wait until full spread of the subarachnoid local anesthetic is achieved (fixation period).
After subarachnoid spread of the local anesthetic, incremental epidural injection in small doses (top-up) is carried out through the epidural catheter. Ca. 1.5–2 mL 0.5% bupivacaine is administered for each unblocked segment.

Advantages
The slow, incremental administration of the local anesthetic and/or opioid markedly reduces the risk of severe circulatory reactions during Cesarean section. The sympathetic block is less marked (lowest possible subarachnoid dosage and slow onset of epidural anesthesia). The body has time to activate compensatory mechanisms.
This procedure is particularly suitable for high-risk patients.

Disadvantage
More time-consuming.

Dosage in Cesarean section [69]
Subarachnoid
0.5% hyperbaric bupivacaine 1.5 ± 0.2 mL. Block target: S5–T8/9.

Epidural
Top-up dose in left lateral decubitus position after the fixation period (ca. 15 min) of the local anesthetic injected subarachnoidally. 1.5–2 mL 0.5% bupivacaine per unblocked segment.

Dosage in outpatient obstetrics [69]
Subarachnoid (single-shot)
0.5% hyperbaric bupivacaine 1–2.5 mg + 7.5–10 µg sufentanil, or:
0.5% hyperbaric bupivacaine 1–2.5 mg + 25 µg fentanyl.

Epidural top-up dose (continuous infusion 10 mL/h)
Bupivacaine 1 mg + 0.075–1.0 µg/mL sufentanil, or:
Bupivacaine 1 mg + 2 µg fentanyl.

Complications
See Chapter 37, p. 285 and Chapter 41, p. 324.
# Combined spinal and epidural anesthesia (CSE)

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
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</table>

<table>
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<tr>
<th>Diagnosis:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Premedication:</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Neurological abnormalities:</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
</table>

## Purpose of block:
- **Surgical**
- **Obstetric**
- **Postoperative**

<table>
<thead>
<tr>
<th>Needle: Spinal:</th>
<th>G</th>
<th>Tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidural: Tuohy</td>
<td>G</td>
<td>Other</td>
</tr>
</tbody>
</table>

| i.v. access, infusion: | Yes |

| Monitoring: | ECG | Pulse oximetry |

| Ventilation facilities: | Yes (equipment checked) |

| Emergency equipment (drugs): | Checked |

| Patient: | Informed |

<table>
<thead>
<tr>
<th>Position:</th>
<th>Lateral decubitus</th>
<th>Sitting</th>
</tr>
</thead>
</table>

| Access: | Median | Paramedian |

<table>
<thead>
<tr>
<th>Injection level:</th>
<th>L3/L4</th>
<th>L4/L5</th>
<th>Other</th>
</tr>
</thead>
</table>

| Injection technique: | Needle-through-needle | Two-segment |

| Epidural space: | Identified |

| Test dose: | Epinephrine added: | Yes | No |

## Subarachnoid:

<table>
<thead>
<tr>
<th>Injection:</th>
</tr>
</thead>
</table>

| CSF aspiration: | Possible | Not possible |

<table>
<thead>
<tr>
<th>Local anesthetic:</th>
<th>mt</th>
<th>%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Addition:</th>
<th>μg/ml</th>
</tr>
</thead>
</table>

## Epidural:

<table>
<thead>
<tr>
<th>Epidural catheter:</th>
<th>Advanced 3–4 cm cranially</th>
</tr>
</thead>
</table>

| Aspiration test: | Carried out |

| Catheter end: | Positioned lower than the puncture site |

<table>
<thead>
<tr>
<th>Bacterial filter:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Local anesthetic:</th>
<th>mt</th>
<th>%</th>
</tr>
</thead>
</table>

(incremental)

| Abnormalities: | No | Yes |

| Patient’s remarks during injection: |

| Duration and area: |

| Objective block effect after 20 min: |

| Complications: |

| Special notes: |

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Caudal epidural anesthesia

47 Caudal anesthesia in adult patients

Definition
Epidural injection of a local anesthetic or a mixture of a local anesthetic and an opioid or steroid through a needle positioned in the sacral canal or through a catheter.

Anatomy
See also Chapter 35, section on the sacral bone, p. 265.

The sacral hiatus is located in line with the median sacral crest. Its lateral boundary is formed by the sacral cornua and it is enclosed by the superficial dorsal, deep dorsal and lateral sacrococcygeal ligaments, which pass from the sacrum to the coccyx (Fig. 47.1). The hiatus represents the caudal entrance to the sacral canal. The sacral canal has a diameter of 2–10 mm in an anteroposterior direction and its capacity varies from 12 mL to 65 mL (average 30–34 mL) [19] (Fig. 47.2). It encloses and protects the dura, arachnoid and subarachnoid space, which in most cases end at the level of the second sacral vertebra, as well as the sacral and coccygeal roots of the cauda equina, the sacral epidural venous plexus, lymphatic vessels and epidural fat. The dura normally ends at the level of the second sacral foramina (1–1.5 cm medial and caudal to the dorsal cranial iliac spines), so that this connecting line externally marks the end of the dural sac (Fig. 47.3).

Fig. 47.1 Sacral hiatus, with the sacrococcygeal ligaments:
1. Superficial dorsal sacrococcygeal ligament,
2. deep dorsal sacrococcygeal ligament,
3. lateral sacrococcygeal ligament

Fig. 47.2 Sacral canal.
1. Sacral canal,
2. supraspinous ligament,
3. interspinous ligament,
4. ligamentum flavum,
5. sacrospinous ligament,
6. sacrotuberal ligament
Anatomic variants are possible (e.g. S2 or S3), so that the distance from the dura to the hiatus can range from 1.6 cm to 7.5 cm (average 4.5 cm). This should be taken into account during insertion [16].

In children under 1 year of age, the dural sac may come up to the level of the fourth sacral vertebra, and particular caution is therefore required during insertion in these patients.

The sacral canal is at its narrowest in the region of the hiatus, and the surrounding area is very well vascularized. This block should only be carried out by experienced anesthetists or under their supervision.

**Indications**

**Surgical**

Procedures and painful examination in the perineal and perianal area (e.g. hemorrhoids or operations on the prostate, bladder or penis).

Inguinal and femoral hernias.

Procedures in the area of the coccyx.

Superficial procedures on the lower extremities (e.g. skin grafts).

**Gynecological**

Procedures and painful examinations (vulva, vagina, cervix, clitoris).

**Obstetric**

Pain during the second stage of labor.

**Diagnostic and therapeutic**

Various painful conditions in the area of the lumbar spine, pelvis, perineum, genitals, rectum and lower extremities.

**Acute pain**

Postoperative and post-traumatic pain.

Lumbar spine syndrome (only after excluding a surgical cause).

Post-herpetic neuralgia.

Vascular insufficiency.

Ergotism.

Frostbite.

Hidradenitis suppurativa.

**Chronic pain**

Lumbar radiculopathy.

Spinal canal stenosis.

Postlaminectomy syndrome.

Diabetic polyneuropathy.

Complex regional pain syndrome, types I and II (sympathetic reflex dystrophy and causalgia).

Postamputation pain.

Vasospastic diseases.

Orchialgia.

Proctalgia.

**Tumor pain**

Genital and rectal, in the pelvis, in the perineum.

Peripheral neuropathy (after radiotherapy or chemotherapy).

**Contraindications**

**Specific**

Patient refusal.

Coagulation disorders, anticoagulant therapy.

Sepsis.

Local infections (skin diseases) at the puncture site.

Immune deficiency.

Severe decompensated hypovolemia, shock.

Specific cardiovascular diseases of myocardial, ischemic, or valvular origin, if the planned procedure requires higher sensory spread.

Acute diseases of the brain and spinal cord.

Increased intracranial pressure.

A history of hypersensitivity to local anesthetics, without a prior intradermal test dose.

**Relative**

- Pilonidal cyst.
- Congenital anomalies of the dural sac and its contents.
Caudal anesthesia in adult patients

Procedure

Full prior information for the patient is mandatory.

Preparation and materials

- Check that the emergency equipment is complete and in working order (intubation kit, emergency drugs); sterile precautions, intravenous access, anesthetic machine.
- Intravenous infusion of a balanced electrolyte solution (250–500 mL).
- Careful monitoring: ECG, BP, pulse oximetry.
- Pillow for patient positioning.

The use of a purpose-designed kit is recommended (e.g. from B. Braun Melsungen) Fig. 47.4).

Puncture needles

Single-shot technique

Plastic indwelling catheter needle with trochar – e.g. Contiplex A plastic indwelling catheter needle 1.3 x 45 mm, 30° bevel.

Special caudal needle with trochar – e.g. Tuohy: Perican 0.90 x 50 mm 20 G, Perican 1.30 x 50 mm 20 G, Perican 1.30 x 50 mm 18 G x 2” or Epican, special 32° tip at 0.9 x 50 mm.

Continuous technique

Tuohy or Crawford or plastic indwelling catheter needle (e.g. Epican, B. Braun Melsungen).

Current information and standards show that only needles with a trochar should be used, particularly for caudal anesthesia in children.

Single-shot technique

Patient positioning

The puncture is usually carried out with the patient in the prone position, with a pillow under the pelvis and legs spread, so that the heels are turned out and the toes rotated inward. This allows optimal relaxation of the gluteal musculature (Fig. 47.5a). In addition, particularly in obese patients, the gluteal cleft is separated by attaching a broad band of sticky plaster between the skin of the buttocks and the operating table (Fig. 47.5b).

This procedure can also be carried out in the lateral decubitus position (particularly in children and in pregnant patients) or in the knee–elbow position (pregnant patients).

Location, skin prep, local anesthesia, skin incision

Locating and marking the sacral cornua

The sacral cornua or sacral hiatus and sacrococcygeal ligaments are palpated with the thumb and index finger (Fig. 47.6a).

Palpation of the dorsal cranial iliac spines

A triangle is drawn to the sacral cornua (sacral hiatus). About 1–1.5 cm caudal and medial to the dorsal cranial iliac spines lies the second sacral foramen, the connecting line of which indicates the level of the dural sac in most patients. This line must not be reached when the needle is being advanced (Fig. 47.6b).

A swab is placed in the gluteal sulcus to protect the area from disinfectant (Fig. 47.5b).
Fig. 47.5a Position

Fig. 47.5b Attachment of a broad adhesive plaster. Placement of a swab in the gluteal cleft

Fig. 47.6a Palpation of the sacral cornua

Fig. 47.6b Palpation of the dorsal cranial iliac spines
Strict asepsis
Thorough, repeated wide skin prep, drying and covering of the puncture site with a sterile drape.

Local anesthesia
Local anesthesia with 1% mepivacaine is injected in the subcutaneous tissue over and around the sacral hiatus. The periosteum around the sacral hiatus is particularly sensitive and should also be injected.
The needle is introduced at an angle of 70° to the skin surface of the back of the sacrum (Fig. 47.7)

Preparing the drugs
A syringe with 3–4 mL of an epinephrine-containing local anesthetic (test dose).
A syringe with the calculated dose of local anesthetic.

Skin incision
Using a stylet or large needle (Fig. 47.8).

Puncture of the caudal epidural space
Puncture
The puncture needle is introduced at an angle of 70° in the direction of the sacral hiatus until bone contact is made (Fig. 47.9a).
The needle is now slightly withdrawn and the anesthetist slowly reduces the angle of the needle (Fig. 47.9b) as far as about 20° in male patients or about 35° in women until perforation of the sacrococcygeal ligament is carried out and the needle can be advanced without resistance parallel to the posterior wall of the sacral canal to a depth of 3 cm [16] (Fig. 47.9c).
Fig. 47.9a–c Puncture of the caudal epidural space.

a Puncture angle of 70°. b Lowering maneuver. c Introducing the needle into the sacral canal
When plastic indwelling catheter needles are used, the trochar is withdrawn slightly after the sacral canal has been entered and the plastic part is advanced 2–3 cm (Fig. 47.10).

**Checking the position of the needle tip in the dural sac (second sacral foramen)**

The trochar is withdrawn and the distance of the needle in the sacral canal checked. This is easily done by placing the trochar on the skin overlying the sacrum (Fig. 47.11).

**Checking for escaping fluid (CSF or blood) (Fig. 47.12)**

**Aspiration test (Fig. 47.13)**
Injection of 5 cm³ of air or 0.9% saline
If no blood or CSF escapes, a rapid injection of 5 cm³ of air or 0.9% NaCl is carried out (Fig. 47.14). The patient is then informed that he or she will feel pressure paresthesias in the legs (a sign of correct needle positioning). The anesthetist palpates the surface of the sacrum with the free hand (crepitation, swelling), to exclude the possibility that the catheter is positioned outside the canal.
If pain occurs during this injection, the needle is not correctly positioned.

Test dose
3–4 mL of an epinephrine-containing local anesthetic (Fig. 47.15).

Waiting period
During the 5-minute waiting period, careful cardiovascular monitoring is carried out. Verbal contact must be maintained with the patient.
Five minutes after administration of the test dose, the lower extremities, abdomen and chest are tested for numbness in order to exclude the possibility of inadvertent subarachnoid injection. Extensive spread suggests dural puncture.

Incremental injection of a local anesthetic
If there is no effect or only a minimal effect, in the form of hypoesthesia in the perineal and perianal area or over the coccyx, and if the patient’s sensory function is unchanged and the circulation is stable, then the injection of local anesthetic can be carried out (Fig. 47.16).
Problem situations

Aspiration of blood
Steel needle or plastic indwelling catheter needle:
Reinsert the trochar, then advance by 0.5–1 cm and wait for 2–3 min.
Steel needle without a trochar:
Advance by about 0.5–1 cm, inject 1 mL 0.9% saline and wait for 2–3 min.

If blood is aspirated again, the puncture procedure must be stopped.

Aspiration of CSF
The puncture procedure must be stopped.

Failure
Owing to the highly variable anatomy in the sacral canal, a failure rate of 5–10% can be expected [16]. Experience shows that the sacral hiatus cannot be identified in about 0.5–1% of patients.

Further steps
After aspiration at two different levels, the catheter is advanced through the needle to a depth of 3–4 cm.

Removing the needle
After the catheter has been positioned as required, the needle is carefully withdrawn, with the catheter being simultaneously secured with the thumb and index finger of the left hand at the injection site (Fig. 47.18).

Continuous caudal anesthesia

Puncture needles
As for the single-shot technique.

Catheter
Atraumatic epidural catheters with a central opening are used.

Before insertion
The length of the needle must be compared with the calibration marks on the catheter to improve assessment of the depth of the catheter after introduction (Fig. 47.17). At the same time, the ability of the catheter to pass through the needle can be tested. Preparation, puncture and introduction of the needle into the sacral canal are the same as in the single-shot technique.

Fig. 47.17 The length of the needle is compared with the calibration marks on the catheter.
Chapter 47

Fig. 47.18a Withdrawing the needle

Fig. 47.18b Securing the catheter with the thumb and index finger

Fig. 47.19a Attaching the adapter

Fig. 47.19b Injection of 1 mL 0.9% NaCl
Aspiration test (Fig. 47.20)

Observe the open end of the catheter carefully
The syringe is disconnected and the open end of the catheter is placed on the sterile drape lower than the puncture site. Any escaping fluid (CSF or blood) is noted (Fig. 47.21).

Test dose
3–4 mL of an epinephrine-containing local anesthetic (Fig. 47.22).
Chapter 47

Waiting period
Wait for 5 minutes. During this time, careful cardiovascular monitoring is carried out. Verbal contact must be maintained with the patient.
Five minutes after administration of the test dose, the lower extremities, abdomen and chest are tested for possible numbness, to exclude the possibility of inadvertent subarachnoid injection.

Incremental injection of a local anesthetic
After placement of a bacterial filter (Fig. 47.23), sterile attachment of the catheter and repeated aspiration, incremental injection of local anesthetic is carried out (Fig. 47.24).

Dosages
The same principles apply here as in lumbar epidural anesthesia. Due to the wide variations in the capacity of the sacral canal in the adult, it is difficult to give precise details of the volume of local anesthetic to be injected.
The concentration of local anesthetic determines the intensity of the block. Usually, 20–35 mL of local anesthetic is administered (2–3 mL per segment in the adult). A delay in the onset of effect must be anticipated. The time to onset of effect is shortened and the motor block is intensified when epinephrine is added.

<table>
<thead>
<tr>
<th>Anesthetic spread</th>
<th>Local anesthetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(segment)</td>
<td>(mL)</td>
</tr>
<tr>
<td>S5−L2</td>
<td>15–20</td>
</tr>
<tr>
<td>S5−T10</td>
<td>25–30</td>
</tr>
</tbody>
</table>

In pregnant patients and obese patients, the dose should be reduced by about 30%.
Caudal anesthesia in adult patients

Local anesthetics

Surgical procedures
Ropivacaine 0.75–1%
Bupivacaine 0.375–0.5% (levobupivacaine 0.375–0.5%)
Prilocaine 2% (contraindicated in obstetrics)
Mepivacaine 1.5–2%
Lidocaine 1.5–2%

Diagnostic and therapeutic blocks
(No addition of epinephrine!)

Block Sensory Sympathetic
Ropivacaine 0.375–0.5% 0.2%
Bupivacaine 0.25% 0.125%
Levobupivacaine 0.25% 0.125%
Prilocaine 1% 0.5%
Mepivacaine 1% 0.5%
Lidocaine 1% 0.5%

Pain therapy
Combination of local anesthetic and corticosteroids
15 mL 0.2% ropivacaine or 15–20 mL 0.125% bupivacaine (0.125% levobupivacaine) mixed with 40–80 mg triamcinolone acetonide (soluble Volon A) (see Chapter 45).
In outpatient procedures, 0.5% prilocaine or 0.5% mepivacaine or 0.5% lidocaine can be used as an alternative.

Opioids
Bolus injections
In combination with a local anesthetic:
Sufentanil: 30–50 µg
Fentanyl: 50 µg
Morphine: 2–5 mg

Continuous administration
See Chapter 41, p. 317.

Complications (Fig. 47.25)

Complications due to poor technique:
Intraosseous injection into the richly vascularized vertebral bodies.

Puncture needle lying on the sacrum: crepitation or subcutaneous swelling may be noticed after injection of air, saline or local anesthetic.

Subperiosteal positioning: this becomes evident through resistance during the injection and associated pain.

Needle positioned ventral to the sacrum: the needle is located between the sacrum and the coccyx. Advancing it further could lead to perforation of the rectum, or in obstetric anesthesia to injury to the head of the fetus.

Prophylaxis: strict observation of the midline.
Infections: in about 0.2% of patients. Strict asepsis is the best form of prophylaxis.

Intravascular injection (see Chapter 6, p. 65). Intrathecal injection, with high or total spinal anesthesia (see Chapter 41, p. 324).

Prophylaxis: in adults, the puncture needle should not be advanced further than 3.5 cm and in children not more than 1 cm.
Check the position of the needle tip in relation to the dural sac. Particular care is required in children (the end of the dural sac is often at 53–4).

Test dose, incremental injection of the local anesthetic, verbal contact with the patient, circulatory monitoring, testing the anesthetic spread.

Massive epidural anesthesia:
When attempting to reach segment T10, unpredictable spread of the anesthesia caused by the local anesthetic must be anticipated.

Hypotension, bradycardia, nausea, vomiting.
Bladder emptying difficulties.
Postdural puncture headache (see Chapter 37, p. 287).

Breaking of the needle or catheter shearing:
Check the needle before the block and do not advance it over its full length. A catheter must never be withdrawn through the needle.

Neurological complications:
These arise very rarely and are usually caused by trauma to the lumbosacral plexus – e.g. by the child's head during delivery or by instruments. The complications include paresthesias, peroneal nerve paralysis or coccygodynia. These complications are not causally connected to the caudal anesthesia.

Cauda equina syndrome (see Chapter 37, p. 292).

Epidural abscess (see Chapter 41, p. 326).
Epidural hematoma (see Chapter 41, p. 326).
Fig. 47.25a–e Complications due to incorrect technique.
a Outside the sacral canal.
b Subperiosteal.
c Into the sacroccygeal ligament.
d Spongiosa.
e Through the sacrum.
## Caudal anesthesia

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
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</thead>
<tbody>
<tr>
<td>Diagnosis:</td>
<td></td>
</tr>
<tr>
<td>Premedication:</td>
<td>Yes No</td>
</tr>
<tr>
<td>Neurological abnormalities:</td>
<td>Yes No</td>
</tr>
<tr>
<td>Purpose of block:</td>
<td>Surgical Therapeutic Diagnostic</td>
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<tr>
<td>Needle:</td>
<td>G With stylet Without stylet</td>
</tr>
<tr>
<td>i.v. access, infusion:</td>
<td>Yes</td>
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<tr>
<td>Monitoring:</td>
<td>ECG Pulse oximetry</td>
</tr>
<tr>
<td>Ventilation facilities:</td>
<td>Yes (equipment checked)</td>
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<tr>
<td>Emergency equipment (drugs):</td>
<td>Checked</td>
</tr>
<tr>
<td>Patient:</td>
<td>Informed</td>
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<tr>
<td>Position:</td>
<td>Prone Lateral decubitus</td>
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<tr>
<td>Epidural space:</td>
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<tr>
<td>Checking position of needle tip relative to dural sac (2nd sacral foramen):</td>
<td>Carried out</td>
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<tr>
<td>Aspiration test:</td>
<td>Carried out</td>
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<tr>
<td>Injection:</td>
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<tr>
<td>Test dose:</td>
<td>Epinephrine added: Yes No</td>
</tr>
<tr>
<td>Motor and sensory function check after 5 min:</td>
<td>Carried out</td>
</tr>
<tr>
<td>Abnormalities:</td>
<td>Yes No</td>
</tr>
<tr>
<td>Injection:</td>
<td></td>
</tr>
<tr>
<td>Local anesthetic:</td>
<td>mL % (incremental)</td>
</tr>
<tr>
<td>Addition:</td>
<td>µg/mg</td>
</tr>
<tr>
<td>Patient’s remarks during injection:</td>
<td>Pain Paresthesias Warmth</td>
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<tr>
<td>Duration and area:</td>
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</tr>
<tr>
<td>Objective block effect after 20 min:</td>
<td>Cold test</td>
</tr>
<tr>
<td>Temperature measurement before after °C °C</td>
<td></td>
</tr>
<tr>
<td>Sensory:</td>
<td>L T</td>
</tr>
<tr>
<td>Motor:</td>
<td></td>
</tr>
<tr>
<td>Complications:</td>
<td>Pain Vasovagal reactions Dural puncture Intravascular injection Total spinal anesthesia Respiratory disturbance Postdural puncture headache</td>
</tr>
<tr>
<td>Special notes:</td>
<td></td>
</tr>
</tbody>
</table>
In children, the caudal approach is the easiest and safest route to the epidural space.

**Advantages** [5, 9]
- Better anatomic relationships and thus easier orientation and shorter time required for puncture.
- Perforation of the sacrococcygeal ligament is more easily palpable.
- Better distribution of the injected anesthetic than in the adult.
- Very effective anesthesia and analgesia with small amounts of local anesthetic.
- An 18-G epidural catheter can be used in children of almost any age group.
- It is easier to advance the epidural catheter than in the adult.
- Higher positioning of the catheter is possible, particularly in neonates and infants.
- The immaturity of the sympathetic nervous system means that circulatory problems are extremely rare, particularly up to the age of eight.
- There is a very rapid recovery phase due to the supplementary light general anesthesia and avoidance of muscle relaxants.
- There is a quiet postoperative phase and thus reduced opioids -- and therefore fewer side effects such as nausea, vomiting, or urinary retention.
- The need for subsequent postoperative intensive therapy is reduced.

**Disadvantages**
- Mild light general anesthesia is needed in principle, so that precise testing of the spread of anesthesia is not possible [5]. This problem can sometimes be overcome when Emla cream is used in combination with sedation.
- The risk of contamination with caudal epidural catheters is higher than with lumbar epidural catheters.

**Characteristics of the epidural space in children** [5]
- In children under 1 year of age, the dural sac reaches to the third or even to the fourth sacral foramen.
- The jelly-like epidural fatty tissue is more permeable and allows the injected local anesthetic to spread much better than in the adult.
- When advancing the epidural catheter, hardly any resistance is produced. In neonates and infants up to 6 kg in body weight in particular, it is possible to reach almost any height due to the relatively wide epidural space, which is almost empty and runs parallel to the dura.
- In older children, obstruction occurs more often when advancing the catheter, particularly in the area from L2 to L5.

**Indications**

**Single-shot technique**
- All surgical procedures below the T10 dermatome with an operating time of up to 90 minutes – e.g. perineal and perianal procedures, orchidopexy (not undescended testis), hypospadias, inguinal hernia, incarcerated hernias.
- Superficial surgical procedures in the lower extremities – e.g. skin grafts, etc.

**Contraindications**
- These correspond to those in caudal anesthesia in the adult (see Chapter 47, p. 362).

**Procedure**
- Full prior information for the patient and parents is mandatory.
- Light general anesthesia, or more rarely sedation in combination with local application of Emla cream, is used with both the single-shot technique and continuous caudal anesthesia.

**Preparation**
- Location and marking of the sacral cornua.
- Palpation of the dorsal cranial iliac spines.
- Strict asepsis (thorough skin prep).
- Local anesthesia or application of Emla cream.
Preparation of the drugs:
Syringe with 1 mL epinephrine-containing local anesthetic (test dose).
Syringe with the calculated quantity of local anesthetic.
Skin incision using a stylet or large needle.

Materials
These correspond to those for caudal anesthesia in the adult (see Chapter 47, p. 363); a precordial stethoscope is also needed.

Caudal needles
A wide variety of needle types are used all over the world for caudal injection in children: normal hypodermic needles, Tuohy or Crawford needles, plastic indwelling catheter needles and in children weighing less than 4 kg, 23-G butterfly needles as well [11]. There are no standardized criteria for assessing these, so that the choice is a matter of personal preference and experience on the part of the anesthetist concerned.

On the basis of numerous publications, the following summary can be given:
the use of puncture needles without a trochar can lead to dangerous transport of free skin particles with epidermal cells into the spinal canal, with later development of epidermoid tumors [3, 10, 12, 18]. For this reason, the following recommendation has been made:
caudal puncture in children should only be carried out after a preliminary skin incision using a large needle or stylet, and a needle with a trochar should always be used [4].
The use of a purpose-designed epidural kit is recommended (e.g. Epican Paed, B. Braun Melsungen).

Pediatric caudal needles:
Size: 0.53 x 30 mm, 25 G, with 32° short bevel and steel trochar.
Or 0.73 x 35 mm, 22 G, also with 32° short bevel and steel trochar.
Or 0.90 x 50 mm, 20 G, also with 32° short bevel and steel trochar.

Single-shot technique

Patient positioning
Lateral decubitus, with the legs bent (Fig. 48.1).

Puncture of the caudal epidural space

In children younger than 1 year, the dural sac reaches as far as the third or even fourth sacral foramen.

The needle is introduced in a cranial direction at an angle of 60–70°, towards the sacral dorsum (Fig. 48.2).
After the very clear sensation of the sacrococcygeal ligament, the needle reaches the sacral canal ("sudden give"). The needle position is not altered any further.
The thumb and index finger remain on the sacral cornua throughout the whole of the location and injection procedure.
Then:
Withdraw the trochar.
Check the end of the needle for escaping fluid (CSF, blood).
Aspirate.
Inject a test dose of 1 mL of an epinephrine-containing local anesthetic.

During the subsequent waiting period:
Careful cardiovascular monitoring is carried out, along with the precordial stethoscope, to recognize the development of tachycardia or arrhythmia. However, this test can lead to unreliable results in anesthetized children [8].

Incremental injection of local anesthetic
After a negative result with the test dose, the calculated dose of local anesthetic is injected on an incremental basis (Fig. 48.3).
As this is done, the index and middle finger are laid on the surface of the sacrum, so that subcutaneous injection can be recognized quickly.

Checking the spread of anesthesia
The spread of anesthesia should always be checked in children who have not received general anesthesia.
As correct testing of the anesthetic spread is not possible in anesthetized children, this method is reserved only for highly experienced anesthetists.
Postoperatively, a detailed examination of sensory and motor function is carried out. The child should be moved to the normal ward only if he or she is able to move the legs freely.
Chapter 48

Continuous caudal anesthesia

Indications
In combination with light general anesthesia in longer-duration operations on the upper and lower abdomen, in the urogenital area and on the legs.

Contraindications
See Chapter 47, p. 362.

Disadvantage
Due to the risk of infection (proximity to the anogenital region), the catheter should be withdrawn immediately after the end of the operation.

Preparation, materials, patient positioning
See Chapter 47, p. 363.

Puncture of the caudal epidural space
Skin incision using a stylet or large needle. The plastic indwelling catheter needle (or Tuohy) is advanced at an angle of 60–70° in the direction of the sacrococcygeal ligament. After perforation of the ligament, the needle is advanced 1 cm into the sacral canal, the trochar is removed and the plastic part is advanced a further 0.5 cm. After palpation of the iliac crests through the drapes, the catheter should be measured to allow the desired dermatome to be located. The catheter is now advanced to the desired dermatome. In neonates, infants and small children, the catheter meets hardly any resistance, so that it is easy to advance it to the upper lumbar or thoracic segments.

A catheter must never be advanced against resistance, which may be caused by the dura, a nerve or a blood vessel.

Checking the catheter position
Removal of the plastic indwelling catheter needle. Checking the patency of the catheter: An adapter is attached to the end of the catheter and 1 mL saline is injected. Aspiration.
Caudal anesthesia in children

The open end of the catheter should be carefully observed. The syringe is disconnected, the open end of the catheter is placed on the sterile drape below the level of the puncture and any escaping fluid (CSF or blood) is noted.

**Test dose of an epinephrine-containing local anesthetic**
During the waiting period: careful circulatory monitoring (ECG, pulse oximetry, precordial stethoscope).

**Placement of a bacterial filter, sterile attachment of the catheter**

**Administration of local anesthetics**
Injection of one-quarter of the calculated dose of local anesthetic.
When there is no resistance to the injection, the remaining dose can be administered at a speed of 0.7 mUs.
Larger amounts of local anesthetic are needed if the injection is carried out more slowly [5].

**Dosages**
The following parameters are particularly important for the dosage of local anesthetics in neonates, infants and small children:

Better penetration of the local anesthetic solution takes place due to the incomplete myelinization of the nerves in infants and due to the small diameter of the nerves in small children. This means that lower doses are required.

Muscle relaxation, particularly in extensive abdominal or orthopedic procedures, can be produced by adding epinephrine. The "threshold block" is much more extensive, reaching as far as five dermatomes.

Surprisingly low plasma concentrations are found in children after administration of the maximum dose of a local anesthetic.
In comparison with adults, the dosage of local anesthetic is more reliable and precise and is based on the tried and tested parameters of age, weight and height.

The following guidelines may be helpful for the dosage of local anesthetic.

**Schulte-Steinberg dose scheme** [17]
The age of the child is used according to the following formula:

\[
0.1 \text{ mL per segment to be blocked} \times \text{age in years}
\]

The pin-prick test is taken into account here and thin C fibers are blocked.

**Busoni and Andreucetti dose scheme** [5–7]
For clinical applications, particularly in longer, more extensive surgical procedures, the age and weight of the child are used as the parameters, with 1% mepivacaine being tested. Testing of the analgesia is carried out by pinching (thicker A-delta fibers) and pin-pricks (thin C fibers). The anesthesia reaches about four to six dermatomes lower ("threshold block").

In neonates and infants, weight is a reliable parameter; in small children, age has proved to be a better parameter for assessing the required dosage. Experienced anesthetists have found Busoni’s diagrams (Fig. 48.4) particularly useful.

**Armitage dose scheme** [1, 2]
This schema is easy to use and has also proved itself with less experienced anesthetists. The following dosage is recommended:

- Lumbosacral block: 0.50 mL/kg b.w.
- Thoracolumbar block: 1.00 mL/kg b.w.
- Mid-thoracic block: 1.25 mL/kg b.w.

**Fig. 48.4** Diagram of the relation between dose, spread of analgesia, age and body weight for various segmental levels.
Concentration of the local anesthetic
Ropivacaine: 0.2%
Bupivacaine: 0.25–0.375%
Levobupivacaine: 0.2%
Mepivacaine: 1%
Lidocaine: 1%

Dosage [13]
Ropivacaine 0.2%: 2 mg/kg b.w.
Bupivacaine 0.25%: 2.5 mg/kg b.w.
Mepivacaine 0.1%: 7–10 mg/kg b.w.

Continuous epidural infusion
Of 0.1% ropivacaine or 0.125% bupivacaine [13]
Neonates and infants: 0.2 mg/kg/h
Small children: 0.3–0.4 mg/kg/h
Older children: 0.4–0.5 mg/kg/h

Opioids
Morphine: 0.03 mg/kg/8 h
Fentanyl: 0.5 μg/kg/h

Clonidine 2–3 μg/kg/24 h

After the volume has been calculated, the maximum dose for the body weight should be calculated and the local anesthetic should be diluted accordingly. If the calculated quantity of local anesthetic is less than 20 mL, administration of 0.25% bupivacaine, for example, is recommended. If the calculated quantity is over 20 mL, dilution in saline should be carried out until a concentration of 0.19% bupivacaine is reached [9].

Complications
See Chapter 47, section on complications, p. 373.
Percutaneous epidural neuroplasty (epidural neurolysis, epidural adhesiolysis) is a form of interventional pain treatment that was first described in 1989 [11]. The method is used at all levels of the spine to treat neuraxial pain conditions or radiculopathies, or both, as well as certain forms of cervicogenic headache.

The development of this procedure and its growing acceptance have been promoted by the following factors: a) new information regarding the importance of epidural and intervertebral structural changes and their role in the development of back pain and radicular pain; b) a better understanding of the structures involved in the origin of pain in the epidural space and its surroundings; c) data on the type and location of pain arising due to stimulation of certain pathological structures in the epidural space and its vicinity; d) the development of reliable percutaneous puncture techniques in the epidural space; e) recognition of epidurography as a valuable method of diagnosis and treatment; f) clear guidelines and theoretical justifications for the procedure and the drugs used in it; g) evidence of the effectiveness of the treatment in patients; and h) recognition of the procedure by qualified physicians.

The aims in percutaneous epidural neuroplasty are:

1. To diagnose pathological changes in the epidural space (e.g., epidural fibrosis) that may prevent administered drugs from reaching these pathological structures. Radiographic contrast media are used to identify the filling defects.
2. To remove all pathological obstructions and scar tissue as potential causes of pain. For this purpose, physiological saline mixed with hyaluronidase is applied to the scar tissue.
3. To determine whether the pathological obstructions causing pain have been removed after a procedure. Radiographic contrast media are again injected for this purpose.
4. To carry out targeted local administration of drugs that lead to the relief or reduction of pain (local anesthetics, steroids and hypertonic saline).

When conducting surgery under local anesthesia in the lumbar spine, Kuslich et al. [3] found that sciatica could be triggered by irritation of swollen, overextended, or compressed nerve roots. By contrast, back pain could be triggered by stimulation of various tissues in the lumbar region—most frequently in the outer layer of the annulus fibrosus and posterior longitudinal ligament. Roffe [13] showed that both of these structures are richly supplied with nerves connected to the CNS via meningeal branches (sinuvertebral nerves) (Fig. 49.1). By contrast, stimulation of the capsule of the facet joints rarely caused back pain, and never caused sensitivity in the synovial bursa or cartilaginous sur-

![Fig. 49.1](image-url)
faces. In patients who had previously undergone a laminectomy, there were always one or more areas of marked perineural fibrosis. It was never the scar tissue itself that was sensitive; instead, there was often marked irritability in the nerve root. It is suspected that the scar tissue immobilizes the nerve root and thereby favors the development of pain when the nerve root is subject to traction or pressure.

Kusslich et al. concluded that “Sciatica can only be caused by direct pressure or traction on an inflamed, stretched, or compressed nerve root. No other tissue in the spine is able to trigger pain in the leg.” However, nerve roots are exposed not only to mechanical effects, but also to material from degenerated intervertebral disks or facet joints [9].

Pressure (Fig. 49.2)
The effects of pressure on the nerves depend on whether it is high pressure or low pressure (e.g. < 200 mmHg) that is being exerted. High pressure can produce direct mechanical effects on the nerve tissue and can distort the nerve fibers, shift the nodes of Ranvier, or press in the paranodal myelin sheath. Lower pressures lead to tissue changes caused by a reduction in the blood supply to the nerve tissue. In animal experiments, it has been found that when inflation of a balloon attached to the spinal cord makes the pressure on the cauda equina equivalent to arterial pressure, blood flow in the cauda equina is interrupted [9]. Even a pressure of 5–10 mmHg interrupts venous blood flow in some small veins, while a pressure of 10 mmHg reduces the transport of nutrients to the nerve roots by 20–30%. Compression can also cause changes in the permeability or transmural pressure conditions in the endoneurial capillaries in the nerve roots, and can lead to edema formation (in the animal experiment, for example, this occurred after 2 min of compression at 50 mmHg).

Intraneural edema due to chronic nerve injury is associated with the development of neural fibrosis, which may contribute to the very slow rate of symptomatic improvement observed in some patients with nerve compression.

Compression of spinal nerves at 10 mmHg for 2 hours by two adjacent balloons (to simulate the clinical conditions occurring in multiple nerve compression) reduced neural conduction and led to a reduction in the recorded amplitudes of action potentials by ca. 65%. By contrast, compression by a single balloon at 50 mmHg for 2 hours did not alter the amplitude of the action potentials. A pressure of 10 mmHg (with incomplete blockage of small veins) only appears to be capable of causing changes in nerve function if the spinal nerve roots are compressed into two segments [9]; intervertebral disk prolapses or protrusions can cause higher levels of compression pressure than central spinal stenosis.

Chemical irritation (Fig. 49.2)
Some chemical substances have been identified in the nucleus pulposus that can lead to irritation of neighboring structures if tears in the anulus fibrosus lead to them being released into the vertebral canal. These substances, which can cause inflammation of nerve roots and meninges, include lactic acid, glycoprotein, cytokines, and histamine. In addition, it is considered theoretically possible that components of the nucleus pulposus can act as foreign proteins and trigger an autoimmune reaction. This type of chemically caused irritation can arise without any compression by an intervertebral disk.

Structural changes
Intervertebral disk anomalies can manifest as degenerative changes, protrusion, or herniation [1]. Constriction of the intervertebral space due to disk injury is often associated with osteophyte formation and arthrosis of the facet joints, which can lead to increased pressure on the spinal nerves. Stretching of the posterior longitudinal ligament by protruding intervertebral disks initially leads to localized back pain, while more severe protrusions also cause pressure on neighboring nerve roots and can lead to radicular pain.

Fig. 49.2 Mechanical and chemical stimulants trigger the development of neuraxial pain and radiculopathy, as well as cervicogenic headache [10].
Theoretical considerations
The current debate has shown that in patients with chronic neuraxial pain and/or radiculopathy or cervicogenic headache, one or more of the following pathological changes may be present (Fig. 49.2):
- Inflammation.
- Edema.
- Fibrosis.
- Venous stasis.
- Mechanical pressure on:
  - Posterior longitudinal ligament
  - Anulus fibrosus
  - Spinal nerve
- Reduced or absent nutrient supply to the spinal nerves or nerve roots.
- Central sensitization.

The inflammatory tissue changes can activate nociceptors or axons that conduct nociceptive information to the CNS. Equally, owing to inflammation, nociceptors or nociceptive axons may react more sensitively to mechanical stimuli. This type of mechanical irritation may be triggered either by pressure stress, as described above, or may be caused by movement-dependent stretching due to entrapment of spinal nerves or nerve roots by fibrous tissue.

Most experience with neuroplasty has been gathered in the treatment of chronic pain conditions. Most of the patients concerned therefore probably have both peripheral and central changes (e.g. central sensitization) contributing jointly to the chronic pain condition. It is therefore theoretically justifiable to treat back pain with or without radiculopathy by local administration of drugs. Possible forms of treatment include:
- Anti-inflammatory drugs (e.g. corticosteroids).
- Drugs that reduce edema formation (e.g. hypertonic saline 10% and corticosteroids).
- Local anesthetics to block the nerve fibers that conduct pain information to the CNS (hypertonic saline also has a local anesthetic effect).
- Addition of hyaluronidase to remove scar tissue. This makes it possible for the drug being used to reach the target tissue.

Figure 49.3 shows the selection criteria for patients who are candidates for percutaneous epidural neuroplasty; noninvasive, conservative treatment methods should be attempted first. Our technique is described in Table 49.1. Table 49.2 lists the most frequently used injection solutions.
### Table 49.2 Injected solutions according to the spinal cord section (volume in mL) in the injection sequence

<table>
<thead>
<tr>
<th>Solution</th>
<th>Cervical</th>
<th>Thoracic</th>
<th>Lumbar</th>
<th>Caudal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iohexol</td>
<td>2-3</td>
<td>4-6</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Iohexol</td>
<td>1-2</td>
<td>2-3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Saline 0.9% + 1500 IU hyaluronidase</td>
<td>4-6</td>
<td>6-8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Ropivacaine 0.2% + corticosteroid* (test dose)</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Ropivacaine 0.2% + cortikosteroid*</td>
<td>2-4</td>
<td>4-6</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Hypertonic saline</td>
<td>4-6</td>
<td>6-8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Saline 0.9%</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Then, on each of the following days:

| Ropivacaine 0.2% (test close)    | 2        | 2        | 3      | 3      |
| Ropivacaine 0.2%                 | 4        | 6        | 7      | 7      |
| Hypertonic saline                | 4-6      | 6-8      | 10     | 10     |
| Saline 0.9%                      | 2        | 2        | 2      | 2      |

* 4 mg dexamethasone or 40 mg methylprednisolone or triamcinolone

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### Technique of percutaneous epidural neurolysis

#### Caudal access route

**Procedure**

*Careful information discussion with the patient before the block*

Full prior information for the patient is mandatory. The patient should be informed about all of the potential complications that can occur during and after the procedure (e.g. epidural hematoma, epidural abscess, numbness in the extremities, rectal or bladder emptying disturbances, paralyses, infection, sexual dysfunction, shearing of the epidural catheter, etc.).

**Materials**

See Chapter 47 on epidural caudal anesthesia.


**Preparations**

See Chapter 47 on epidural caudal anesthesia. Intravenous access is required in order to treat potential adverse events (e.g. total spinal anesthesia, subdural injection, intravascular injection, etc.), as well as to administer analgesia and sedation during the procedure and antibiotics postoperatively.

Analgesia and sedation are recommended before the procedure (e.g. 1-2 mg midazolam + 25-50 μg fentanyl), as the injection is usually painful in patients with epidural adhesions. The injection pain is probably caused by stretching of the nerve roots affected, and it spreads in the corresponding cutaneous innervation area. The patient should not receive deep sedation. The patient needs to be capable of cooperating during the procedure to ensure that any signs of spinal cord compression are not overlooked. (The patient has to be able to move the extremity affected and report any weakness or paralysis during the procedure).

All procedures are conducted under fluoroscopic guidance, using a C-arm with a storage function (reduced radiation exposure). Fluoroscopic guidance optimizes the results of the procedure (correct needle positioning, easier identification of the defect, ability to check the spread of the contrast and correct positioning of the catheter). The usual protective measures for staff are obligatory.

**Selection of drugs**

**Radiographic contrast media**

To exclude inadvertent subarachnoid injection, a water-soluble contrast medium is used. In our experience, the presence of epidural adhesions increases the risk of subarachnoid injections. Subarachnoid injection of a contrast medium that is not water-soluble can lead to serious complications (spinal cord irritation, spinal cramp or clonus, arachnoiditis, paralysis, and death).

**Local anesthetic**

E.g. 0.2% ropivacaine.
Corticosteroids
The choice of the corticosteroid to be used (Table 49.2) mainly depends on which agents are available. Long-acting steroid emulsions have a particle size of ca. 20 μm and it is therefore not possible to inject them through bacterial filters.

Hypertonic saline (10%)
The local anesthetic effect of hypertonic saline is used to prolong the intended pain relief so that the patient can receive physiotherapy twice a day.

Antibiotics
30 min before the start of the procedure, 1 g ceftriaxone (Rocephin) is administered intravenously. During the hospital stay, the same dose is administered every 24 hours. Patients who are allergic to penicillin receive 500 mg ciprofloxacin (Ciprobay) or levofloxacin orally 1 hour before the procedure, as well as over the following 5 days (500 mg cefalexin or ciprofloxacin every 12 hours, or 500 mg levofloxacin every 12 hours).

Technique
Patient position
The patient is placed in the prone position on the fluoroscopy table (see Chapter 47, p. 364).

Landmarks
The sacral region is prepared and covered with sterile drapes, and the sacral cornua and sacral hiatus are palpated. The puncture site is located in the gluteal cleft opposite the affected side, approximately 1 cm lateral to and 2.5 cm below the sacral hiatus. From this point, it is easier to guide the needle and catheter towards the affected side. The lateral access reduces the risk of the needle or catheter penetrating the dural sac or subdural space.

Local anestheisa
Infiltration of the puncture site with 1% lidocaine is carried out.

Puncture
After a skin incision with a stylet, an epidural needle (preferably a 16-G R-K or 15-G RX-Coudé needle; Fig. 49.5) is introduced into the sacral hiatus.

Tuohy needles should not be used.

The needle is introduced caudal to the S3 foramen. Lateral fluoroscopy is used to check that the needle is positioned inside the osseous canal. This radiographic check is particularly important when there are unusual anatomical features in the sacral bone. Anteroposterior radiography is used to check that the needle tip is directed toward the affected side. A check is then made for escaping fluid (CSF or blood), and an aspiration test is carried out. After a negative aspiration test, 10 ml lohexol (Omnipaque 240) is injected under fluoroscopic guidance. When injected into the epidural space, the contrast forms a Christmas-tree-shaped distribution pattern. The presence of epidural adhesions prevents the contrast from spreading in this characteristic pattern, with the affected nerve roots being omitted.

Problem situations
Subarachnoid needle location
If the puncture needle is in a subarachnoid location, the contrast medium spreads in a central and cranial direction. If it is in a subdural position, the contrast spreads in a similar fashion, but not as far as with a subarachnoid injection. Despite this, the contours of the nerve roots and dura are visible, since the contrast spreads into the less resistant subdural space. Injection of a local anesthetic into the subarachnoid or subdural space leads to a motor block that is much stronger and has a much faster onset of effect than injection into the epidural space.

Aspiration of blood
When blood is aspirated, the needle position should be carefully corrected until no more blood is aspirated.

Aspiration of CSF
If CSF is aspirated, it is best to halt the procedure and repeat it on the following day.

Allergic reactions
When the patient has an allergic reaction to an iodine-containing contrast agent, it is best to continue the rest of the procedure without radiographic guidance after confirming fluoroscopically that the needle is in the correct position.

Introducing the epidural catheter (Fig. 49.4)
Radioopaque catheters with soft tips are used in the injections of local anesthetics, corticosteroids, and hypertonic saline described below. For this purpose, a fluoropolymer-coated epidural catheter made of stainless steel, with a spiral tip (Racz-Tun-L-Kath/24) or a less flexible Racz-Tun-Kath XL (Fig. 49.5) is introduced into the adhesions through the needle. The beveled side of the needle should be directed toward the ventrolateral side of the caudal canal, since this position — together with a 15–30° bend about 2.5 cm below the catheter
Fig. 49.4a, b Radiographs of a patient with “failed back surgery syndrome” and bilateral sciatica in the region of L2-L5. The pain was more severe on the right than on the left. a Epidurogram at the start of the procedure. The contrast has not spread beyond the iliosacral joint, and a filling defect is seen on the right. b After catheter placement and injection of the solutions (see text). The tips of two catheters were placed in the intervertebral spaces in L4-L5 and L5-S1.

tip – makes it easier for the catheter tip to reach the desired anterolateral position and reduces the risk of catheter shearing. As the epidural adhesions are usually irregularly distributed, several corrections of the catheter position may be needed to achieve the correct position of the catheter in the desired area. For this reason, it is recommended to use a 16-G R-K or 15-G RX-Coudé epidural catheter, or an SCA catheter introducer, to make it easier to carry out the necessary corrections of the catheter’s position.

Contrast injection
After the catheter tip has been placed in the correct position and after a negative aspiration test, contrast is injected again (Table 49.2). Previously recognizable filling defects along the targeted spinal nerves or nerve roots should now fill.

Injection of the local anesthetic and corticosteroid
Following a repeated aspiration test, 0.2% ropivacaine and 40 mg triamcinolone acetate is now injected through the catheter (Table 49.2). The areas in which epidural adhesions had developed and were dissolved should be documented.

Injection of hypertonic saline
30 min later, after a negative aspiration test, the patient is placed in the lateral decubitus position on the painful side for the following 30–60 min. 10 mL of a hypertonic saline solution (10%) is injected epidurally via an infusion pump over 30 min. The indwelling catheter is then rinsed with 0.9% saline (Table 49.2). Hypertonic saline has a reversible weak-
ly anesthetic effect and reduces edema formation in previously scarred or inflamed nerve roots. However, the injection of hypertonic solutions into the epidural space is extremely painful if no local anesthetics have been administered beforehand. Consequently, if the hypertonic saline spreads beyond the segment in which local anesthesia was previously applied, it is possible that the patient may experience extreme pain requiring intravenous administration of sedatives or an additional epidural dose of local anesthetic. However, the pain rarely lasts for more than 5 min.

If iodine-containing radiographic contrast is not used when the patient has a known history of allergy, the procedure is carried out in the same way without it. To exclude a subarachnoid or subdural position of the needle or catheter, a test dose of local anesthetic is administered. In this case, the patient experiences pain in the skin area corresponding to the scarred epidural region. As the catheter is advanced, resistance is felt when contact is made with adhesions. It is necessary to advance the catheter slowly to avoid penetrating the subarachnoid or subdural space.

After the procedure
Securing the catheter
When the procedure has been completed, the catheter is firmly secured with a skin suture. The exit point is generously covered with antibiotic ointment (triple combination) and covered with two slit compresses (5 x 5 cm). Benzoin tincture is spread on the surrounding skin. Fixation with a transparent Tegaderm plaster (10 x 5 cm) is then carried out. Finally, fixation with four strips of a porous elastic Hypafix plaster is carried out, so that the patient cannot "sweat off" the plaster over the course of the 3 days.

An injection syringe adapter and a bacterial filter are attached to the catheter. The free end of the catheter is attached to the patient’s side. During the hospital stay, prophylactic antibiotic treatment continues to be administered to prevent bacterial colonization (which is favored by steroid administration). After discharge, antibiotics are prescribed for a further 5 days.

Technique for subsequent injections
The indwelling catheter remains attached for the following 3 days. Further injections are given on the second and third days. After each negative aspiration test and administration of a test dose, as described above, a local anesthetic and then after ca. 30 min hypertonic 10% saline are slowly injected. On the third day, the catheter is removed ca. 10 min after the last injection. The patient should keep the insertion site as dry as possible for as long as the catheter is in place. We also recommend our patients to keep the area dry for a further 48 hours after removal of the catheter in order to reduce the risk of infection.

Epidural adhesiolysis usually leads to a significant improvement in pain symptoms and motor function. After this, it is important to start intensive physiotherapy in order to improve muscle strength and muscle tone.

Due to their size, existing epidural adhesions cannot always be fully dissolved. The procedure can be repeated if necessary. A 3-month pause is recommended between each treatment (due to the steroids used). During this period, intensive physiotherapy must be carried out, with targeted muscle training.

Percutaneous epidural neuroplasty in the cervical, thoracic and lumbar regions
The technique has to be modified for percutaneous epidural neuroplasty in the cervical, thoracic and lumbar regions, in order to ensure that the needle is located in the epidural space and to avoid compression of the spinal cord during subsequent injections.

Technique of cervical epidural neuroplasty
The patient is placed in the left lateral position on the fluoroscopy table. The “3D” technique (direction, depth, direction) is used.

Cervical placement of the epidural catheter using the 3D technique
Preoperative
Examination of the patient and identification of the puncture area.
Laboratory tests to assess the usual parameters that are important when carrying out neuraxial blocks.

Intraoperative
The patient is placed in the left lateral position.
Preparation and draping.
Puncture site: C7–T1 or T1–T2.
Access: paramedian, 1 cm or less lateral to the midline, one intervertebral space below the planned epidural access.
Epidural puncture is carried out with a 16-G R-K or 15-G R-K-Coude needle.
Anteroposterior fluoroscopy to assess the puncture direction.
Lateral fluoroscopy to assess the injection depth.
Anteroposterior fluoroscopy to assess again and if necessary correct the puncture direction.
The needle is advanced to the base of the spinous process. The injection depth corresponds to the po-
sition of the lamina of the vertebral arch in the vicinity of the posterior epidural space.

Removal of the trochar.

Attach a pulsator syringe (low-friction) filled with 4 mL 0.9% NaCl and 2 mL air.

Identification of the epidural space is carried out using the loss-of-resistance technique.

Optimal positioning of the needle in the midline.

Injection of 1–2 mL radiographic contrast (for the cervical epidurogram).

Introduction of the catheter through the epidural needle in the direction of the targeted nerve root in the lateral epidural space. Lateral positioning of the catheter is important because the nociceptors are concentrated in the lateral space. Repeated aspiration is important.

Injection of 1500 IU hyaluronidase mixed with 4–6 mL NaCl 0.9%.

Incremental injection of the local anesthetic and corticosteroid (in 2–3 mL portions).

The needle is removed under fluoroscopic guidance.

Attachment of a bacterial filter.

The catheter is secured with a skin suture, an antibacterial and antymycotic ointment is applied, followed by a dressing.

Postoperative (recovery room)

Careful monitoring of the patient for at least 30 min after the procedure, checking the spread of the anesthesia to exclude the ever-present risk of inadvertent subarachnoid or subdural injection.

Administration of 6 mL hypertonic 10% saline through the epidural catheter using an infusion pump.

Rinsing of the catheter with 2 mL of preservative-free 0.9% saline.

In the following two postoperative days (pain treatment unit)

Aspiration test before the injection.

Injection of a test dose of 2 mL 0.2% ropivacaine through the catheter. After 5 min – after excluding a subarachnoid or subdural injection – a further 4 mL 0.2% ropivacaine is administered.

Wait 20 min.

Infusion of 6 mL hypertonic 10% saline using an infusion pump, over 30 min.

Rinsing of the catheter with 2 mL 0.9% saline.

Removal of the catheter.

The patient must be informed about the risk of infection (e.g. meningitis after a latency period of 2–4 weeks, as the injected corticosteroids have a long-lasting effect).

Larkin et al. [4] recently described a technique of epidural steroid injection in which the catheter is used as a monopolar stimulation electrode for better localization of the cause of the pain.

Percutaneous thoracic epidural neuroplasty

A paramedian access route is also used for catheterization of the thoracic epidural space (percutaneous thoracic neuroplasty). The procedure is carried out in the same sequence of steps as that described for lumbosacral and cervical neuroplasty. The dosages for the drugs injected are listed in Table 49.2.

Placement of the catheter in the anterior epidural space or in an intervertebral foramen

Drugs that are injected into the posterior or posterolateral epidural space do not reach possible pathological changes in the intervertebral foramina or anterior epidural space. It may therefore be necessary to place the catheter in these areas. The catheter’s direction is checked a) by introducing the R-K epidural needle or SCA catheter introducer in the target direction; b) by bending the catheter tip to make it easier to guide the catheter in the desired direction. When neuroplasty is being carried out through the sacral hiatus in order to place the catheter in the anterior lumbosacral area, the catheter should reach this area below S3. The transfornaminal access route should be used for all other segments.

Complications

The potential side effects and complications of percutaneous epidural neuroplasty include:

- Inadvertent subarachnoid or subdural injection of local anesthetics or hypertonic 10% saline. A subarachnoid injection of hypertonic saline can lead to cardiac arrhythmia, paralyses, or loss of sphincter function.
- Epidural abscess (see Chapter 41, p. 326).
- Epidural hematoma (see Chapter 41, p. 326).
- Paralyses.
- Disturbances of bladder or rectal function.
- Infections (corticosteroid administration leads to immune suppression, with the resulting risk of infection; strictly aseptic conditions should therefore be observed).
- Catheter shearing.
Percutaneous epidural neuroplasty

It is possible in some circumstances for septation to occur, or for fluid to collect in a separate compartment of the epidural space. This is associated with a substantial increase in epidural pressure, which can lead to local damage or even – when the pressure is transferred via the subarachnoid space – to injury to the central nervous system [12].

Undiagnosed neurogenic bladder and rectal disturbances

The problem of preoperatively unrecognized neurogenic bladder disturbances in patients with “failed back surgery syndrome” or spinal cord injuries led to distrust both of practicing physicians and of the technique. It is therefore important to carry out and document the necessary urological examinations before neuroplasty. This prevents previously existent micturition disturbances or rectal disturbances from being incorrectly attributed to injury after a neuroplasty procedure has been carried out. This type of examination is particularly important in patients with constrictive arachnoiditis, as this not infrequently leads to disturbances of rectal and bladder function, and of sexual function as well in men.

Spinal cord compression

As discussed above, all injections should be carried out slowly. Fast injections into the epidural space can in some circumstances create a strong increase in CSF pressure, with the risk of cerebral hemorrhage, visual disturbances, headache and disturbances of the blood supply to the spinal cord.

Infection

Patients are informed that epidural infections can occur in the first 2-6 weeks after the procedure – both due to the procedure itself and due to the steroid-related immunosuppression it involves. Until proved otherwise, any occurrence of nausea, vomiting, stiffness in the neck, severe pain, weakness, numbness, or paralysis must therefore be regarded as due to the procedure and correspondingly treated. Patients should be advised to contact the physician who conducted the procedure, or their general practitioner, immediately if any of these symptoms arise. Appropriate in-patient treatment must be immediately instituted (see Chapter 41, epidural anesthesia, complications). No cases of epidural abscesses have so far been observed among the patients we have treated. However, due to the potentially extremely serious sequelae of unrecognized and untreated epidural abscesses, extreme attentiveness and careful patient information are indispensable.

Hyaluronidase hypersensitivity

In a follow-up study by Moore [8] including 1520 patients who underwent epidural hyaluronidase administration, hyaluronidase hypersensitivity was observed in 3% of the patients. The fact that this 3% incidence was not observed with the technique described here may possibly be due to the injection of a corticosteroid in the same site at which the hyaluronidase was injected. The steroid remains in the epidural space for longer than the hyaluronidase, and may provide protection against allergic reactions. The reduction in the incidence of treatment-resistant pain conditions obtained with this procedure entirely justifies the use of hyaluronidase; however, very careful attention must be given to any signs of hypersensitivity.

Experience at the Texas Tech University Health Sciences Center (TTUHSC)

At our center, the epidural adhesiolysis technique described here has been carried out in more than 4000 patients. Only a few complications were observed. Subarachnoid or subdural injection of the local anesthetic is extremely rare. Two of the patients developed meningitis after epidural adhesiolysis and were quickly and effectively treated with antibiotics. No cases of paralysis were observed in any of the patients; one patient developed transient motor weakness (caudal access). There were no significant, longer-lasting cases of rectal or bladder dysfunction, although a few patients developed mild micturition or defecation disturbances during the first 2 weeks after the procedure. There was a report of transient numbness in the perineal area, which resolved again after 1-2 months.

Additional aspects

This chapter describes a procedure involving a 3-day course of injection treatment based on the results of a randomized, prospective double-blind study [2]. However, Manchikanti et al. [6] have shown that one-day treatments are also effective. The pain reduction is more persistent, however, when more frequent and repeated injections are carried out [5]. There is evidence that the epidural neuroplasty procedure is also suitable for pain treatment in cases of spinal canal stenosis. Previously disturbed motor function also improves after treatment in some patients [7].

Summary

Percutaneous epidural neuroplasty is an interventional procedure in the treatment of pain caused by structures in the epidural space or its vicinity and in the in-
tervertebral foramina in all segments of the spine. Adequate scientific justification for the procedure appears to be provided by the current state of knowledge regarding the pathogenesis of back pain and radiculopathy. To ensure the safety of the procedure and achieve the best possible results, it is recommended that the details of the procedure described here (regarding technique and patient selection) should be followed precisely.
Opioids, vasopressors, clonidine (an alpha-2-adrenoceptor antagonist), ketamine and – in subarachnoid administration in particular – glucose can be used as adjuncts to a neuraxially administered local anesthetic.

Glucose

In the hyperbaric spinal anesthesia technique, glucose is mixed at concentrations of 5–10% with a local anesthetic in order to produce a density higher than that of CSF.

Vasopressors

Vasopressors that can be used to prolong the duration of effect of a local anesthetic include:

Phenylephrine (Neo-Synephrine)
- 0.5–5 mg (0.05–0.5 mL in a 1% solution), with which the duration of effect of the local anesthetic is extended by 30–100% [31].

Epinephrine (adrenaline)
- 0.2–0.5 mg (0.2–0.5 mL, 1 : 1000 in solution), with which the duration of effect of the local anesthetic can be extended by 40–50% [31].

Advantages and disadvantages of phenylephrine/epinephrine

The addition of a vasopressor leads to slower vascular resorption of the local anesthetic. This slows down contact with neural tissue, while at the same time reducing systemic toxicity.

Reservations regarding the possible association of added vasopressors with spinal cord ischemia, with subsequent neurological complications, have not been clinically confirmed [10, 23].

The causes of neurological injury are fairly multifactorial, and include the technique, equipment and injected drugs. In addition, the patient’s individual situation and possible distinctive anatomic features play a role. However, this topic continues to be a controversial one [31].

Neuraxial administration of an opioid – as a single agent, or in combination with a low-dose local anesthetic – produces very good analgesia during surgery and in the postoperative period.

Central or systemic side effects are seen very rarely.

The receptors specific for opioids are located alongside areas in the brain and particularly in the substantia gelatinosa of the spinal cord. Their concentration there is at its most dense.

In comparison with a local anesthetic, an opioid injected in the vicinity of the spinal cord has a selective effect – i.e. it produces pure analgesia, without sensory or motor block and with only a slight sympathetic block.

In comparison with systemic administration, opioids are very potent and have a marked segmental effect, a long duration and a low tendency to produce side effects.

The following characteristics of opioids are important for optimal effectiveness:

**High affinity with the receptor** and thus **high analgesic potency.**

**High lipophilia,** causing acceleration of their passage through the dura and CSF to the spinal cord. At the same time, however, there is a high rate of elimination, which is reflected in a short duration. Agents such as sufentanil or fentanyl, for example, remain in the CSF for only a very short time and are quickly absorbed by the lipid-rich structures of the spinal cord. They are characterized by a steep gradient of effect, but also by a short duration.

**Low hydrophilia** and thus a short period of persistence in the CSF.

The strongly hydrophilic opioids – the main representative being morphine – remain in the CSF for a longer period, so that a larger proportion is transported to the brain before binding with opioid receptors can take place.

The consequences of this are slow systemic resorption, a slower gradient of effect, a long duration of effect, a low elimination rate and the risk of cranial diffusion.
Chapter 50

Due to the slow circulation of CSF, the patient is at risk of respiratory depression even after several hours. This applies particularly to hydrophilic substances – so that after morphine administration, depending on the dosage, respiratory depression can be expected after even 18–24 hours.

Long receptor binding and thus a long duration of effect (e.g., buprenorphine).

Low tendency for tolerance to develop.

Pharmacokinetic data for the most frequently used opioids

Administration of an opioid can be carried out intrathecally or epidurally. It is mainly pure opioid agonists that are used.

Strongly lipophilic opioids

Sufentanil
High lipophilia, high receptor affinity, ca. 1000 times more effective than morphine – the drug of the future in neuraxial applications.
Suitable for acute pain therapy.

Epidural:
Dosage 30–50 μg, onset 10 min, duration 4–5 h.

Subarachnoid:
Dosage 7.5–10 μg, onset 2–10 min, duration 1–3 h.

Fentanyl
Strongly lipophilic and 75 times more effective than morphine. Suitable for acute pain therapy.

Epidural:
Dosage 50–100 μg, onset 5–10 min, duration 2–3 h.

Subarachnoid:
Dosage 25–50 μg, onset 2–10 min, duration 30–120 min.

Strongly hydrophilic opioids

Morphine

Epidural:
Dosage:
Adults: 2–5 mg morphine sulfate (only after appropriate dilution with 10–15 mL isotonic saline), onset ca. 30–60 min, duration 8–22 h.
Children: 0.01 mg/kg b.w.

Subarachnoid:
Dosage:
Adults: 0.2–0.5 mg morphine sulfate (only after appropriate dilution with 1–4 mL isotonic saline), onset 10–20 min, duration 8–24 h.
Children: 0.001 mg/kg b.w.

Combinations

In some clinical situations, the effect of opioids alone is not adequate. A combination of opioids and local anesthetics leads to an additive or multiplied analgesic effect, characterized by faster onset, longer duration and reduced motor block. The blocking of pain takes place at various sites – at the neural axon and via the opioid receptors in the spinal cord. The use of such combinations is becoming more and more routine.

Types of application [27]

Epidural bolus injection
The lowest possible volume should be selected, with volumes of 5–10 mL normally being preferred.

Epidural infusion
A bolus dose of 10 mL bupivacaine (0.0625–0.125%) in combination with 1–2 μg/mL sufentanil is followed by infusion of a mixture of bupivacaine (0.031%) and sufentanil (0.2–0.3 μg/mL) at a speed of 6–10 mL/h. These low dosages are used in obstetrics in particular.

Patient-controlled epidural anesthesia (PCEA)
This mode of application leads to a significant reduction in the total dose, by up to 30%. A bolus dose of 10–30 μg sufentanil is followed by a baseline infusion rate of 5 μg/h. The maximum single dose is 5 μg, with a lockout time of 10–20 minutes.

Factors influencing epidural infusion

Important factors that influence the opioid/local anesthetic dosage in epidural infusions are:
The location and type of surgery.
Pain type (obstetric, post-traumatic).

Opioid type and its initial dosage.

Injection volume.

Concentration of the local anesthetic.

Patient characteristics (age, obesity, concomitant diseases).

Intraoperative blood loss.

Pharmacokinetics of the injected opioid.

Position of the catheter tip in the epidural space.

Complications and side effects [13, 28]

Respiratory depression
This is the most feared complication, particularly after subarachnoid administration.

The cause is either overdose, or systemic absorption of the opioid. Respiratory depression occurs relatively
soon after administration, or may be delayed by slow rostral diffusion to the respiratory center. Delayed respiratory depression is particularly seen after morphine administration, since its marked hydrophilia leads to larger amounts remaining in the slowly circulating CSF and spreading towards the respiratory center. Slowly circulating CSF takes 6–10 hours to pass from the lumbar subarachnoid space to the fourth ventricle.

Low levels of respiratory depression are possible even after the administration of lipophilic opioids [16, 34]. Monitoring of respiration after giving both hydrophilic and lipophilic opioids is therefore strongly recommended. Despite the binding of lipophilic opioids to the receptors in the spinal cord, the analgesic effect of these agents is mainly systemic rather than spinal. Thus, the same quality of analgesia can be achieved independently of the catheter position (lumbar or thoracic, after a thoracotomy: see Chapter 42, p. 331).

The following measures are regarded as effective forms of prophylaxis to reduce the risk of respiratory depression:
- Careful monitoring of respiration and circulation.
- Use of lipophilic opioids.
- Individual dose adjustment and dose reduction by titration.
- Low volumes.
- Dose reduction in older patients, pregnant patients and obese patients.
- If the patient becomes somnolent, it is a warning signal.
- Particular caution should be used when there is intraoperative blood loss and a drop in blood pressure.
- Lumbar injection and epidural infusion are preferable.
- Possible catheter dislodgement should be carefully monitored.
- Avoid the use of intravenous supplementation (opioids or sedatives).

Therapy
- Naloxone 0.1–0.2 mg i.v. as a bolus, or as infusion 5–10 μg/h
- Nalbuphine 5–10 mg i.v.

Pruritus
This is a harmless side effect, which can be observed in a large proportion of patients (40%) after administration of an initial dose. In most cases, it resolves spontaneously after 10–20 minutes without any treatment being needed. In resistant cases, treatment with nalbuphine 5–10 mg i.v. or naloxone is recommended.

Alternatively, propofol (10–20 mg) and antihistamines can be used.

Urinary retention
This is often observed after spinal administration of opioids.
Treatment: carbachol (Doryl) i.m. or catheterization.

Nausea/vomiting
These side effects are often seen after the administration of pethidine.
Treatment: metoclopramide 10–20 mg i.v. nalbuphine 5–10 mg i.v. or propofol 10–20 mg i.v. A final alternative is naloxone 0.2–0.4 mg.

Drop in blood pressure
Occurs in 11.5% of cases [13].

Bradycardia
Occurs in 1.6% of cases [13].

Muscle relaxation
Occurs in 7% of cases [13].

Clonidine
Clonidine, a derivative of imidazoline, binds to alpha-2-adrenoceptors.
The alpha-2-adrenoceptors are mainly found in the intermediomedial nucleus (preganglionic sympathetic cells of origin for T4–L2/3), in the intermediolateral nucleus (preganglionic parasympathetic cells of origin for the sacral spinal cord) and in the substantia gelatinosa of the dorsal horn.
The receptor density in the sacral cord is 50% greater than in the thoracic and lumbar spinal cord [29, 30]. Clonidine’s high lipid solubility and low plasma protein binding (20%) allows it to pass the blood–brain barrier more quickly.
Its analgesic effect is segmental. Maximum CSF levels are observed 30 minutes after epidural administration of clonidine, and these are about 100 times higher than the simultaneous plasma levels.
The elimination half-life in CSF is about 80 minutes and in plasma 12 ± 7 hours. The elimination is mainly renal.

Hemodynamic side effects
As clonidine is a potent hypotensive drug, bradycardia, hypotension, or sedation can be expected after epidural or subarachnoid application. Administration of clonidine in patients with cardiac insufficiency or hypovolemia is therefore contraindicated.
Nerve injury in the form of ischemia due to vasoconstriction has not as yet been observed after epidural or subarachnoid administration of clonidine.

**Combination with local anesthetics or opioids**

Clonidine has a very good additive effect when combined with local anesthetics or opioids.

**Subarachnoid administration**

Subarachnoid administration of clonidine (150 µg) combined with a local anesthetic leads to a prolonged duration of effect and prolonged motor block in spinal anesthesia, due to its additive effect.

The dose required for adequate effect in subarachnoid injection is about one-third of the epidural dose.

In subarachnoid combination with a local anesthetic, clonidine does not lead to more severe circulatory depression in comparison with pure spinal anesthesia with a local anesthetic.

Long-term subarachnoid administration of clonidine in pain therapy has been reported [18].

**Epidural administration**

The combination of clonidine with a local anesthetic or an opioid leads to a significant improvement in the quality and duration of analgesia.

This has been reported in particular in orthopedics [12], obstetrics [21], pediatric anesthesia [17] and in long-term pain therapy [20].

**Dosage recommendations for clinical application**

If opioids and alpha-2-agonists are being used in neuraxial analgesia procedures, it can be assumed that oxycodone undergoes an additive effect, if not a synergistic one.

This is associated with a doubling of the duration of effect and has been reported for combinations of clonidine with morphine, fentanyl and sufentanil.

**Suggested dosages**

**Subarachnoid:**

- Clonidine 150 µg in combination with a local anesthetic.
- Epidural:
  - Clonidine 2–4 µg/kg b. w. + morphine 30–50 µg/kg b. w. [29].
  - Clonidine 4 µg/kg b. w. + fentanyl 2 µg/kg b. w. + 0.25% bupivacaine ad 50 mL, infusion at 0.05 mL/kg/h [29].
  - Clonidine 150 µg + fentanyl 100 µg [29].
  - Clonidine 150 µg + sufentanil 10 µg [36].

Clonidine 2–4 µg/kg b. w. + sufentanil 0.2–0.3 µg/mL + 0.125% bupivacaine ad 50 mL, infusion at 6–10 mL/h.

**Ketamine**

Ketamine was synthesized in 1963 and is structurally related to the addictive hallucinogen phencyclidine (PCP, "angel dust").

It is used as an analgesic, narcotic and for tracheal intubation in status asthmaticus.

It has a firmly established place in anesthesia, intensive care medicine and in emergency medicine. Its importance as a low-dose co-analgesic drug in neuraxial applications is growing. In particular, intravenous or epidural administration of the stereoisomer S-(+)-ketamine is likely to become more important. In comparison with the racemate form, it has double the analgesic and anesthetic potency, an equally fast onset of effect, shorter recovery times and a wider range of therapeutic application [2–4].

**Mechanism of effect** [2–4]

Ketamine is a nonspecific N-methyl-D-aspartate (NMDA) receptor antagonist.

The most important binding site for the analgesic effect of ketamine is the NMDA-sensitive glutamate receptor channel.

The NMDA receptors belong to the excitatory amino acid system (EAA) of the central nervous system. Glutamate is the most important excitatory neurotransmitter in the vertebrate central nervous system. PCP receptor agonists such as ketamine inhibit the effect of glutamate at the NMDA receptor channels noncompetitively and thus prevent calcium transport into the cells. The analgesic effect of ketamine is mainly produced by this process.

The local anesthetic effect of ketamine, in contrast, is based on sodium ion channel inhibition, with raised concentrations being found at the site of application.

At low dosages, the local anesthetic effect (in the spinal cord) is very low. Ketamine is also thought to have a neuroprotective effect in the context of NMDA receptor antagonism [3].

There is an affinity with other receptors, but the significance of these in mediating the effect has not yet been fully clarified: opioid receptors, nicotinic (nACh) and muscarinic (mACh) acetylcholine receptors, dopamine receptors (indirectly), serotonin receptors (indirectly), adrenoceptors (indirectly), ion channel block (voltage-operated channels, particularly Na⁺, K⁺, Ca++) and GABA.
receptor A binding (modulation of the chloride channel).

Neuraxial use of ketamine

The use of ketamine in combination with an opioid or local anesthetic (rarely as a monooanalgesic) has proved its value in the following areas:
- Postoperative pain therapy.
- Various chronic pain syndromes that are treatment resistant.
- Cancer pain.

A combination of subanalgesic doses of ketamine and morphine synergistically enhances the effect of morphine and interaction with various receptors. This leads to the following advantages:
- Very good analgesia, comparable with that of high-dose morphine administration [40].
- A substantial reduction in the rate of adverse side effects, particularly respiratory depression, resulting from the reduced dosage of morphine.
- Prophylaxis against developing opioid tolerance.
- In cases of morphine tolerance, ketamine is a good way of potentiating the effect through an additional attack at the NMDA receptor.

Subarachnoid application

Subarachnoid administration of ketamine as a co-analgesic (rarely as a single agent) is not recommended, due to the neurotoxicity of the preservative benzethonium chloride that is contained in ketamine preparations.

Ketamine may only be used exceptionally and in the form of a preservative-free solution for subarachnoid applications [14, 15, 37, 40].

Cancer pain

Treatment-resistant cancer pain is the principal indication for the subarachnoid administration of ketamine as a co-analgesic with morphine [41], or as an addition to clonidine and a local anesthetic [24] in the form of a continuous infusion.

The potentiating effect of ketamine leads to a substantial reduction in the morphine dosage and thus a reduction in the risk of adverse side effects.

Anesthesiology

The use of ketamine as a single agent in anesthesiology has not as yet proved successful.

The reasons for this are the high dosages required (0.7–0.95 mg/kg), the short duration of effect and its dose-dependent central sympathomimetic side effects [15].

Epidural application

The first publications reporting the epidural use of ketamine date from 1982.

The administration of ketamine as a co-analgesic, usually with morphine (more rarely as a single drug) leads to very good postoperative analgesia, particularly when administered pre-emptively.

The nociceptors are blocked to an extent such that a subsequent pain stimulus does not lead to increased sensitivity in its effects on the nerve cell. Pain-related central adaptation processes, which increase postoperative pain, are thereby prevented.

Ketamine should be used without a preservative substance and at a concentration of 0.1–0.3% [15, 37, 40].

Surgical indications

- Gynecological procedures [1, 19].
- Upper abdominal procedures via a thoracic catheter [9].
- General surgery [8].
- Cholecystectomy [25].
- Orthopedic prostheses [37, 38].
- Pediatric surgery (orchidopexy) via caudal administration [11, 32].

The epidural dosage of ketamine is 20–50 mg [14].

Indications in pain therapy

Post-herpetic neuralgia [39].
- Complex regional pain syndrome (CRPS), types I and II [22, 35].
- A dose of 7.5–10 mg in combination with 0.75–1 mg morphine and 0.1% bupivacaine is recommended here.
- For continuous epidural infusion, a dose of 25 μg/kg/h is recommended [35].
- Phantom pain [26].
- Cancer pain.

Specific contraindications

- Poorly adjusted or untreated arterial hypertension.
- Pre-eclampsia and eclampsia.
- Manifest hyperthyroidism.

Relative contraindications

- Unstable angina pectoris.
- Myocardial infarction within the previous 6 months.
Chapter 50

Raised intracranial pressure without adequate ventilation.
Glaucoma and perforating eye injuries.

**Interactions**
Combined application with thyroid hormones leads to severe hypertension and tachycardia.
Chapter 1: Regional nerve blocks and infiltration therapy in clinical practice


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(André van Zundert, Danilo Jankovic)


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Chapter 18: Intravenous sympathetic block with guanethidine (Ismelin®)


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(James E. Heavner, Gabor B. Racz, Miles Day, Rinoo Shah)

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