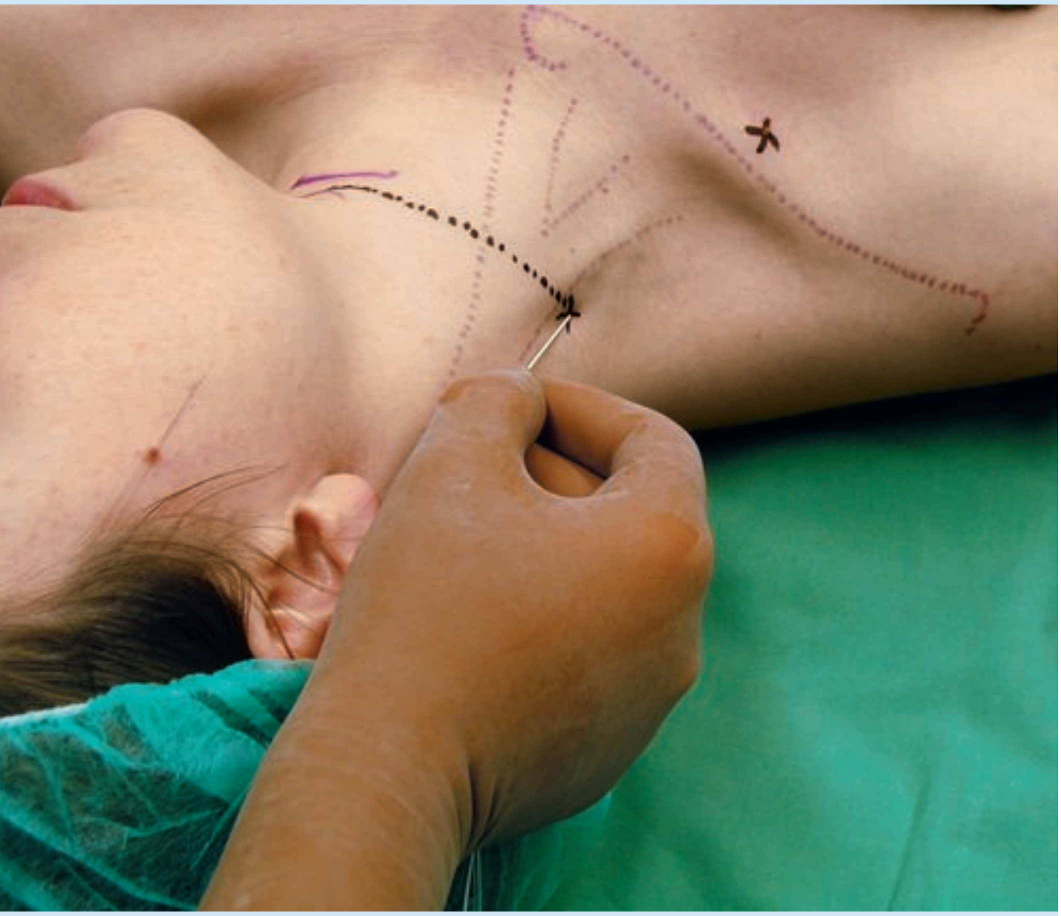
PERIPHERAL REGIONAL ANAESTHESIA

Tutorial
in the Ulm Rehabilitation Hospital



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3RD EXPANDED EDITION

Preface to the First Edition

Despite increasing use in recent years, peripheral regional anaesthesia techniques continue to occupy a rather secondary position in comparison to spinal procedures. This is particularly the case for peripheral blockade techniques of the lower extremities.

The manifold advantages of complete anaesthesia of a single extremity for operative procedures of the most diverse sort have prompted us to devote particular attention to these techniques over many years. Urged on by interested colleagues as well as our own aspirations, the idea emerged of developing a practically oriented, anatomical-clinical training on this subject so as to pass on the exceedingly positive experiences accumulated both by practitioners and patients to a wider circle of colleagues. Previous and current employees have now produced an accompanying text for this "Peripheral Regional Anaesthesia Tutorial", which summarises the content of this course in condensed form.

The support of the B. Braun Co. now makes it possible for us to make this text available in the present form to a wider audience. We hope that this will contribute to the wider dissemination of the regional anaesthesia methods presented herein and thus to the greater well being of our patients. In this connection, the particular worth of these procedures with the help of the continual catheter technique for long-term pain management should not be overlooked.

My thanks to all the employees who have worked so hard to see this brochure through to completion. My particular appreciation goes to Prof. M. Herrmann, M.D., the previous director of the Institute for Anatomy at Ulm University, for his unstinting efforts in helping with the organisation of the Tutorial, as well as to our orthopaedic colleagues, Prof. W. Puhl, M.D., Director of the Orthopaedic Clinic and his employees, without whom the realisation of the clinical-practical portion of the tutorial could not have been accomplished.

Ulm, September 1997 Prof. H.-H. Mehrkens, M.D.

Preface to the Second Expanded Edition

Three years have passed since the first tutorial was published. The time has now come to revise the accompanying script to include all the further developments that have meanwhile taken place.

The extremely positive response and the continued and generous support provided by AstraZeneca and B. Braun Melsungen have additionally helped us dare take a quantum leap into the era of modern media. We are eagerly awaiting the results of the new and extensive visual and interactive possibilities offered by CD-ROM media and the Internet.

This new forum that has been created will ultimately open up possibilities for more direct and quicker feedback. We would like to expressly encourage all those colleagues interested to send us their critique and constructive suggestions.

Ulm, March 2000 Prof. H.-H. Mehrkens, M.D.

Preface to the Third Expanded Edition

Following the 2004 publication of the compact version of our tutorial on "Peripheral Regional Anesthesia in the RKU", now, to keep pace with rapid advancements, we release the new, comprehensively revised and updated edition of the original script. This brochure has been expanded by several, meanwhile established block techniques. Useful knowledge and experience from clinical routine gathered over the past years have been included in equal measure with current and newly developed materials. Its publication takes place in sync with a new DVD version with expanded contents and an updated homepage www.nerveblocks.net . For mobile use, we recommend the compact version in PDF format that fits on a pocket PC. Once again, all of the above would not have been possible without the continuingly generous support of B. Braun Melsungen and the commitment of our own clinical team.

Ulm, September 2005 Prof. H.-H. Mehrkens, M.D.

Contents

Chapter 1

1.1 Anatomy

Brachial plexus

The brachial plexus is formed from the ventral roots C5 to Th1, with small additions from C4 and Th2. The 5th and 6th cervical nerves unite to form the upper trunk, which continues on to become the major component of the lateral cord. The ventral root of the 7th cervical nerve becomes the middle trunk and together with portions of the upper and lower trunk continues on to become the posterior cord. Ultimately, the 8th cervical nerve and the 1st thoracic nerve unite to form the lower trunk, which together with portions of the middle trunk becomes the medial cord.

The brachial plexus passes through the posterior scalenus gap relatively close to the surface between the scalenus anterior and scalenus medius muscles. A short distance away, it leaves the suprascapular nerve, which primarily supplies the shoulder joint, exiting from the upper trunk to the dorsal. The trunks subsequently divide to form the individual cords just above the clavicle.

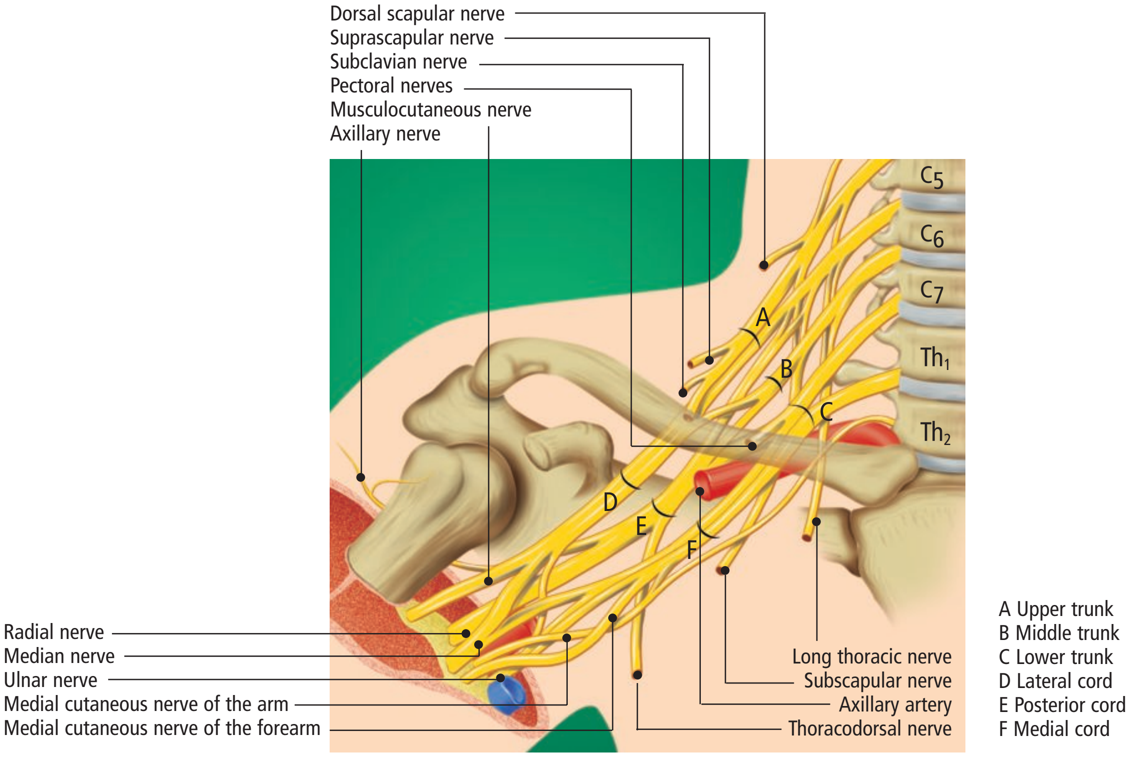


Fig. 1: Anatomy of the brachial plexus

The axillary artery is encased together with the cords in a common sheath which runs beneath the clavicle in the direction of the axilla. This neurovascular sheath should run from the deep cervical fascia to the axilla. Before reaching the axilla, the plexus divides into the following nerves:

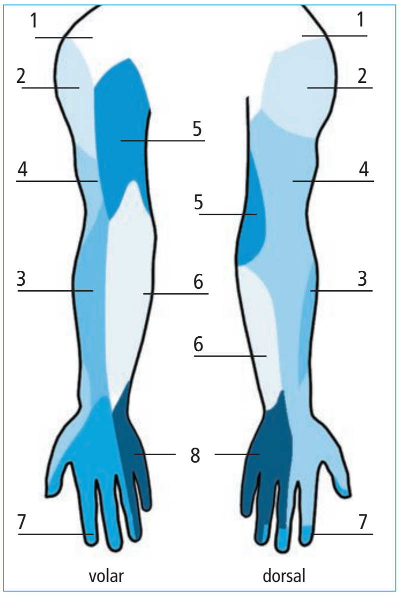
- Musculocutaneous nerve from the lateral cord
- Median nerve from the lateral and medial cords
- Ulnar nerve from the medial cord
- Radial, axillary and circumflex humeri nerves from the posterior cord.

It is assumed that differing septation within this common sheath is responsible for the varying susceptibility of the individual nerves to the effects of anaesthesia. This septation as well as the functional existence of a common fascial sheath have been the subject of discussion. Nonetheless, clinical practice and a number of studies have shown that there must be an anatomical basis for a single injection technique. Our own investigations on the cadaver did not reveal a common "tube", rather a filigreed, hexagonal, certainly very easily penetrated septation.

Motor supply areas

Peripheral nerve	Muscle	Function
Suprascapular nerve	Supraspinatus/ infraspinatus muscles	Forms parts of the rotator muscles
Axillary nerve	Deltoid muscle	Abduction of the arm in the shoulder joint
Musculocutaneous nerve	Biceps brachii muscle Brachial muscle	Bends the elbow in supination
	Flexor pollicis brevis muscle	Pronates the forearm (flexes proximal phalanx of thumb)
Median nerve	Flexor carpi radialis muscle	Flexes and abducts wrist radialward
	Flexor digitorum profundus muscle (I-III)	Flexes and adducts the thumb, flexes fingers I-III
Radial nerve	Triceps brachii muscle	Extends elbow
	Extensor carpi radialis (brevis) muscle	Extends and abducts wrist radialward
	Extensor digitorum muscle	Extends and flexes the hand dorsally Extends and spreads the fingers
Ulnar nerve	Flexor carpi ulnaris muscle	Flexes and abducts wrist ulnarward
	Flexor digitorum profundus muscle (IV-V)	Flexes fingers (IV-V)

Sensory supply areas



1 Supraclavicular nerves (from the superficial cervical plexus)
2 Axillary nerve
3 Musculocutaneous nerve
4 Radial nerve
5 Medial cutaneous nerve of the arm
6 Medial cutaneous nerve of the forearm
7 Median nerve
8 Ulnar nerve

Fig. 2: Sensory supply areas of the brachial plexus

Lumbosacral plexus

Innervation of the leg takes place in the lumbar and sacral plexuses.

After exiting the intervertebral foramina (Th 12-L4), the lumbar plexus runs within a fascial sheath between the psoas major muscle and the quadratus lumborum muscle. The lumbar vertebrae and the transverse processes are located mediad.

The iliohypogastric nerve (Th12, L1), the ilio-inguinal nerve (L1) and the genitofemoral nerve (L1, L2) are formed from the cranial portion of the lumbar plexus. The lateral femoral cutaneous nerve (L2, L3), the obturator nerve (L2-4) and the femoral nerve arise further caudad to this.

The femoral nerve extends along the ventral side of the iliopsoas muscle, beneath the inguinal ligament and through the muscular lacuna approximately 1-2 cm lateral of the femoral artery where it divides into its branches. Its cutaneous branch, the saphenous nerve extends to the medial lower leg. The lateral femoral cutaneous nerve is purely sensory. It passes slightly medially to the anterior superior iliac spine and emerges beneath the inguinal ligament to supply the skin of the lateral part of the thigh. Here, however, there are frequently variations to the point that the lateral skin of the thigh is sometimes principally supplied by the femoral nerve. The obturator nerve proceeds along the medial edge of the psoas major muscle and emerges from the false pelvis through the obturator foramen somewhat mediodorsal to the pubic tubercle towards the medial thigh: although the literature assigns it to a circumscribed sensory area of skin in middle of the medial thigh, it is rarely demonstrable in clinical practice. One must therefore assume that this region is supplied entirely by the branches of the femoral nerve. The lumbosacral trunk emerging from the roots L4 / L5 (the fourth lumber nerve) unites the two plexuses.

The sacral plexus extends dorsally, emerging from the lower pelvis through the greater sciatic foramen. The posterior femoral cutaneous nerve develops directly out of the sacral plexus. The sciatic nerve is formed from segments L5 to S3. In the buttocks region, it proceeds beneath the gluteus maximus muscle and passes between the ischial tuberosity and the greater trochanter of the femur to the dorsal thigh. At this point it supplies motor fibres to the dorsal musculature of the thigh. Approximately 10 to 15 cm above the level of the knee joint, is commonly where it diverges into the tibial nerve and common peroneal nerve.

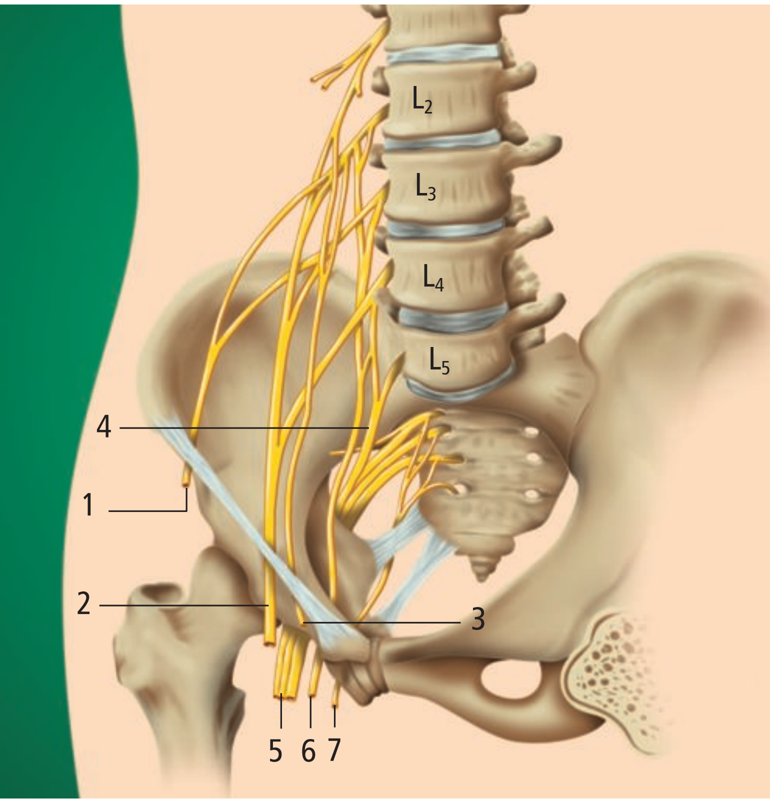


Fig. 3: Diagram of the lumbosacral plexus

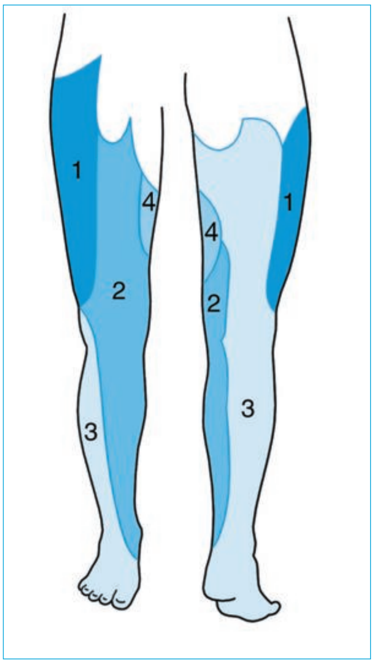
1 Lateral femoral cutaneous nerve
2 Femoral nerve
3 Genitofemoral nerve
4 Furcal nerve (fourth lumbar nerve)
5 Sciatic nerve
6 Obturator nerve
7 Pudendal nerve

Fig. 4: Lumbosacral plexus in a dissected cadaver

Motor supply areas

Peripheral nerve	Muscle	Function
Femoral nerve	Quadriceps femoris muscle	Flexes the hip Extends the knee
Obturator nerve	Adductors of thigh at the hip joint	Adducts thigh
Tibial nerve	Biceps femoris muscle Semimembranosus muscle Semitendinosus muscle Triceps surae muscle	Flexes knee
	Flexor hallucis longus muscle	Flexes foot
	Flexor digitorum longus muscle	Flexes toes
Common peroneal nerve (deep and superficial)	Tibialis anterior muscle	Dorsiflexion and inversion of foot
	Extensor digitorum muscles Extensor hallucis muscles Peroneal muscles	Extend, evert and pronate the outer foot

Sensory supply areas



1 Lateral femoral cutaneous nerve
2 Femoral nerve
3 Sciatic nerve
4 (Obturator nerve)

Fig. 5: Sensory supply areas of the lumbosacral plexus

1.2 Electrical nerve stimulation

Peripheral nerves are comprised of thousands of nerve fibres; they contain either sensory or motor fibres of the somatic and autonomic nervous systems, but sometimes both in combination. Electrical impulses reaching a nerve, when they exceed a specific threshold stimulus current (rheobase), trigger depolarisation of the neuron membrane, thereby inducing transmission of excitation along the nerve fibres. If the nerve contains motor fibres, the electrical current will induce contractions at the effector muscle. If these stimuli are induced on sensory fibres, they cause paraesthesia in the distribution of the nerve. This underlying principle of electrical nerve stimulation is utilised in peripheral regional anaesthesia.

Physiology

Nerve fibres can be divided into different classes which are based on myelination, nerve conduction velocity and function. Chronaxie, the duration of the stimulus required at twice the maximum rheobase strength to cause depolarisation of the neuron membrane, is used as a measure of the excitability threshold for different types of nerve tissue, i.e. it indicates the duration of an effective electrical stimulus required to elicit a response. Stimulation of selective motor and sensory fibres occurs when the duration of the stimulus current (pulse duration) is within chronaxie.

Class	Function	Chronaxie
Aa	Motor	0.05–0.1 ms
Ab	Touch, pressure	
Ag	Touch	
Ad	Pain, temperature	0.150 ms
B	Sympathetic nervous system	
C	Sympathetic nervous system, pain, temperature	0.4 ms

The stimulator

We use the new Stimuplex® HNS 12 nerve stimulator (B. Braun Melsungen) which features the following functions among others:

- Exact amplitude ranges are selectable between 0 and 1 mA (or 5 mA). The device displays the actual current.
- Pulse durations of 0.1, 0.3 or 1.0 msec are selectable.
- The pulse frequency can be set to between 1-2 Hz.

At a given current, the electrical current required to trigger muscle contractions correlates with the distance of the tip of the needle to the nerve. That means that the closer the needle is to the nerve, the lower the electrical current that is required to induce contractions or sensory responses. In routine clinical practice, an initial electrical current, called threshold current, of 1 mA is used to elicit a response. The stimulation needle has reached the desired position at the nerve when contractions of the effector muscle are induced at a threshold current of 0.2 - 0.3 (pulse duration of 0.1 ms). Lower pulse amplitudes may cause injury to the nerve. Therefore, as a general rule, the lowest stimulation current should be determined: This will allow the user to correct the needle position by retracting the needle if it gets too close to the nerve.

At this threshold current, motor fibres can be selectively stimulated by setting a pulse duration of < 150 μs on the nerve stimulator. Pain fibres are not affected at this pulse duration, thereby allowing the patient to experience the electrical nerve stimulation more pleasantly. A pulse duration of >150 μs is selected when a purely sensory nerve, such as the lateral femoral cutaneous nerve, is targeted. The patient will then notice the corresponding paraesthesia in the supply area of the sensory nerve.

The pulse duration is usually set at 2 Hz. A higher pulse duration is better for stimulation because a rapid pulse sequence allows a more precise localisation. This virtually eliminates the danger of slipping past the nerve. A lower pulse duration (1 Hz) may be preferable in traumatised patients in order to minimise the pain caused by contractions of the muscle.

Fig. 6: Nerve stimulator:
Stimuplex® HNS 12
(B. Braun Melsungen AG)

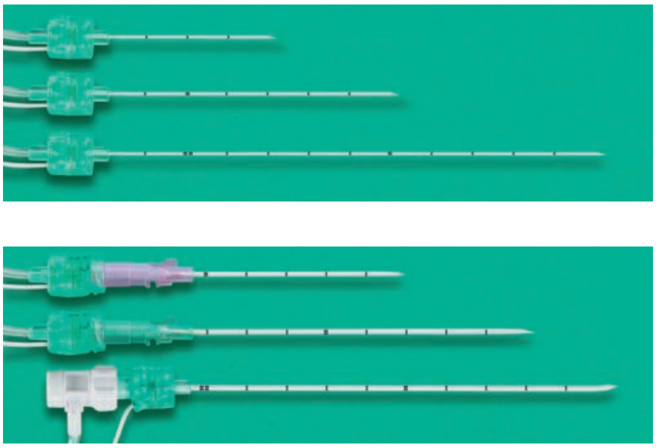


Fig. 7/8: Stimulation needles:
Stimuplex® D / Contiplex® D / Contiplex® Tuohy
(B. Braun Melsungen AG)

The needles

We use stimulation needles that are completely insulated, except for a small area on the tip. They are fully coated and therefore have no sharp edges. This type of needle is call monopolar or unipolar. The electrical current has a very small exit opening. Because of this, the electrical field is bundled and generates higher current density at the tip of the needle. The higher the current density at the tip of the needle, the lower is the current required for stimulation. As the needle approaches the nerve, the current required for depolarisation drops. If the tip slips past the nerve, this value starts rising again just as rapidly. This method makes it possible to localise the nerve exactly while keeping the risk of injury at a minimum. Various opinions prevail with regard to the role the bevel plays in the risk of injury. The use of short-bevelled needles (45°) is supposed to reduce the danger of nerve lesions. It is easier to identify fascial structures, which is also important when a nerve stimulator is not used. We employ unipolar needles with a 15° bevel because they pass through tissue more easily and cause less trauma, which is helpful for localizing the nerves. In our opinion, the risk of nerve lesions is kept extremely low when a suitable nerve stimulator is used and nerve stimulation applied properly.

The procedure

- Test the function of the nerve stimulator.
- Disinfect the skin, create a skin weal and, if necessary, infiltrate puncture channel. When blocking superficial nerves (e.g. brachial plexus, femoral nerve), infiltrate the puncture site cautiously, as otherwise the effect of stimulation may be reduced by a premature partial block.
- Place an injection line with NaCl 0.9% syringe, rinse the injection line and needle, connect the current line and create a connection to the neutral electrode.
- Pierce the skin with the stimulation needle and advance it into the subcutaneous tissue.
- Switch on the stimulator and select the pulse duration (0.1 ms for mixed nerves), pulse frequency (2 Hz) and stimulation current (1 mA). Check to make sure that the selected stimulation current corresponds to the actual current reading. If the actual stimulation current deviates markedly from the pre-selected value, check to electrode and the stimulator once more.
- Advance the stimulation needle towards the nerve until the first muscle contractions occur in the area of the target muscle. While monitoring the stimulatory response, reduce the stimulation current incrementally until the threshold electrical current (>0.2<0.3 mA) is reached and contractions are still visible. To rule out a too close needle position, the amplitude is reduced further until the muscle response disappears. If a stimulatory response is still triggered at 0.2 mA, the needle must be retracted slightly Here it is important that the anaesthesiologist and assistant co-ordinate their activities. Only one of them may make the adjustments – either the anaesthesiologist changes the position of the stimulation needle or the assistant adjusts the current.
- If visible contractions of the target muscle continue to occur at the threshold current, perform a negative aspiration test and then inject the local anaesthetic.
- Turn the stimulation current back up to 1.0 mA after the first 10 ml of the local anaesthetic have been injected. This is done to rule out an accidental intravascular position. If the needle is inadvertently positioned intravascularly, the local anaesthetic will be washed away and any increase in the stimulation current would lead to renewed and strong muscle contractions. Aspiration checks should be performed repeatedly throughout the entire injection.
- When using the catheter technique, it is advisable to make a stab incision of the injection site with a steel needle or lancet before puncturing. This will make it easier to advance the fine Teflon introducer mounted on the stimulation needle through the skin. We usually inject the full dose through the stimulation needle. This dilates the connective tissue surrounding the nerve, thereby facilitating placement of the catheter. After the stimulation needle is fixated, the capillary is released from the screw adapter by turning it clockwise and then the needle removed.

Transdermal nerve stimulation

For locating nerves with a superficial location and in patients of normal weight, the Stimuplex® Pen can be used together with the stimulator to trigger a transdermal response from the target muscle. The pulse duration of the device must be set to 1 ms and the current range to the 5 mA. In this way, it is possible to get a better fix on the puncture site or even correct the puncture direction more precisely. Another important aspect is its use to demonstrate the proper stimulus of the target muscle when training inexperienced colleagues.

Fig. 9: Transdermal nerve stimulation of the femoral nerve with the Stimuplex® Pen: (B. Braun Melsungen AG)

Fig. 10: Transdermal nerve stimulation of the brachial plexus

Evaluation of electrical nerve stimulation

As in the past, peripheral electrical nerve stimulation continues to be the method of choice for localising nerves. The criteria for judging whether electrical nerve stimulation is successful are clearly defined. Each block has its own target muscle which is the object of the search. It is only in this way that the high and reproducible success rates of more than 95% can be achieved.

The anaesthesiologist is not dependent on specific information from the patient. Unless a purely sensory nerve is sought, the patient can be sedated during the block. A proper motor response to stimulation is sufficient to localise mixed nerves. The risk of nerve lesions is minimal. The use of electrical nerve stimulation for localising nerves is not without controversy, however. When nerve structures located near the surface are involved, such as in an axillary block of the brachial plexus, it is certainly possible for a skilled anesthesiologist to perform successful blockade without nerve stimulation. Nonetheless, in our opinion and regardless of the puncture site, the nerve stimulator represents a very helpful tool that enables exact and reliable localisation. For that reason, it is our general policy to use it for all blockades. Also, we regard the nerve stimulator as an indispensable tool for training purposes.

Ultrasound-guided nerve blocks

The ultrasonographic visualisation of the nerves to be blocked is a relatively new technique that holds promise for the future. It not only requires that the user has extensive ultrasound experience, but requires an understanding of anatomy (sonoanatomy) from a different perspective. The parallel development of special needles and catheter materials is still playing catch-up and not every institution will be able to make the not insubstantial investment in the purchase of a suitable, portable ultrasound machine. Although we have little experience in this area, we nevertheless believe that ultrasound-guided peripheral regional anaesthesia is at present too complicated for application in clinical routine. In exceptional cases, the technique can be used to support peripheral nerve stimulation. Currently, it is difficult to predict how this technique will develop on a broader scale.

1.3 Local anaesthesia

Drugs

	Protein binding	Rel. Strength (Procaine = 1)	Onset of action	Duration of action (min)
Prilocaine (Xylonest®)	55 %	2	Rapid	90
Mepivacaine (Scandicain®)	75 %	2	Rapid	120
Bupivacaine (Carbostesin®)	92%	8	Slow	360
Ropivacaine (Naropin®)	95 %	8	Rapid	720

Xylonest®, Scandicain®, Carbostesin®, Naropin® are registered trademarks of the AstraZeneca Co.

Mechanism of Action

Local anaesthetics reversibly inhibit impulse conduction along the nerve fibres by blocking sodium channels. Depending on their structure, the different nerves show varying susceptibility to the effects of anaesthesia. Thin, unmyelinated fibres are more susceptible than thick, myelinated ones.

Side effects

At their respective toxic plasma levels, all local anaesthetics can have side effects on the cardiovascular or central nervous systems. The higher the plasma levels and the quicker the rate of increase, the more pronounced are the symptoms. Allergic reactions are extremely rare with conventional local anaesthetics of the amide group. Some products, however, do contain the preservative methylparaben, which is an allergen. With prilocaine, in particular, metabolites can lead to a dose-dependent formation of methaemoglobin. This is hardly clinically relevant as long as the contraindications are observed (patients with impaired cardiac reserves or impaired pulmonary gas exchange, patient with glucose 6-phosphate-dehydrogenase deficiency).

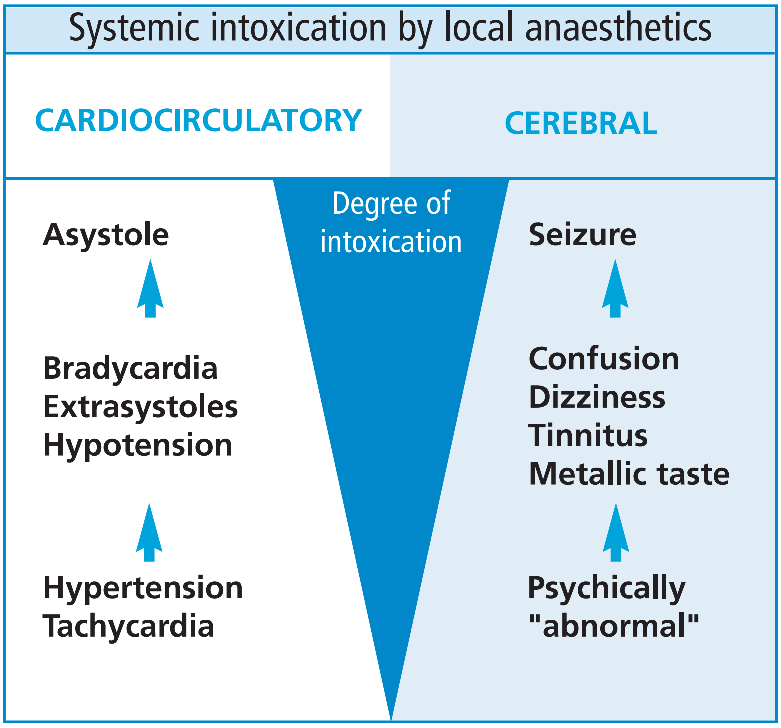
Central nervous system complications

Preconvulsive hallmarks are restlessness, metallic taste, muscle twitches, slurred speech and tinnitus. These warning signs may be followed by a generalised seizure and/or central respiratory paralysis. If high toxic levels are reached very rapidly, e.g. by inadvertent intravascular injection, a primary generalised seizure or coma may occur without any warning.

Cardiovascular complications

Disturbances of pacemaker activity, excitability and conduction: bradycardia, signs of A-V block, arrhythmia, asystoles, negative inotropia, decreased cardiac output, and hypotension.

Typically, when the blood levels of a local anaesthetic increase, central nervous system effects occur first, then cardiovascular complications. Bupivacaine is an exception because it can cause cardiac arrhythmias at subconvulsive doses. This bupivacaine cardiotoxicity is caused by a dose-dependent depression of ATP synthesis. Whilst most patients can survive central nervous system intoxications with bupivacaine without any sequelae when the appropriate measures are taken immediately, cardiovascular complications may take a lethal turn. Therefore, the chronological sequence of cardiovascular and central nervous system effects should be strictly monitored to ensure safe administration of local anaesthetics. Successful management may be crucially dependent on the time factor if central nervous system effects become manifest before cardiovascular complications.



Evaluation of the Drugs

We prefer to use prilocaine for peripheral regional anaesthesia as our basic local anaesthetic because of its low toxicity and rapid onset of action. When a longer action is required, we combine prilocaine with ropivacaine or bupivacaine. We use mepivacaine for local anaesthesia of the puncture site or for infiltration of a stab incision. Mepivacaine can moreover be used in patients with contraindications for prilocaine.

Its lipophilia lends bupivacaine a longer duration of action, which, conversely, is one reason for its higher toxicity. On bupivacaine, a dose-dependent reduction or, in come cases, complete cessation of ATP synthesis occurs in the mitochondria of the myocardial cells. This is the reason for the therapy-refractory asystoles associated with bupivacaine.

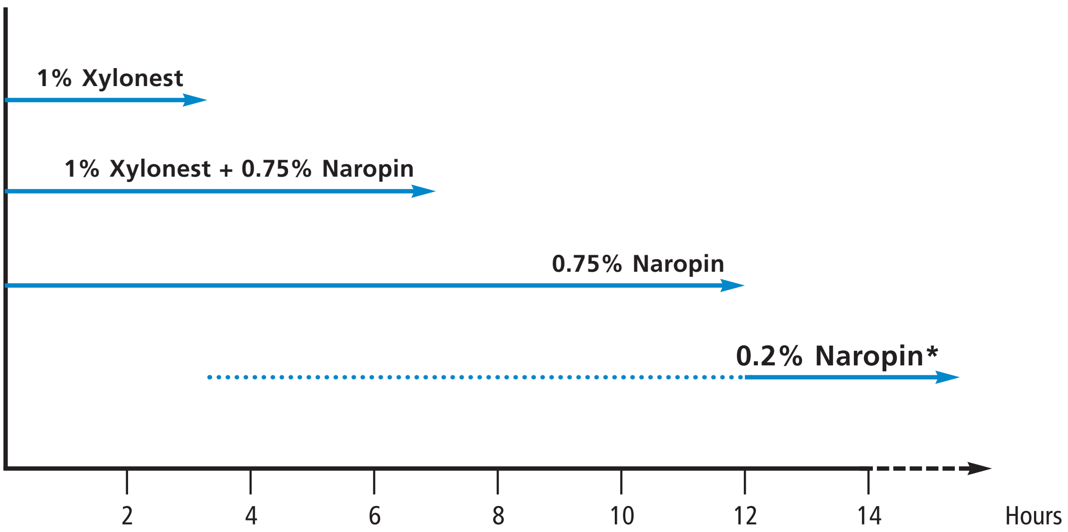
Ropivacaine, a further development of bupivacaine, was launched in Germany in 1997. It differs chemically from its congener bupivacaine by just one propyl group. Ropivacaine presents as a pure S-enantiomer and not as a racemate.

The motor blockade achievable with ropivacaine is dose-dependent. Motoric block adequate for surgical interventions is achieved with 0.5%-0.75% ropivacaine. When a 0.2% solution used for postoperative pain therapy is given, there is at the most a slight impairment of motor function.

Just like bupivacaine, ropivacaine has a high protein binding, but is less lipophilic which makes it long acting, while its toxicity is comparatively reduced. On ropivacaine, ATP synthesis is impaired, but not completely abolished. Compared to bupivacaine, there is a much greater margin between the convulsive and lethal dose of ropivacaine. The arrhythmogenic risk associated with ropivacaine is considered to be twice as low as that of bupivacaine. Hence, we increasingly use ropivacaine instead of the conventional bupivacaine, especially for postoperative pain therapy.

Because of its short duration of action, our department does not use lidocaine for regional anaesthesia. Neither do we see any clinical benefits to be derived from levobupivacaine, in terms of substance-specific and toxicological properties. We are unlikely to use special preparations (bicarbonate or added CO_2 to accelerate the onset of action or added vasoconstrictor to prolong the action). Such parameters hardly pose problems in our daily clinical routine. Adding clonidine, particularly in combination with medium-acting local anaesthetics, appears to prolong the anaelgetic action and is therefore used in ambulatory patients occasionally.

Duration of action of local anaesthetics: Intra- and Postoperative Analgesia



* Start the infusion before intense postoperative pain occurs; otherwise start with an initial bolus. Information provided by AstraZeneca Co.

Blocks of the upper extremity

Introduction

A sound knowledge of anatomy is a vital prerequisite for achieving successful nerve blocks. In simple terms, the course of the brachial plexus, for example, can be compared to an hourglass. Near the spine, its roots extend out broadly and then narrow around the middle of the clavicle, where the nerve bundles form thick clusters that are packed tightly together. This, to continue our metaphor, would be the waist of our hourglass. Towards the armpit, the nerves fan out again. In regional anaesthesia of the arm, this hourglass form has the following consequences:

More or less complete anaesthesia of the arm (excepting the shoulder) is best achieved at the hourglass's waist, namely infra- and medioclavicular. Proximal to this (interscalene nerve blocks), as the technique also includes the sensory parts of the superficial cervical plexus (supraclavicular nerve), anaesthesia will reach the shoulder, but not always the ulnar parts of the lower forearm and the hand. These types of block will rarely reach the caudad segments of the brachial plexus. Distad to this (e.g. as with axillary nerve blocks) anatomical gaps can be expected in the region of the radial and musculocutaneous nerves.

Thus, in order to choose the most suitable procedure for the patient it is especially important to be properly informed about the localisation and the extent of the planned surgical intervention.

2.1 Interscalene nerve blocks

Interscalene nerve blocks represent the most cranial approach to the brachial plexus. Various puncture techniques are possible. In the following, we describe two different means of access: the anterior (according to Meier) and the posterior (according to Pippa). Both procedures can be said to be essentially equivalent with respect to their indications, contraindications and side effects. According to our own studies, the anterior approach proves to be somewhat less time consuming and complicated and (as reported in the literature) less risky. The posterior approach, by contrast, offers certain benefits under specific anatomical circumstances, like in no-neck patients, and in terms of adverse side effects, including potential catheter dislocations, particularly when combined with continuous catheter analgesia. Not least, the use of one or the other technique also depends on the personal skills of the individual anaesthesiologist.

Anterior access (according to Meier)

The interscalene nerve block is a modification of the technique described by Winnie in 1970. In the classical technique of Winnie, the interscalene nerve block is performed at the posterior scalene gap. This puncture site is thus at the level of the cricoid. The puncture is made in the medial, dorsal and caudal direction.

In the modified technique, by contrast, the puncture point is located at the height of the superior thyroid notch at the posterior edge of the sternocleidomastoid muscle. The puncture is directed caudad, slightly to the lateral and aims at the puncture site of the vertical-infraclavicular blockade (see Chapter 2.2).

There are several reasons to prefer the modified technique: a lower risk of inadvertent vessel puncture (of the vertebral artery), the production of high spinal or peridural anaesthesia and the fact that more favourable conditions are created for placement of a catheter for the continuous block technique. In our department, we have replaced the classical interscalene technique according to Winnie with the modified technique for those reasons.

Anatomical landmarks

Superior thyroid notch, sternocleidomastoid muscle (posterior scalene gap)

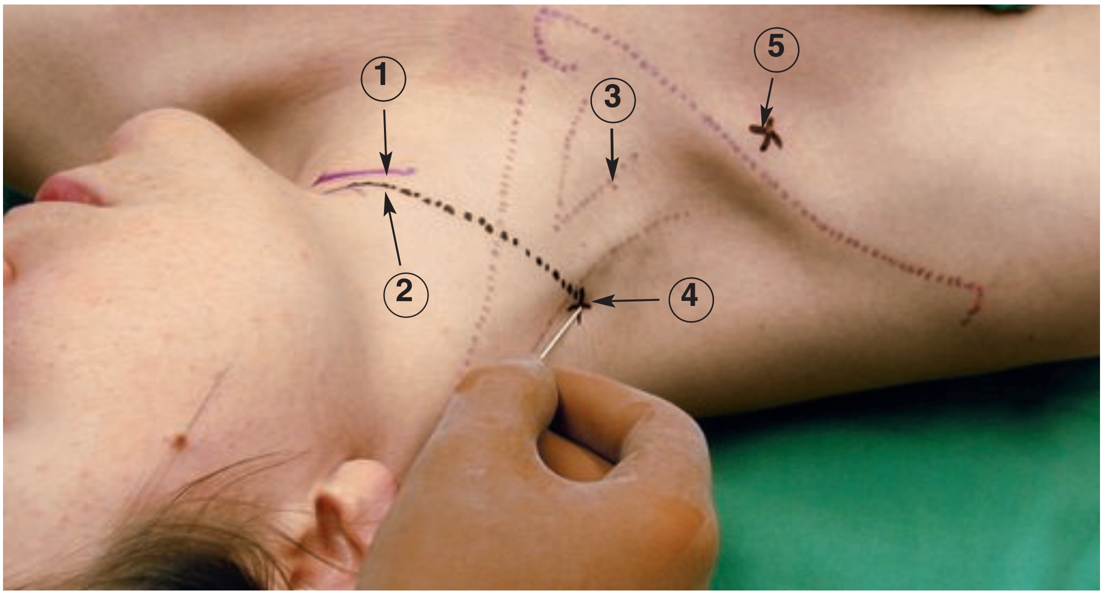


Fig. 11: Interscalene nerve block: Modification according to G. Meier

1. Cricoid
2. Superior thyroid notch
3. Sternocleidomastoid muscle
4. Puncture site for anterior access
5. Vertical, infraclavicular puncture site

Block technique

The patient lies supine (without a pillow!) and the arm that is to be blocked is positioned comfortably on the abdomen. The head is turned slightly to the side. Briefly raising the head from the table may help to identify the posterior edge of the sternocleidomastoid muscle. The puncture point is located at the level of the superior thyroid notch at the posterior edge of the sternocleidomastoid muscle. Care should be taken with the external jugular vein, which is to be found in this region with a relatively high frequency. The direction of insertion is caudad, however with a discrete dorsal orientation relative to the body axis. After 3-4 cm, the upper trunk or portions of the lateral sheath are reached which becomes evident by contractions in the region of the biceps brachii muscle (musculocutaneous nerve). Inject the local anaesthetic after the threshold current (0.2-0.3 mA) is reached. Complete dissemination of the blockade takes between 10-15 minutes.

Posterior access (according to Pippa)

A posterior access can be used as an alternative to the anterior access. The puncture site is located on the back of the neck, at the level of C6/C7 and is directed dorsad towards the scalenus gap. This technique was first described by Kappis in 1912. Then it was forgotten until Pippa started using the posterior interscalene block again in 1990, applying the loss-of-resistance technique for localising the target. Thanks to the use of electrical nerve stimulation, this approach has gained importance over the last few years.

Anatomical landmarks

Processus spinosus C7 (vertebra prominens), Hinterrand M. sternocleidomastoideus, Cricoid

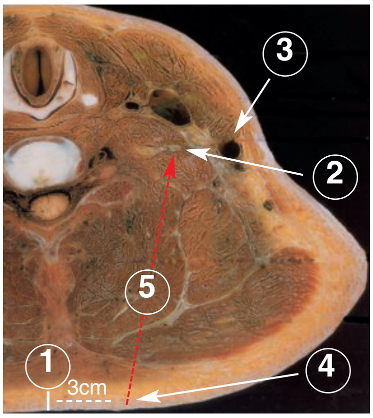


Fig. 12: Posterior access - Anatomy:

1. Interspinal line (midline)
2. Upper trunk (C5/6)
3. Posterior edge of the sternocleidomastoid muscle
4. Puncture site
5. Puncture direction

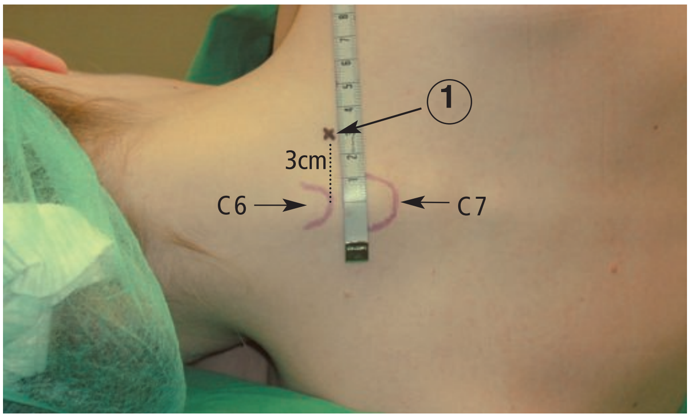


Fig. 13: Posterior access - Positioning

1. Puncture site

Block technique

The patient is placed in the lateral recumbent position, the head is placed axially on a pillow, the cervical spine is flexed backwards. The puncture can also be made with the patient in a sitting position.

The spinous process of the 7th cervical vertebra is usually well palpable. A mark is made in the middle between the spinous process of the sixth and seventh cervical vertebra. The puncture site is 3 cm lateral to this. The puncture is made 5 -10° laterally, towards the direction of the easily felt posterior edge of the sternocleidomastoid muscle at the level of the cricoid. Once the transverse process of C7 is encountered, the direction of puncture is corrected just slightly to the cranial, until, after another 1 -2 cm, the upper trunk (C5/C6) is reached. This becomes visible by contractions of the biceps brachii muscle.

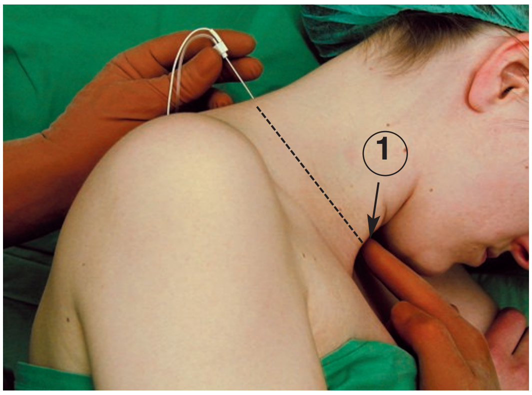


Fig. 14: Posterior access
- Puncture technique

1. Cricoid

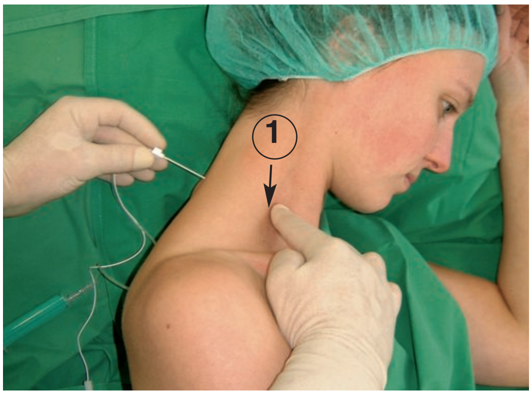


Fig. 15: Posterior access
-Puncture technique

1. Posterior edge of the sternocleidomastoid muscle

Indications for interscalene nerve blocks

Single-shot technique

All surgical interventions on the shoulder including shoulder total arthroplasty, proximal humerus, lateral clavicle.

Catheter technique

For operations known to have high postoperative analgesia requirements, e.g., arthroplasty of the shoulder joint or in supportive physiotherapy following mobilisation of the shoulder joint.

Contraindications for interscalene nerve blocks

- Contralateral recurrent paresis
- Contralateral phrenic paresis

Side effects/complications of interscalene nerve blocks

- Phrenic paresis
- Horner Trias (stellate ganglion)
- Recurrent paresis
- Vessel puncture (external jugular vein, internal jugular vein, common carotid artery)
- Pneumothorax (rare)

Limits of the Method

The application of local anaesthetic into the more cranial area of the plexus will relatively frequently lead to incomplete analgesia of the supply area of the nerves arising from the more caudad region of the plexus (medial cord, ulnar nerve, cutaneous nerve of the arm, medial cutaneous nerve of the forearm). Neither can this be prevented by the administration of high doses of local anaesthetics. Hence, interscalene nerve blocks belong in the realm of shoulder surgery.

2.2 Infraclavicular vertical brachial plexus block

Problems that may arise with the axillary plexus block, such as incomplete dissemination of the anaesthesia (radial and musculocutaneous nerves), pain resulting from an Esmarch upper-arm tourniquet, as well as positioning difficulties (fractures, rheumatic patients) prompted us to look for an alternative means of access to the brachial plexus. The infraclavicular vertical brachial plexus block (VIP) was determined to be a procedure that is safe and low-risk, easy on the patient and simple for the anaesthesiologist to perform.

Anatomical landmarks

Jugular fossa, ventral apophysis of the acromion, infraclavicular fossa

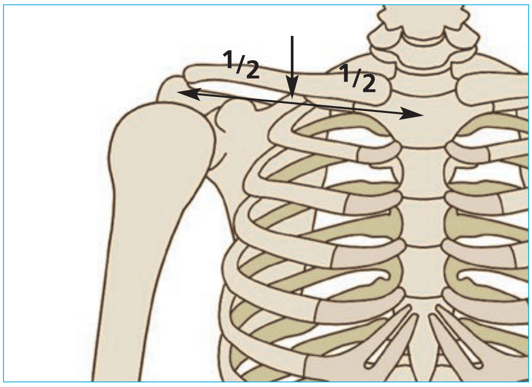


Fig. 16:
IVBP- Principal structures for orientation

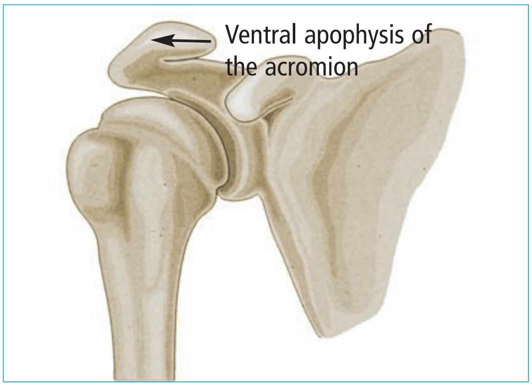


Fig. 17:
IVBP - Lateral limit

The point at which the plexus goes beneath the clavicle in the vicinity of the midclavicular line is important for determination of the puncture site. In dissected cadavers, the plexus lay at a maximum depth of 4 cm lateral to the axillary artery and vein, whereby its three cords were always joined at the entrance to the trigonum. For the definition of bone-based orientation points, a very good connection emerged between the halfway point of the ventral apophysis of the acromion and the jugular fossa. The puncture must be made directly beneath the clavicle and in a strictly vertical direction. Under these conditions, no injury of nerves, vessels or even of the pleura was to be found on the cadaver. Shifting of the puncture site in a medial direction creates the possibility of injuring the axillary vein or artery in a high percentage of cases. In the cadavers, faulty medial punctures would have resulted in injury to the pleura at a depth of > 6 cm, but the first rib provided relatively good protection.

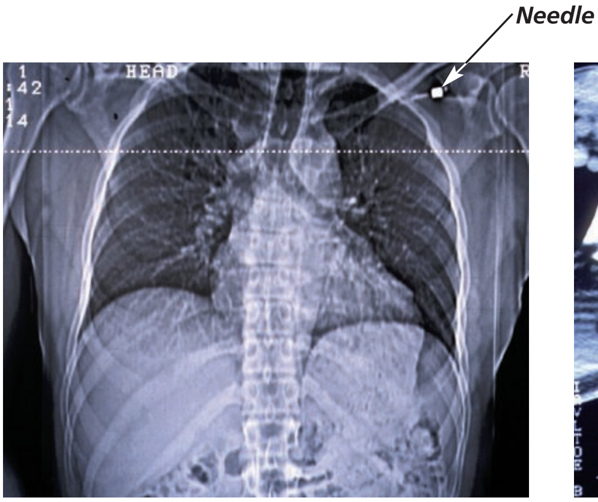


Fig. 18: VIP – Puncture site

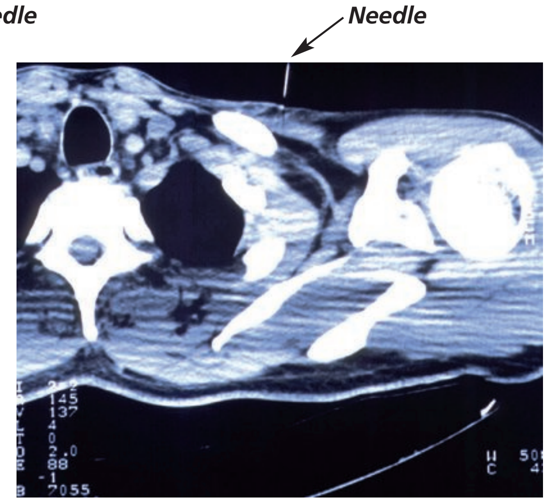


Fig. 19: VIP – Puncture channel

Block Technique

The patient is supine, with the hand of the side to be blocked positioned in a relaxed manner, preferably on the abdomen. This allows optimal observation of the peripheral muscle contractions. The puncture site is located in strict accordance with the anatomical findings, i. e. at the halfway point between the ventral apophysis of the acromion and the jugular fossa. The puncture site is checked by placing one's index finger in infraclavicular fossa. The measured puncture site must be located directly medial to the finger. The anticipated depth of the puncture can now be judged with a high degree of accuracy. To do so, the inferior edge of the clavicle is palpated and the distance to the surface measured. By adding 1 cm to the result, the puncture depth defines the point at which the first muscle response will be triggered. This technique has proven its merits, especially in very slim patients, whose plexus is located very close to the surface and who represent a risk group with regard to iatrogenic pneumothorax. Usually, primary segments of the lateral cord (contractions of the biceps brachii muscle) are stimulated. The desired motor response is the peripheral contractions of the finger muscles: extensors or flexors D I-III, i.e. muscles supplied by the radial or median nerve This response is achieved by retracting the needle into the subcutaneous tissue and re-advancing it more laterally in a perpendicular direction and around 0.5 cm deeper. Once the threshold current is reached, 40-50 ml of the local anaesthetic are injected. A complete blockade will develop within 5 to 15 minutes.

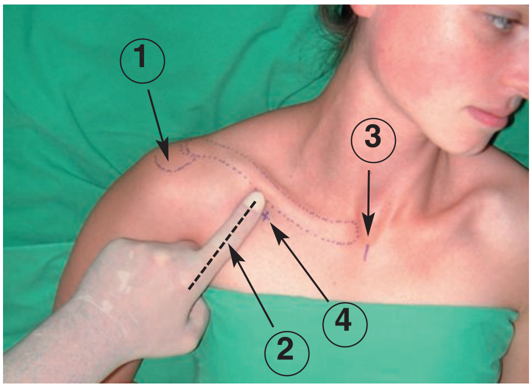


Fig. 20: VIP - Puncture site

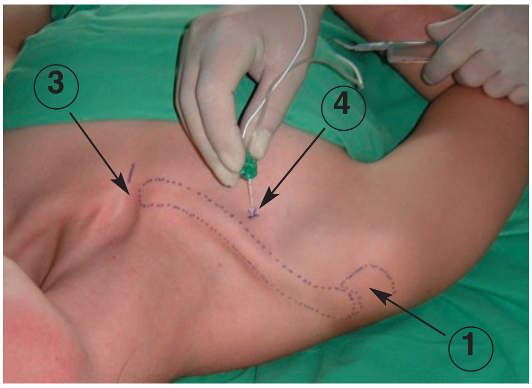


Fig. 21: VIP - Puncture technique

1. Ventral apophysis of the acromion
2. Infraclavicular fossa
3. Jugular fossa
4. Puncture site

Indications

Operative procedures in the region of the distal upper arm, on the forearm and the hand.

Contraindications

- Chest deformities
- Healed, but dislocated fracture of the clavicle
- When the puncture site cannot be defined with certainty

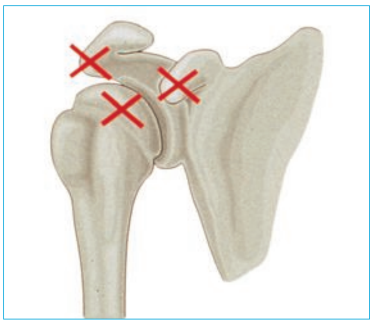
Side effects/complications of the infraclavicular vertical brachial plexus block

- Horner syndrome
- Vessel puncture (cephalic vein, subclavian artery and vein and their branches)
- Pneumothorax
- Phrenic nerve paresis (very rare)

Sources of error

Precise definition of the specified guide points is crucial for the success and safety of the blockade. In contrast to the jugular fossa, the exact localisation of the lateral point is occasionally more difficult. This point, however, is essential for accurate determination of the puncture site. A number of aids in localising this point have emerged in the course of routine clinical practice. Feeling the progress of the clavicle from medial to lateral leads to the acromioclavicular joint; this means the ventral apophysis of the acromion must be sought ventral and slightly lateral. Feeling the progress of the crest of the scapula leads to the acromion, meaning that the precise lateral guide point must be ventral from it. In order to rule out mistaken identification of part of the head of the humerus, passively move the patient's arm in the shoulder joint. At the same time, palpate the previously identified guide point, which must not move in conjunction with this manipulation. The coracoid is considerably more medial and may be clearly felt in most patients. The measurement must be started from exactly in the middle of the jugular fossa. The puncture must be performed absolutely perpendicular to the supporting surface at all levels. The distance from the clavicle must be kept small (however, painful contact with the periosteum should be avoided). The site is too medial if blood is aspirated during the puncture. If there is no stimulation response, the puncture site should be localised once again to be sure. If you arrive at the same result, then the puncture site should be shifted 0.5 to 1.0 cm laterally and the puncture performed once more with a vertical orientation. If this correction of the puncture site still does not produce the desired stimulation response, adjust the position 0.5 - 1 cm in a medial direction.

In the exceptional case that the puncture site cannot be defined with certainty, then another procedure should be used. Under no circumstances should one simply "poke about" or ever change from a vertical puncture direction.



Cardinal mistakes:
Puncture site too medial
Puncture depth > 6 cm
Medial puncture direction

BEWARE: Astheniker
Very slim persons

Fig. 22: Sources of error and risks

Advantages of the infraclavicular vertical brachial plexus block

- Clearly defined guide points - clearly defined puncture direction
- Simple to learn - high success rate
- No anaesthetic gaps resulting from the procedure
- No problems with the Esmarch tourniquet
- Comfortable positioning of the patient

2.3 Axillary nerve block (according to de Jong)

The classical axillary blockade of the brachial plexus is performed in an area in which cords have already formed the peripheral nerves of the arm. The axillary nerve and musculocutaneous nerve (which contains the fibres of the lateral cutaneous nerve of the forearm) emerge from the plexus above the puncture site. This is one reason why troublesome gaps can occur in the radial lower and upper arm. Despite this, the axillary nerve block is a widespread technique because it is simple to use and has few complications.

Anatomical landmarks

Axilla, axillary artery, medial bicipital groove, pectoralis major muscle, coracobrachialis muscle

Fig. 23:
Axillary nerve block - Puncture site

Fig. 24:
Axillary nerve block -Puncture technique

Block technique

With the patient lying supine, the arm to be blocked is abducted 90° at the most and should be positioned on a cushioned surface (e.g. arm table) in a relaxed manner.

The course of the axillary artery of the medial upper arm can be palpated dorsad from the medial bicipital groove. The puncture site is located slightly above the axillary artery, at the highest point in axilla and slightly beneath the pectoralis major muscle which borders the axilla to the ventral.

After disinfection and local anaesthetising of the puncture site with 1% mepivacaine, the stimulation needle is inserted parallel to the axillary artery at a 30°-angle to the skin. Contractions are sought in the area of the median nerve, or even better, of the radial nerve. Once the threshold current is reached, 40-50 ml of the local anaesthetic are injected. Under no circumstances should the anaesthetic be injected if the musculocutaneous nerve has been stimulated, since at this height it has already left the neurovascular sheath and runs within the coracobrachialis muscle.

Indications

All procedures on the elbow, forearm and hand.

Contraindications

There are no specific contraindications for the axillary block of the brachial plexus. The general contraindications apply that will be summarised at the end of this chapter.

Side effects/complications

There are no specific side effects of the axillary block of the brachial plexus. The general side effects apply that will be summarised at the end of this chapter.

Summary

Advantages of axillary brachial plexus block

The method is simple and low-risk and can be performed with or without the nerve stimulator.

Disadvantages of axillary brachial plexus block

A high upper arm tourniquet may be poorly tolerated because the medial upper arm is supplied by the intercostobrachialis nerves (Th2) and the lateral upper arm by the axillary nerve (which is usually not blocked). Frequent gaps in the area of the musculocutaneous nerve and the radial nerve are another disadvantage. These technique-related weaknesses can be compensated by carrying out secondary peripheral blocks of isolated nerves.

2.4 Suprascapular nerve block (according to Meier)

A very effective and easy-to-perform technique for the selective, complete anaesthesia of the suprascapular nerve where it emerges through the scapular notch on the floor of the supraspinous fossa. This nerve does not supply its own skin region, but innervates the infraspinatus / supraspinatus muscles and essential portions of the capsule and ligaments in the shoulder joint. This block is thus very well suited for conservative physiotherapeutic management of frozen shoulder syndromes or for analgesia secondary to shoulder surgery. We describe the technique according to Meier, which virtually eliminates the potential complication of pneumothorax.

Anatomical landmarks

Scapular spine

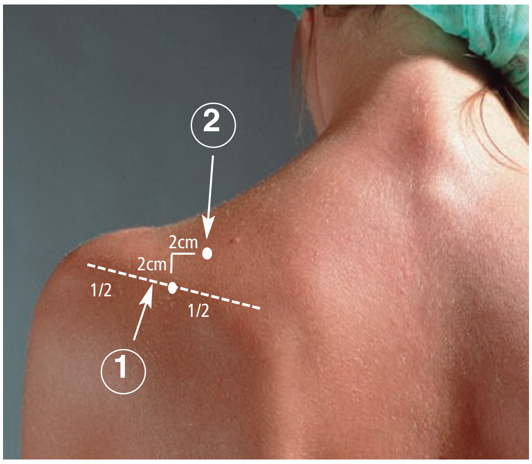


Fig. 25: Suprascapular nerve block - Puncture site

1. Scapular spine
2. Puncture site

Fig. 26: Suprascapular nerve block - Puncture technique

Block technique

The patient is seated, their head hanging forward; they place their hand of the side to be blocked on their contralateral shoulder. The scapula is thereby lifted up from the dorsal chest wall, making the spine of scapula easy to palpate. The medial and lateral edges of the spine are marked and the connecting line between the two points is halved. The puncture site is marked about 2 cm cranially and 2 cm laterally from this point.

After disinfection and infiltration of the puncture channel, the stimulation needle is advanced at an angle of approximately 45-60° in the caudolateral direction towards the humerus head. The desired stimulatory response constitutes a slight abduction and outward rotation of the shoulder joint. Once the threshold electrical current is achieved, 15 –20 ml of local anaesthetic are injected. If sufficient stimulation cannot be achieved, the local anaesthetic can also be injected into the floor of the supraspinous fossa since these muscle contractions are not imperative for the success of the nerve block.

Indications

Pain and physiotherapy of frozen shoulder syndromes, analgesia after shoulder surgery, completion of an incomplete interscalene block

Contraindications

No specific

Side effects/complications

No specific

Blocks of the lower extremity

Introduction

Two large nerve trunks are responsible for supplying the legs: the femoral nerve, the obturator nerve and the lateral femoral cutaneous nerve arising from the lumbar plexus and the sciatic nerve and the posterior femoral cutaneous nerve from the sacral plexus. Thus, it is always necessary to block both nerve trunks to achieve complete anaesthesia of the leg. There are various ways to access the branches of the lumbar plexus and to the sciatic nerve that we will discuss in the following.

3.1 Psoas block

The posterior approach to the lumbar plexus, first described by Chayen et al. in 1976, is called the psoas compartment block. The knowledge gained since that time now shows that such a type of delineable compartment "sandwiched" between the psoas muscle with its distribution of branching nerves does not exist as such; but rather an "unorderly arrangement" of fibres of the lumbar plexus (including the lateral femoral cutaneous nerve and the femoral nerve in particular) runs between the layers of the psoas muscle, but also caudad between the psoas muscle and the quadratus lumborum muscle. Analogous to the brachial plexus block near the clavicle, the three nerves of the lumbar plexus that are important for neural supply to the lower extremity (femoral nerve, lateral femoral cutaneous nerve, obturator nerve) are located very closely together. This means that a single injection at this site is sufficient to anaesthetise all three nerves completely. Moreover, partial anaesthesia of the lumbosacral trunk can occasionally be expected. However, this effect does not usually mean that one can forego the additional block of the sciatic nerve.

Anatomical landmarks

Spinous process of the 4th lumbar vertebra, posterior superior iliac spine

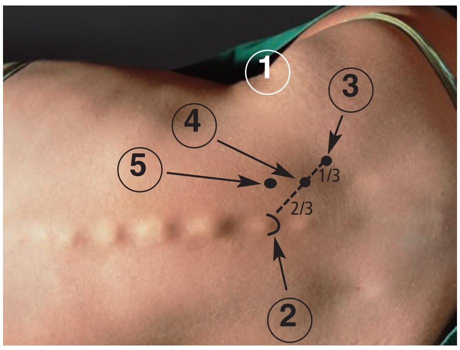


Fig. 27:
Psoas block - Puncture site

1. Iliac crest
2. Spinous process of L4
3. Posterior superior iliac spine
4. Puncture site
5. Puncture site: alternative access

Fig. 28:
Psoas block - Dissection on the cadaver

Block technique

The patient is placed in the flexed lateral recumbent position, similar to that used in spinal anaesthesia, with the legs bent and with the leg to be blocked uppermost. The landmarks include the spinous process of the 4th lumbar vertebra (L4) and the posterior superior iliac spine, which are marked. The puncture site is located along the connecting line between the landmarks at the transition from the medial to the lateral third. Following skin disinfection and infiltration of the puncture channel, the electronic stimulation needle is advanced with a strictly sagittal orientation. In the event of bone contact with the transverse process of the 5th lumbar vertebra (L5), the puncture direction should be corrected in a cranial direction so as to pass over the transverse process. The femoral nerve is reached by continuing to advance the needle by 1 – 2 cm. Contractions of the femoral quadriceps muscle show that the needle is in the direct vicinity of the nerve. Once a threshold current of 0.2 -0.3 mA is reached, a test dosage of the local anaesthetic is injected. This is done in order to rule out an intravascular or intraspinal position of the needle. If no adverse effect is noted after 1 to 2 minutes, then the remainder of the dosage may be administered.
An alternative puncture technique similarly starts by locating the spinous process of the L4; the puncture is at the same level, but now at distance of approx. 4 cm to the lateral. During puncture, the aim is to achieve contact with the transverse process L 4. Once this is accomplished, the direction of puncture must be corrected caudad under the transverse process. In both cases, the femoral nerve is reached at approximately the same place, but approached at different angles. The latter method sets up a more favourable situation for the catheter technique.

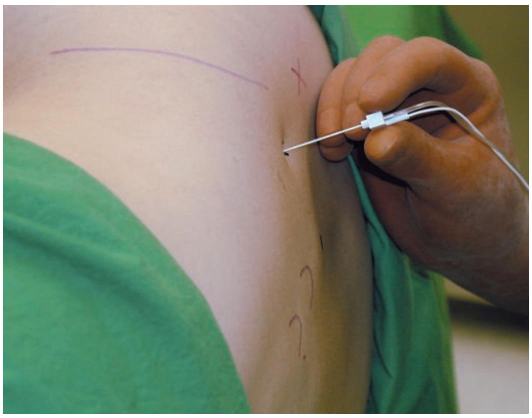


Fig. 29:
Psoas block - Puncture technique

Indications

Operations on a lower extremity distal to the hip, in combination with a proximal sciatic nerve block. Particularly suited for complex operations on the knee joint or operations using a tourniquet in the inguinal region.

The catheter technique is particularly suited for operations known to have high postoperative analgesia requirements, e.g., cruciate ligament grafting, synovectomies, and knee joint replacements.

Contraindications

Coagulation disorders; the same rules apply as with as procedures performed close to the spinal cord. General contraindications are listed at the end of this chapter.

Side effects/complications of the psoas block

Atypical (epidural anaesthesia-like) bilateral blockade

Intrathecal injection with high bilateral dissemination of anaesthesia

3.2 Femoral nerve block

In contrast to the psoas compartment block, the femoral nerve block is a caudad, ventral approach to parts of the lumbar plexus. The technique described here is often called the 3-in-1 block. This name derives from the fact that one injection blocks three nerves (femoral, obturator and lateral femoral cutaneous). However, our own clinical studies suggest that the sensory supply to the thigh is primarily provided by the femoral nerve or its cutaneous branches. It has additionally become widely accepted that, even though an inguinal femoral nerve block can block the lateral femoral cutaneous nerve when an adequate volume of local anaesthetic is injected, but, due to the subfascial dissemination to the lateral, the obturator nerve cannot be blocked. Insurmountable anatomical barriers (including the iliopsoas muscle among others) counteract the simultaneous spread of the local anaesthetic to the mediodorsal.

The areas of the lateral femoral cutaneous nerve and the obturator nerve show much variation. Moreover, they are usually not clinically demonstrable as independent supply areas. Neither is there is verified evidence on the supply areas of the obturator nerve in the region of the medial condyle of the femur and the tibial region of the knee joint.

Anatomical landmarks

Anterior superior iliac spine, pubic tubercle, inguinal ligament, femoral artery, inguinal fold

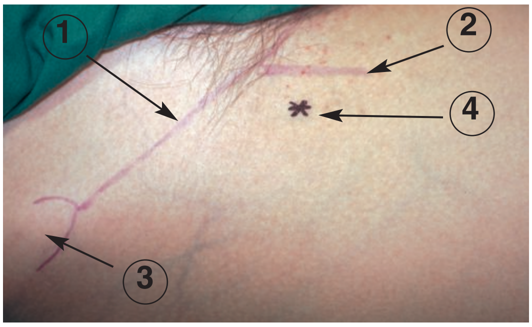


Fig. 30: Femoral nerve block - Puncture site

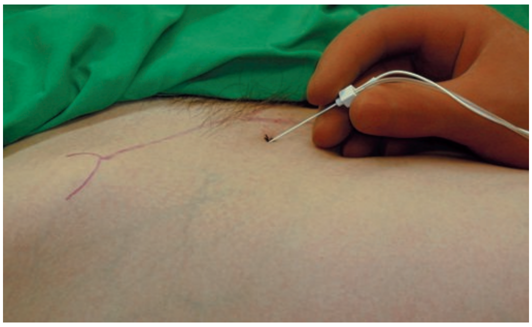


Fig. 31: Femoral nerve block - Puncture technique

1. Inguinal ligament 2. Femoral artery 3. Anterior superior iliac spine 4. Puncture site

Block technique

The patient lies on his back with legs spread slightly apart. The foot of the leg to be anaesthetised should be turned loosely to the outside.

The puncture site is located approximately in the region of the inguinal fold, 1.5 cm lateral of the femoral artery, approx. 2-3 cm below the inguinal ligament (**IVAN** = **I**nner **V**ein **A**rtery **N**erve). Local anaesthesia is only injected superficially with 0.5 of 1% mepivacaine so as not to block the femoral nerve and to impede stimulation. The stimulation needle (Stimuplex® D 50 mm) is inserted at an angle of approx. 30° to the skin and advanced in a cranial direction. After reaching a depth of around 2-4 cm, the femoral nerve is encountered. Contractions of the quadriceps femoris muscle signal the direct proximity to the nerve. Stimulation of the rectus muscle of the thigh is crucial for the block to be effective. The kneecap must "dance". Contractions of the sartorius muscle are usually not sufficient. In the femoral nerve block, it is particularly important to conduct the aspiration test carefully when injecting the local anaesthetic. Place a finger beneath the puncture site for compression to prevent the local anaesthetic from flowing in the distal direction and to promote its dissemination in the cranial direction. The latter can also be supported by lifting up the leg.

Indications

In combination with a proximal sciatic nerve block, the femoral nerve block is indicated in all diagnostic and operative procedures on the lower extremities, also with expected application of a tourniquet at the thigh for up to one hour.

In isolation, the femoral nerve block can be used for analgesia in fractures of the neck of the femur (and thus preparation for spinal conduction anaesthesia), for operations on the ventral, medial and lateral thigh (e.g. muscle biopsies) without the use of a tourniquet.

This type of block is less well suited for complex surgical interventions on the knee, such as ligament reconstructions or TKA.

Contraindications

There are no specific contraindications for the femoral nerve block. The general contraindications that apply are listed at the end of this chapter.

Side effects/complications

There are no specific side effects of the femoral nerve block. The general side effects associated with this block are listed at the end of the chapter.

3.3 Saphenous nerve block

Anatomical landmarks

Superior edge of the patella, vastus medialis and sartorius muscles.

Alternatively: tibial tuberosity, medial head of the gastrocnemius muscle, Achilles' tendon

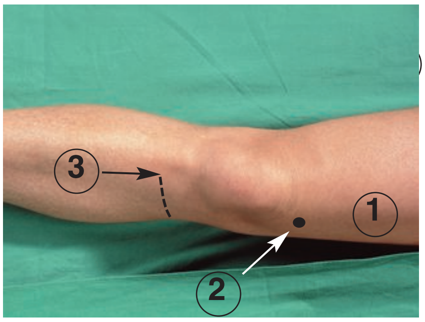


Fig. 32: Saphenous nerve block - Puncture technique

1. Sartorius muscle
2. Puncture site
3. Alternatively: subcutaneous infiltration

Block technique

By palpation, the compartment between the vastus medialis and sartorius muscles is identified about 2 – 4 cm above and medial to the patella. Here, the stimulation needle is inserted perpendicular to the table until it reaches the subsartorial fatty tissue. At a pulse duration of 1.0 ms, electrical paraesthesias can be elicited from a cooperative patient. The amplitude is reduced accordingly to between 0.3 and 0.5 mA, and 10 to 15 ml of local anaesthetic are injected. In many cases, the saphenous nerve is still accompanied by a muscular branch of the femoral nerve which innervates the vastus medialis muscle. In such cases, a motor stimulatory response from the vastus medialis muscle can be judged as successful. A catheter can be placed without any trouble.

As an alternative technique that does not require cooperation from the patient, subcutaneous infiltration can be carried out from the medial head of the gastrocnemius up to the tibial tuberosity. In general, this infiltration technique is possible in every level of the medial lower leg. Infiltration is performed in the distal part of the Achilles' tendon towards the anterior edge of the tibia.

Indications

Pain management, completion of a sciatic nerve block, when the medial side of the lower leg is also located within the surgical field.

Contraindications

No specific

Side effects/Complications

No specific

3.4 Obturator nerve block

Anatomical landmarks

Proximal sinewy insertion of the long adductor muscle, femoral artery, anterior superior iliac spine, pubic tubercle

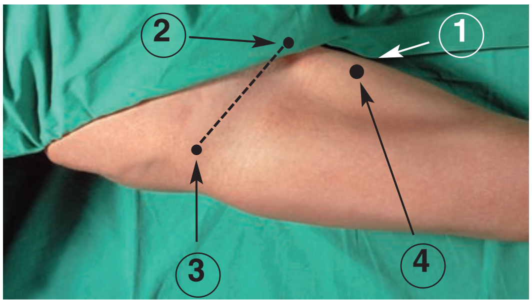


Fig. 33: Obturator nerve block - Puncture site

1. Long adductor muscle
2. Pubic tubercle
3. Anterior superior iliac spine
4. Puncture site

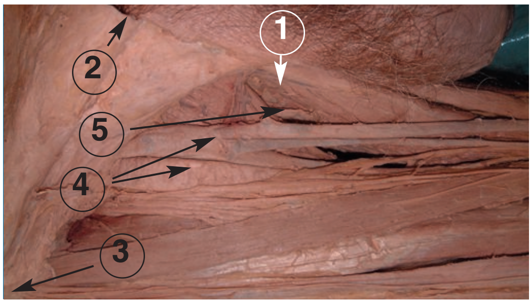


Fig. 34: Obturator nerve block - Anatomy

1. Long adductor muscle
2. Pubic tubercle
3. Anterior superior iliac spine
4. Femoral artery and vein
5. Obturator nerve

Block technique

With the patient's leg rotated outwardly and abducted slightly, the sinewy origin of the long adductor muscle is felt. The puncture site is located 5 –10 cm beneath the pubic tubercle directly lateral to the tendon of the long adductor muscle. The needle is inserted in the craniolateral direction at an approx. 45° angle dorsal to the table pointing towards the anterior superior iliac spine. At a puncture depth of 4-6 cm, the anterior branch of the obturator nerve is reached and stimulus responses are visible from the adductor group. The amplitude is reduced in steps down to the threshold electrical current. Following a negative aspiration test, 10 – 15 ml of local anaesthetic are injected. Allow a reasonable period of approx. 10 – 15 min. for the anaesthetic to take effect. If an adequate adductor paresis is not achieved within this time, the patient presumably has an accessory obturator nerve that runs along with the femoral nerve through the lacuna musculorum. In such cases it is necessary to perform an additional femoral nerve block.

Indications

Pain management, adjunct to femoral nerve blocks for postoperative medial knee joint pain, Suppression of the adductor reflex for transurethral lateral bladder wall resection, treatment of adductor spasms

Contraindications

No specific

Side effects/complications

Vessel puncture (obturator artery or vein)

3.5 Proximal sciatic nerve blocks

Proximal sciatic nerve blocks target the nerve where it emerges from the lower pelvis. Here, various means of access are possible. In most patients, the two branches of the sciatic nerve – the tibial nerve and the common peroneal nerve – are still united in the gluteal region or, at least, are located very close together. It is also of clinical relevance that proximal sciatic nerve blocks reach the posterior femoral cutaneous nerve. For that reason, to achieve full analgesia of the leg, it is sensible to combine the proximal sciatic nerve block with a lumbar plexus block (psoas or femoral).

Parasacral approach (according to Mansour)

Anatomical landmarks

Posterior superior iliac spine, ischial tuberosity, (greater trochanter)

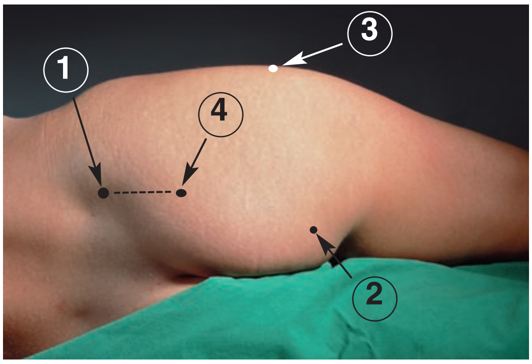


Fig. 35: Parasacral access

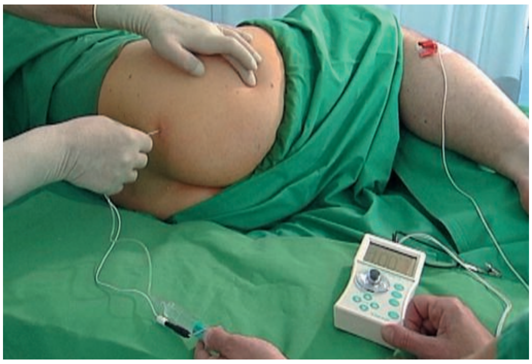


Fig. 36: Puncture technique

1. Posterior superior iliac spine
2. Ischial tuberosity
3. Greater trochanter
4. Puncture site

Block technique

The parasacral block targets the sciatic nerve at its most proximal point where it induces fast and full anaesthesia. The block is performed with the patient seated or in the lateral recumbent position. We prefer the lateral recumbent position, given that, in combination with the psoas compartment block, the technique is especially suited for complex surgical interventions on the leg, and avoids the inconvenience of repositioning and re-draping of the patient between the two procedures. The side to be blocked is upward, the lumbar spine shows a kyphosis and the hip flexed to facilitate orientation. The posterior superior iliac spine and the ischial tuberosity are marked. From the posterior superior iliac spine, the palpating finger follows the tuberosity until no more bony structures are encountered. Here, approximately 5 – 7 cm caudad to the posterior superior iliac spine, the puncture site is marked. After disinfection and deep infiltration of the puncture channel, a stimulation needle of 80 –120 mm in length is advanced sagittally in the direction of the tuberosity until a stimulatory response is elicited from the peroneal or tibial part of the sciatic nerve.

The amplitude is reduced accordingly down to the threshold current and 20 to 40 ml of local anaesthetic are injected. If no primary stimulatory response is achieved or bony resistance encountered, the insertion direction is corrected to the caudolateral (around to midline between greater trochanter and ischial tuberosity). Here, there will be no problems placing an indwelling catheter. Whilst contractions of the gluteal muscles are of no value, a stimulation of the ischiocrural muscle group is a promising response.

Indications

Surgical interventions on the dorsal thigh, lower leg (not in the supply area of the saphenous nerve), whole foot, pain management. In combination with psoas compartment block/femoral nerve block for operations on the whole leg below the hip.

Contraindications

No specific

Side effects/complications

Vessel puncture (inferior gluteal artery)

Transgluteal approach (according to Labat)

Anatomical landmarks

Posterior superior iliac spine, greater trochanter, sacral hiatus, ischial tuberosity

Abb. 37: Transglutaealer Zugang - Lagerung

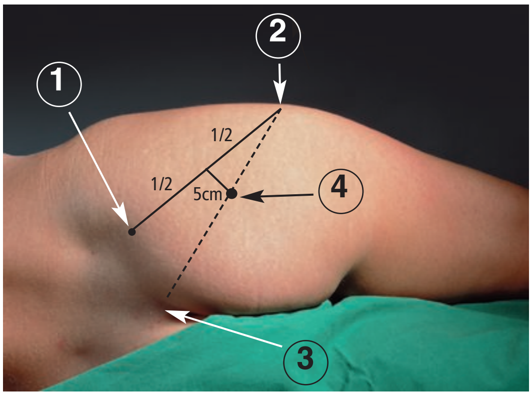


Fig. 38: Transgluteal approach - Puncture site

1. Posterior superior iliac spine
2. Greater trochanter
3. Sacral hiatus
4. Puncture site

Block technique

The patient is placed in the lateral recumbent position, with the leg to be blocked uppermost. The other leg is extended. The upper leg is bent approx. 30-40º at the hip joint and approx. 90º at the knee joint. The upper knee should rest on the table. The uppermost foot must not be "hooked behind" the calf of the bottom leg.

In this position, the greater trochanter and the posterior superior iliac spine at the dorsal end of the iliac crest should be identified by touch and a mark is made at each point. A line is drawn perpendicularly from the mid-point of the line connecting these two marked points to the medial and the puncture site is marked at a point 4 to 5 cm along this line. To check this location, the connecting line between the greater trochanter and the sacral hiatus is halved. As a rule, this point is the same or in the direct vicinity as the previously marked puncture site.

After disinfection and local anaesthetising of the puncture site, a puncture perpendicular to the skin surface is made with the stimulation needle (Stimuplex® D, 80 mm). Advancing the needle results at first in contractions of the gluteal musculature by means of direct stimulation. Upon bone contact, the needle should be withdrawn and advanced after correcting the direction. Contact with the sciatic nerve is encountered at a depth of 5 to 8 cm. Contractions of the calf musculature with plantar or dorsal flexion of the foot are triggered until a stimulation current of 0.2 – 0.3 mA is reached.

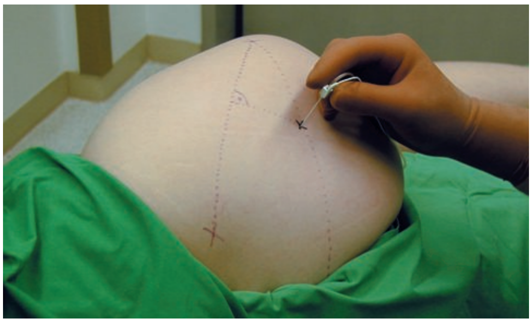


Fig. 39: Transgluteal approach
- Puncture technique

Indications

Surgical interventions on the dorsal thigh, lower leg (not in the supply area of the saphenous nerve), whole foot, pain management. In combination with psoas compartment block/femoral nerve block for operations on the whole leg below the hip.

Contraindications

No specific

Side effects/complications

Vessel puncture (inferior gluteal artery)

Anterior approach (according to Meier)

The anterior approach to the sciatic nerve is advantageous in patients who cannot be reasonably placed in the lateral recumbent position due to pain or their condition.

Anatomical landmarks

Posterior superior iliac spine, symphysis, greater trochanter

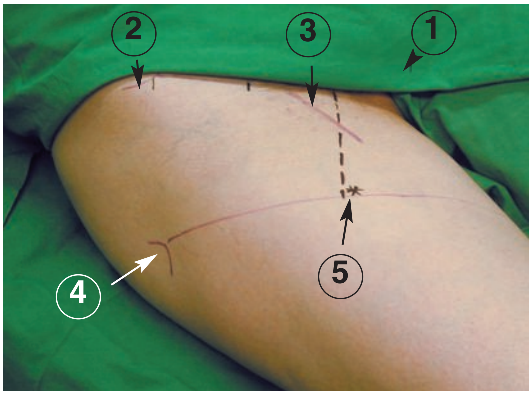


Fig. 40: Anterior approach
- Puncture site

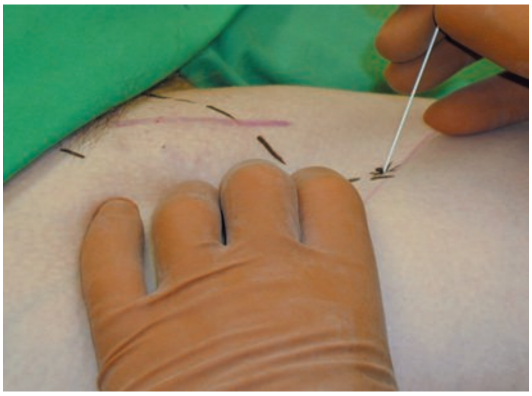


Fig. 41: Anterior approach
- Puncture technique

1. Symphysis
2. Anterior superior iliac spine
3. Femoral artery
4. Greater trochanter
5. Puncture site

Block technique

The patient is supine on his back, with the leg in a neutral position, not rotated outwardly like in the femoral nerve block. The line connecting the anterior superior iliac spine and the symphysis is marked. A parallel to this line is drawn to the greater trochanter.

The length of the first line (between the anterior superior iliac spine and the symphysis) is divided into thirds. A perpendicular line is drawn from the medial third point to the distal. This perpendicular line intersects the second guideline. This puncture is made at the point of intersection.

Use finger of one hand to feel along the muscle compartment between the rectus femoris muscle and the vastus medialis and/or the sartorius muscle, taking the femur as a counter point. By doing so, the neurovascular bundle is forced to the medial. The puncture is made lateral to this, thereby minimising the risk of hitting a vessel. Insert the stimulation needle (Stimuplex® D 120 mm) into the skin at a 75-85° angle, guiding it in a dorsocranial direction. Stimulation of parts of the femoral nerve is possible in the superficial areas. At a depth of 6-10 cm, you reach the dorsal thigh compartment. The sciatic nerve is encountered by advancing the needle a bit further. The tip of the needle is positioned correctly when plantar flexion (tibial part) and dorsal flexion (peroneal part) are elicited.

Indications

Surgical interventions on the dorsal thigh, lower leg (not in the supply area of the saphenous nerve), whole foot, pain management. In combination with psoas block/femoral nerve block for operations on the whole leg below the hip.

Contraindications

No specific

Side effects/complications

Vessel puncture (femoral artery, profunda femoris artery)

Neural injury (femoral nerve or its branches)

Subtrochanteric approach (according to Guardini)

As with the anterior approach to the sciatic nerve, the subtrochanteric approach offers the advantage that it does not require painful repositioning of the patient, for example secondary to trauma or fractures. Another even greater advantage over the anterior approach, we believe, is the low puncture depth into the nerves and the fact that no vulnerable structures are located in or along the puncture channel.

Anatomical landmarks

Greater trochanter, ischial tuberosity

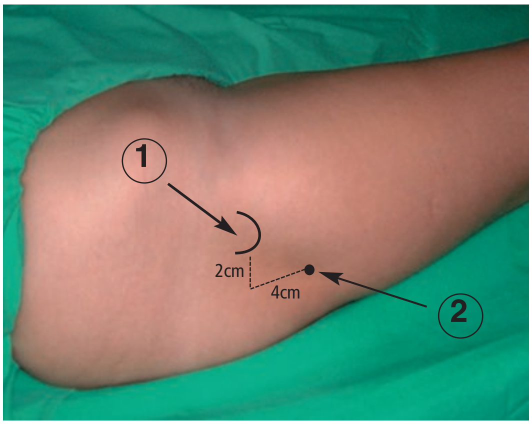


Fig. 42: Subtrochanteric approach - Puncture site

1. Greater trochanter
2. Puncture site

Fig. 43: Subtrochanteric approach - Puncture technique

Block technique

The patient is supine, with the leg in a neutral position or rotated slightly inwards. Padding placed under the lower leg and pelvis helps facilitate puncture, but is not imperative. By passive rotation of the hip joint, it is possible to palpate and mark the greater trochanter, even in adipose patients. The puncture site is located approx. 2 cm inferior and 4 cm distal to the greater trochanter. The direction of insertion is horizontal and slightly cranial to the ischial tuberosity. Needles of between 80 and 120 mm in length are employed. The anticipated distance to the nerve can usually be judged very accurately in advance by measuring the horizontal distance from the greater trochanter to the sartorius muscle compartment. If the femur is encountered during puncture, the insertion point must be changed to the dorsal. Should stimulation at a reasonable depth fail to achieve the desired response, a correction of the insertion direction a little to the ventral will often help along with shifting the accentuation of inward rotation of the hip. Placement of a pain catheter should pose no problems.

Alternative technique

The leg to be anaesthetised is placed on the table with the knee bend. About 2 – 3 cm distal to the midpoint between greater trochanter and ischial tuberosity is where the puncture site is marked. The insertion is now made in the cranial and slightly medial direction.

Indications

Surgical interventions on the dorsal thigh, lower leg (not in the supply area of the saphenous nerve), whole foot, pain management. In combination with psoas block/femoral nerve block for operations on the whole leg below the hip.

Contraindications

Relative: Status secondary to total ipsilateral hip replacement

Side effects/complications

No specific

Indications for proximal sciatic blocks

In combination with a femoral nerve block or psoas block:

The proximal sciatic block is indicated in operations on the lower extremity, also with application of a tourniquet at the thigh.

Isolated proximal sciatic nerve block (rare):

Surgical interventions on the lower leg and foot (not in the supply area of the saphenous nerve).

The catheter technique (proximal sciatic catheter) is especially suited for operations known to have high postoperative analgesia requirements, such as revision osteotomies of the toes, synovectomies of the foot, amputations of the toes and anterior foot.

Contraindications

There are no specific contraindications for proximal sciatic blocks. The general contraindications that apply are listed at the end of this chapter.

Side effects/complications

There are no specific side effects of the proximal sciatic blocks. The general side effects associated with this technique are summarised at the end of the chapter.

3.6 Distal sciatic nerve blocks

Distal sciatic nerve blocks reach the sciatic nerve in a region where the courses of the tibial and common peroneal nerves are still so close together that they can be reached reliably with one puncture.

Lateral distal approach

Anatomical landmarks

Superior edge of the patella, vastus lateralis muscle, long head of the biceps femoris muscle

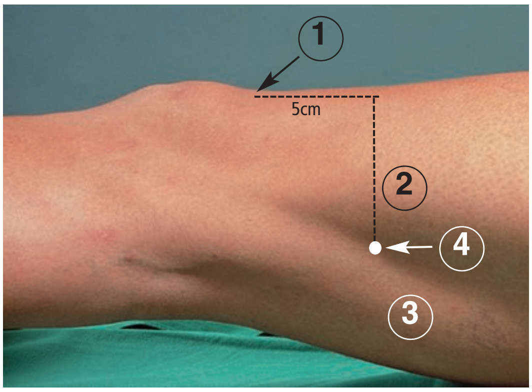


Fig. 44:
Distal sciatic nerve block - Puncture site

Fig. 45:
Distal sciatic nerve block - Puncture technique

1. Patellar crest
2. Vastus lateralis muscle
3. Long head of the biceps femoris muscle
4. Puncture site

Block technique

This technique affords a block of the sciatic nerve just superior to its bifurcation without any complicated positioning. The patient is supine on his back, with the leg in a neutral position; padding is placed distally under the lower leg to allow the knee to hang suspended. The compartment between the vastus lateralis muscle and the sinewy part of the biceps femoris muscle is identified by palpation approx. 5 cm (3 – 8 cm) above the patella. This site is marked. A needle of 50 mm in length is usually sufficient for puncture. The insertion direction points 30° dorsally and 5 – 10° cranially. Again, the positive stimulatory response is elicited from muscles on the lower leg or foot innervated by the peroneal or tibial nerves. Once the threshold electrical current is reached, 30 – 50 ml of local anaesthetic are injected. Compared to the proximal sciatic nerve blocks, onset of action is significantly longer, between 20 – 40 min. A pain catheter can be positioned easily.
Under certain circumstances, it may be helpful for localizing the muscle compartment to actively tense the ventral and dorsal thigh muscles against resistance. One common error is made by searching for the nerve too ventrally and too deeply. (The nerve's position is always more superficial and dorsal than one thinks).

Indications

Surgical interventions on the lower leg (not in the supply area of the saphenous nerve), whole foot, pain management. In combination with saphenous nerve block/femoral nerve block for operations on the whole lower leg.

Contraindications

No specific

Side effects/complications

No specific

Distal dorsal approach

Anatomical landmarks

Popliteal fossa between the semitendinosus muscle and biceps femoris muscle, medial epicondyle of femur and the lateral epicondyle of femur, popliteal artery

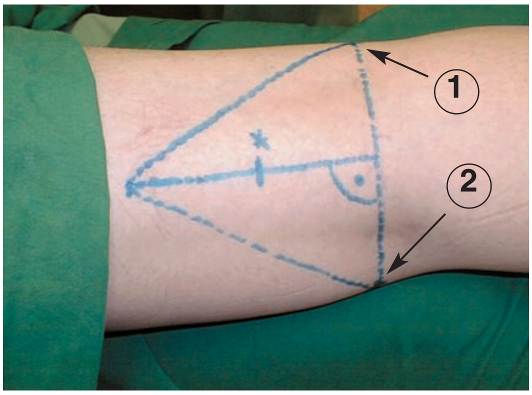


Fig. 46:
Distal sciatic nerve block - Puncture site

1. Lateral 2. Medial

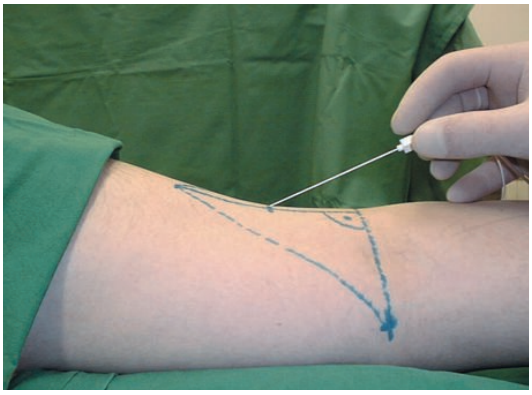


Fig. 47:
Distal sciatic nerve block – Puncture technique

Block technique

The patient is either in the prone position or lying on the side that is not to be anaesthetised. The upper leg must then be well extended.

With the patient in one of these positions, the popliteal fossa is first identified and then demarcated medial to the semitendinosus muscle and lateral to the biceps femoris muscle. Drawing an isosceles triangle between the medial and lateral condyles of the femur with its tip pointing in the cranial direction can help you find the median line through the popliteal fossa. The puncture site is located 5 – 8 cm cranial from the base of this triangle and about 1 cm lateral of the median line. The puncture site is located approximately 1 cm lateral of the site where the popliteal artery is palpable.

After disinfection and infiltration of the puncture site, insert the stimulation needle (Stimuplex® D 50 mm or 80 mm) and advance it in the cranial direction at a flat angle to the skin (approx. 30°). At a depth of about 3 – 5 cm, muscle contractions are triggered in the supply area of the peroneal nerve or the tibial nerve.

Indications

Operations on the lower leg, ankle and foot (additional block of the saphenous nerve may be necessary).
Distal sciatic catheter for (postoperative) pain therapy, e.g. following amputations of toes or anterior foot, and to achieve a sympatholytic effect.

Contraindications

There are no specific contraindications for distal sciatic blocks. The general contraindications that are applicable are listed at the end of this chapter.

Side effects/complications

There are no specific side effects of distal sciatic blocks. The general side effects associated with this block are listed at the end of the chapter.

General side effects and contraindications for the aforementioned types of block

Side effects

- Infection, haematoma or nerve lesion in the vicinity of the puncture site
- Intoxication (central nervous and/or cardiovascular complications) secondary to intravasal injection
- Methaemoglobinaemia when using prilocaine
- Allergy (extremely rare)

Absolute contraindications

- Infection or haematoma in the vicinity of the puncture site
- Lesion of the nerves to be stimulated distal to the puncture site
- Refusal of the procedure by the patient

Relative contraindications

- Neurological deficit of the leg to be anaesthetised
- Peripheral nerve block is possible upon careful diagnosis of the neurological status prior to the block

Catheter Technique in Peripheral Regional Anaesthesia

Chapter 5

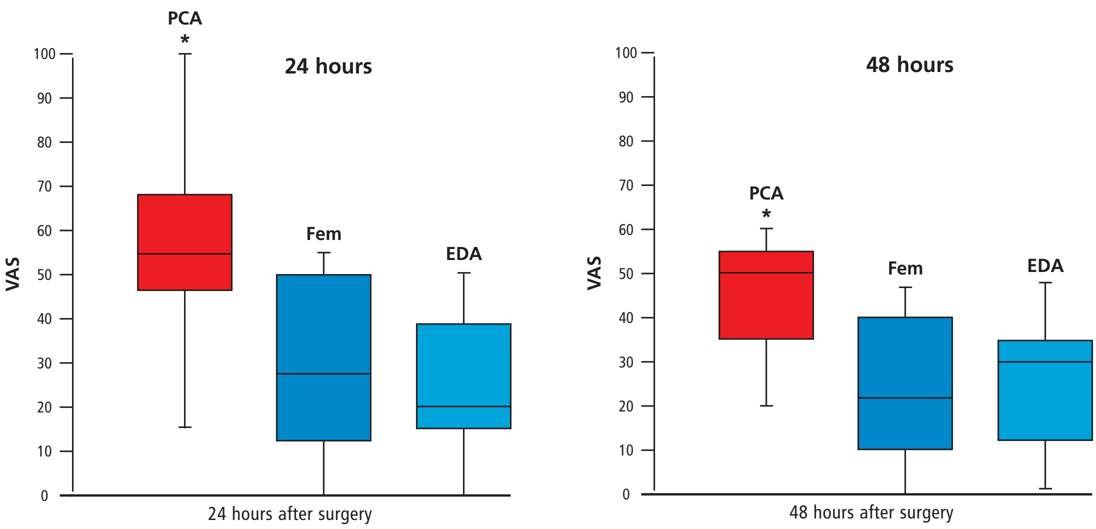
Introduction

Back in 1946, Ansbro described a technique for continuous nerve block to achieve postoperative analgesia of the brachial plexus. However, it was not until the mid 1970's that the development of suitable local anaesthetics and appropriate catheter materials led to the increased use of catheter techniques in various peripheral nerve blocks.

The clinically established catheter procedures are those performed close to the spinal cord. By comparison, peripheral catheter techniques play a more subordinate role. A survey on catheter-based postoperative analgesia conducted by Lehmann found that lumbar and thoracic epidural and spinal catheters were used at a frequency of 85%, plexus catheters 11.5% of the time and other procedures like intercostal, interpleural catheters and femoral nerve catheters were only used in 3.5% of the cases.

The advantages of the regional anaesthesia in our increasingly older and multimorbid patients should encourage us to turn to the use of regional methods of anaesthesia whenever possible. At the same time, safety and comfort aspects, such as fasting, PONV (postoperative nausea and vomiting), and freedom from postoperative pain are equally of significance. Especially for pain management after surgery on the lower extremity, continuous peripheral nerve blocks (PNB) show the same efficacy as the EDA, with a low risk profile and high degree of comfort for the patient. The prerequisites for a high acceptance of regional anaesthesia procedures among patients, surgeons and anaesthesiologists are optimally pain-free puncturing, quick location of nerves, a high rate of success, good operating theatre conditions (motoric block), long-acting postoperative analgesia, few side effects, rare and readily managed complications.

Mobilisation Pain - Comparison of systemic and regional analgesia



* p < 0.01 vs. Fem and EDA

Fem = continuous block of the femoral nerve

Modified according to Capdevila, X. et al. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. Anesthesiology 1999; 91: 8-15.

5.1 Indications for catheter use

- Continuous regional analgesia
- Acute pain therapy (postoperative)
- Management of chronic pain (CRPS)
- Supportive adjunct to physiotherapy/exercise therapy
- Sympatholysis (for improving wound healing)
- Preventive analgesia (phantom pain prophylaxis)

5.2 Possible catheter techniques

In principle, a pain catheter can be used together with all of the blocks described in this tutorial.

For all procedures, the catheter is equipped with a connector and bacteria filter, fixated using bandage strips and covered with a sterile dressing. Before attaching the filter, an aspiration test must rule out any intravasal positioning of the catheter.

Fig. 48

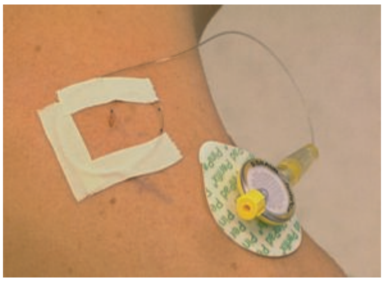


Fig. 49

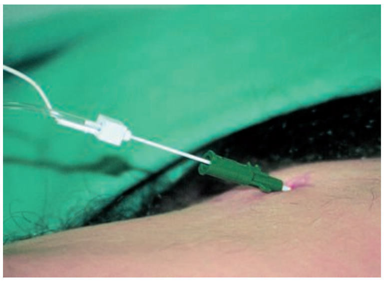


Fig. 50

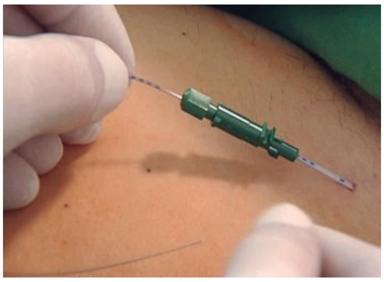


Fig. 51

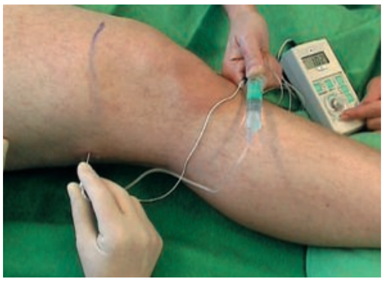


Fig. 52

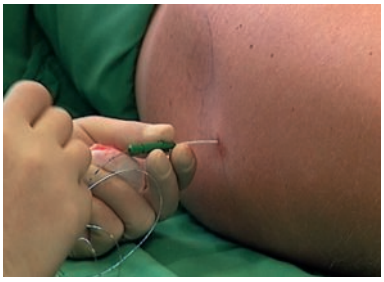


Fig. 53

Abb. 48-53: Various catheter techniques

Fig. 48: *Suprascapular catheter* ***Fig. 49:*** *Suprascapular catheter, fixation technique*
Fig. 50: *Femoral nerve block* ***Fig. 51:*** *Placement of a femoral nerve catheter*
Fig. 52: *Lateral distal sciatic nerve block* ***Fig. 53:*** *Subtrochanteric sciatic nerve block*

Fig. 54: IVBP -Catheter - Spread of contrast medium

Fig. 55: Femoral nerve catheter - Spread of contrast medium

Fig. 56: PC block - Spread of contrast medium

5.3 Equipment and Drugs

Catheter sets, pumps and disposables

In our hospital, we use Contiplex D sets exclusively, placing great emphasis on soft catheters without a stylet.

For inpatient postoperative pain management, we preferentially equip our catheters with PCA pumps. Alongside the electronic devices, we also employ so-called elastomeric pumps (mechanical). Their easy handling and error-free operation make these single-use pumps ideal for use in outpatient settings.

Fig. 57: Contiplex® D Set, (B. Braun Melsungen AG)

Fig. 58: Elastomeric pump Easypump® with PCA unit, (B. Braun Melsungen AG)

Fig. 59: Postoperative pain therapy with PCRA (I pump™, Baxter AG)

Fig. 60: Postoperative pain therapy with Infusomat® Space (B. Braun Melsungen AG)

Local anaesthetics

For postoperative analgesia, we routinely use 0.2% ropivacaine. The drug is best administered by PCA pump with a basal rate and bolus option. Continuous infusion is equally possible. For the most part, we have turned away from purely bolus injections. The decision as to which of these to use depends on the organisational structure. The decisive advantage of continuous administration is that it ties up less anaesthesia staff, and the nursing staff on the peripheral wards can adjust the doses independently within the prescribed range. Disturbing motor blocks on 0.2% ropivacaine are rare.

In the postoperative sector, we do not routinely use any other local anaesthetics.

5.4 Contraindications

For the catheter technique, the contraindications are in line with those that apply to single-shot techniques. When a bacteriemia can be presumed, the indications for a catheter must be subject to very rigorous review.

- Infections in the puncture area
- Systemic (bacterial) infection
- Refusal of the procedure by the patient

5.5 Complications

- Dislocation of the catheter
- Infections at the puncture site
- Catheter breakage, formation of knots or loops (rare)
- Toxic reactions (rare)

Catheter dislodgment resulting from the patient's movements is rare. The analgesic effect following injection of the local anaesthetic is weakened or absent. In such cases, the catheter must be removed. In our opinion, it is not necessary to fixate the catheter with a suture. This type of fixation can create a shear point. To date we have not encountered any complications involving other types of dislodgment or any instances of catheter breakage.

Although we frequently use catheters in immunocompromised patients (diabetics, patients receiving long-term cortisone and/or methotrexate therapy), there have been virtually no serious cases of local infection. It goes without saying that catheter placement is performed under sterile conditions (facemask, gloves). Toxic reactions have not been observed to date and are not to be anticipated either during continuous infusion at the aforementioned doses or at a bolus dose given repeatedly at intervals of approx. 6-8 hours.

5.6 Organisation

The majority of pain catheters are placed in conjunction with a surgical intervention. After the operation, the patients will be initially monitored in the recovery room. A functional renewal of the block is not necessary until the patient has been transferred to the peripheral ward. In rather rare cases, elective catheters used for physiotherapy, sympatholysis in OAD patients or in patients with reflex sympathetic dystrophy. For every patient who receives a catheter, we establish an accompanying patient chart. The chart contains a record of the patient's data, the type of catheter, the depth of needle penetration required for successful stimulation and the date the catheter was placed. Every patient who leaves the recovery room with a pain catheter is entered into a catheter database we have set-up ourselves. A current list of all "pain catheter patients" can be viewed at any time from any PC workstation.

Two to three times a day on our "pain rounds", we check the effect on a visual analogue scale, the patient's satisfaction, if continuation of therapy is indicated, the motor and sensory responses in the region of anaesthesia and if any side effects have occurred. We conduct a palpation check every day and inspect the puncture site every two days when we change the dressing in order to identify any inflammatory complications at an early stage.

The catheter is removed if the puncture site shows any signs of infection or the patient is also free of pain without the conduction analgesia. The patient's catheter record is closed (date, puncture site findings, motor and sensory findings) and the patient is removed from the current catheter list.

6.1 Single-Shot Technique - Upper Extremity

Block	Target muscle	Stimulation needle	Drugs	Dosage
Anterior interscalene block (Approach according to Meier)	Biceps muscle and/or brachialis muscle (Stimulus response from the upper trunk -> lateral cord)	Stimuplex® D 50 mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® 0.5% Naropin® (or 0.5%Carbostesine®)	0.5ml 40ml 10ml
Posterior interscalene block (Approach according to Pippa)	Biceps muscle and/or brachialis muscle (Stimulus response from the upper trunk -> lateral cord)	Stimuplex® D 80 - 100 mm 15° bevel, 22 G	1% Scandicaine® (for puncture channel infiltration) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	2ml 40ml 10ml
Infraclavicular vertical brachial plexus block (According to Kilka, Geiger, Mehrkens)	Extensor or flexor muscles D 1-3 (Stimulus response from the posterior cord = radial nerve and/or median nerve)	Stimuplex® D 50 mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	0.5ml 40ml 10ml
Axillary blockade (Approach according to de Jong	Flexor digitorum muscle (Stimulus response from median nerve)	Stimuplex® D 50 mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® 0.5% Naropin® (or 0.5%Carbostesine®)	0.5ml 40ml 10ml
Suprascapular nerve block (Approach according to Meier)	Supra- or infraspinatus muscles -> external rotation of arm (Stimulus response: suprascapular nerve)	Stimuplex® D 50 mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® and/or 0.5% Naropin®	0.5ml 10-15ml

6.2 Single-shot technique - lower extremity

Block	Target muscle	Stimulation needle	Drugs	Dosage
Psoas block (Approach according to Chayen)	Quadriceps muscle (usually vastus lateralis muscle) (Stimulus response: femoral nerve)	Stimuplex® D 80 - 120mm 15° bevel, 22 G	1% Scandicaine® (for puncture channel infiltration) 1% Xylonest® 0.5% Naropin® (or 0.5%Carbostesine®)	3ml 30-40ml 10ml
Femoral nerve block	Rectus muscle of the thigh ("dancing knee-cap") (Stimulus response: femoral nerve)	Stimuplex® D 50 mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	0.5ml 30-40ml 10ml
Saphenous nerve block	Paraesthesia on the medial lower leg **Important**: 1.0 ms pulse duration (Stimulus response: saphenous nerve)	Stimuplex® D 50 - 80-mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® and/or 0.5% Naropin® (or 0.5% Carbostesine®)	0.5ml 10-15ml
Obturator nerve block	Adductor group -> Adduction of thigh (Stimulus response: obturator nerve)	Stimuplex® D 80 - 100mm 15° bevel, 22 G	1% Scandicaine® (for puncture channel infiltration) 1% Xylonest® and/or 0.5% Naropin® (or 0.5% Carbostesine®)	3ml 10-15ml
Parasacral sciatic nerve block (Approach according to Mansour)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Stimuplex® D 80 - 120mm 15° bevel, 22 G	1% Scandicaine® (for puncture channel infiltration) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	5ml 20-30ml 10ml
Transgluteal sciatic nerve block (Approach according to Labat)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Stimuplex® D 80 - 100mm 15° bevel, 22 G	1% Scandicaine® (for puncture channel infiltration) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	5ml 20-30ml 10ml
Anterior sciatic nerve block (Approach according to Meier)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Stimuplex® D 100 - 120mm 15° bevel, 22 G	1% Scandicaine® (for puncture channel infiltration) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	5ml 20-30ml 10ml
Subtrochanteric sciatic nerve block (Approach according to Guardini)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Stimuplex® D 80 - 100mm 15° bevel, 22 G	1% Scandicaine® (for puncture channel infiltration) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	5ml 20-30ml 10ml
Lateral distal sciatic nerve block	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Stimuplex® D 50 - 80-mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	2ml 30-40ml 10ml
Distal dorsal sciatic nerve block	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Stimuplex® D 50 mm 15° bevel, 22 G	1% Scandicaine® (Skin weal) 1% Xylonest® 0.5% Naropin® (or 0.5% Carbostesine®)	0.5ml 30-40ml 10ml

Whenever two nerve blocks are combined (e.g. psoas compartment block + sciatic nerve block or femoral + sciatic nerve block), we use the long stimulation needle for both puncture sites.

6.3 Catheter technique - upper extremity

All catheter techniques can be preceded by a single-shot blockade (see above).

Block	Target muscle	Stimulation needle	Drugs/Dosage
Anterior interscalene block (Approach according to Meier)	Biceps muscle and/or brachialis muscle (Stimulus response from the upper trunk -> lateral cord)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 10-15ml
Posterior interscalene block (Approach according to Pippa)	Biceps muscle and/or brachialis muscle (Stimulus response from the upper trunk -> lateral cord)	Contiplex® D Set: 100-mm needle, 15°, 22 G, mounted on a 80-mm Teflon introducer, 18 G or 130-mm needle, 15°, 22 G, mounted on a 110-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 10-15ml
Infraclavicular vertical brachial plexus block (According to Kilka, Geiger, Mehrkens)	Extensor or flexor muscles D 1-3 (Stimulus response from the posterior cord = radial nerve and/or median nerve)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 10-15ml
Axillary blockade (Approach according to de Jong)	Flexor digitorum muscles (Stimulus response from the median nerve)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 10-15ml
Suprascapular nerve block (Approach according to Meier)	Supra- or infraspinatus muscles -> external rotation of arm (Stimulus response: suprascapular nerve)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 10-15ml

In addition to the stimulation and its Teflon introducer, the Contiplex® D Set contains a catheter with connector and a bacterial filter with fixation pad.

6.4 Catheter technique - lower extremity

Before inserting the catheter, we usually inject the whole single-dose shot for all catheter techniques.

Block	Target muscle	Stimulation needle	Drugs/Dosage
Psoas compartment block (Approach according to Chayen)	Quadriceps muscle (usually vastus lateralis muscle) (Stimulus response: femoral nerve)	Contiplex® D Set: 100-mm needle, 15°, 22 G, mounted on a 80-mm Teflon introducer, 18 G or 130-mm needle, 15°, 22 G, mounted on a 110-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 5-8 ml/h - bolus: 5ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-20 ml/h Bolus: 0.2% Naropin® 20 ml
Femoral nerve block	Rectus muscle of the thigh ("dancing kneecap") (Stimulus response: femoral nerve)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 5 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 20 ml
Saphenous nerve block	Paraesthesia of medial lower leg -> Important: 1.0 ms pulse duration (Stimulus response: saphenous nerve)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 10 ml
Obturator nerve block	Adductor group -> Adduction of thigh (Stimulus response: obtu-rator nerve)	Contiplex® D Set: 100-mm needle, 15°, 22 G, mounted on a 80-mm Teflon introducer, 18 G or 130-mm needle, 15°, 22 G, mounted on a 110-mm Teflon introducer, 18G	PCRA pump: 0.2% Naropin® Basal rate: 5 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 10-15ml
Parasacral sciatic nerve block (Approach according to Mansour)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Contiplex® D Set: 100-mm needle, 15°, 22 G, mounted on a 80-mm Teflon introducer, 18 G or 130-mm needle, 15°, 22 G, mounted on a 110-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3-5 ml/h - bolus: 5ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 20 ml
Transgluteal sciatic nerve block (Approach according to Labat)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Contiplex® D Set: 100-mm needle, 15°, 22 G, mounted on a 80-mm Teflon introducer, 18 G or 130-mm needle, 15°, 22 G, mounted on a 110-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3-5 ml/h - bolus: 5ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 20 ml
Anterior sciatic nerve block (Approach according to Meier)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Contiplex® D Set: 130-mm needle, 15°, 22 G, mounted on a 100-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3-5 ml/h - bolus: 5ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 20 ml

Catheter technique - lower extremity - table continued

Block	Target muscle	Stimulation needle	Drugs/Dosage
Subtrochanteric sciatic nerve block (Approach according to Guardini)	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Contiplex® D Set: 100-mm needle, 15°, 22 G, mounted on a 80-mm Teflon introducer, 18 G or 130-mm needle, 15°, 22 G, mounted on a 110-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3-5 ml/h - bolus: 5ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 20 ml
Lateral distal sciatic nerve block	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer 18 G or 100-mm needle, 15°, 22 G, mounted on a 80-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3-5 ml/h - bolus: 5ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 20 ml
Distal dorsal sciatic nerve block	Extensors and/or flexors of feet/toes (Stimulus response: peroneal or tibial nerves)	Contiplex® D Set: 70-mm needle, 15°, 22 G, mounted on a 55-mm Teflon introducer, 18 G	PCRA pump: 0.2% Naropin® Basal rate: 3-5 ml/h - bolus: 5ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h Bolus: 0.2% Naropin® 20 ml

In addition to the stimulation and its Teflon introducer, the Contiplex® D Set contains a catheter with connector and a bacterial filter with fixation pad s. Kap. 6.3

6.5 Conclusion

In virtually all peripheral regional anaesthetic procedures, the use of catheter techniques is a significant enhancement to intra- and postoperative analgesia. We would particularly like to emphasise the fact that these techniques provide very reliable and effective postoperative pain therapy and also give the opportunity to start pain-free early mobilisation.

Possible indications for peripheral regional anaesthesia

7.1 Operations on the upper extremity

The following tables give examples of the regional anaesthesia procedures used in our hospital for the various surgical indications. The indication for the placement of a pain catheter is dependent upon the level of postoperative pain to be expected, but because the analgesia is safe and reliable we are generally inclined to be more generous about deciding on its use.

Intervention	Regional anaesthesia technique	Catheter	Postoperative Pain Therapy
Arthroscopy of the shoulder joint, (e.g. arthroscopy, arthrolysis, rotator cuff suture, total shoulder joint replacement), Proximal upper arm (prox. humerus fracture, biopsy) and lateral clavicle (AC joint dislocations (Tossy III), lateral clavicle fractures etc.)	Anterior interscalene block (Anterior approach according to Meier) or Posterior interscalene block (Posterior approach according to Pippa)	IInterscalene plexus	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h
Plate osteosynthesis for fractures of distal humerus and radius, ulna, wrist and finger bones; synovectomy of elbow, hand and finger joints; spacer implants for rheumatically destroyed finger joints	Infraclavicular vertical brachial plexus block (according to Kilka, Geiger, Mehrkens)	Vertical infraclavicular plexus	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h
Plate osteosynthesis for fractures of radius, ulna, wrist and finger bones; synovectomy of elbow, hand and finger joints; spacer implants for rheumatic destruction of finger joints	Axillary blockade	Axillary plexus	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - Bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h
For pain management and physiotherapy only: Mobilisation for "frozen shoulder"	Suprascapular nerve block	Suprascapular	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - Bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h

In our hospital, axillary blockades of the brachial plexus are conducted only when a vertical infraclavicular block is not successful or contraindicated (e.g. if the puncture site is infected, in patients with clavicular deformities or secondary to clavicular fracture).

7.2 Operations on the lower extremity

Intervention	Regional Anaesthesia Technique	Catheter	Postoperative Pain Therapy
Complex operations on the whole leg distal to the hip (e.g. TKA, cruciate ligament reconstruction, plate osteosynthesis of distal femur, thigh amputation, tibial head reconstruction)	Psoas block + proximal sciatic nerve block	Psoas area	PCRA pump: 0.2% Naropin® Basal rate: 5-8 ml/h - Bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-20 ml/h
For TKA and thigh amputation, place sciatic nerve catheter,		Sciatic nerve	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - bolus: 5 ml - lockout: 20 min.
Arthroscopy of the knee joint involving extensive cartilage shaving, reconstruction of ruptured fibulotalar ligaments	Femoral nerve block + proximal sciatic nerve block	Femoral nerve	PCRA pump: 0.2% Naropin® Basal rate: 5 ml/h - Bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h
Tibial head fracture, lower leg amputation For lower leg amputation, additionally place sciatic nerve catheter		Sciatic nerve	PCRA pump: 0.2% Naropin® Basal rate: 3 ml/h - Bolus: 5 ml - lockout: 20 min.
Minor soft tissue operations on leg distal to hip joint, e.g. muscle biopsy (quadriceps muscle)	Femoral nerve block	No catheter	
Operations on the distal lower leg, ankle joint and foot (e.g. arthroscopy/ arthroscopy of ankle joint, fibular reconstruction of knee ligaments, plate osteosynthesis of anterior foot, toes/ amputations of anterior foot); reconstruction of Achilles' tendon	Distal sciatic nerve block	Sciatic nerve	PCRA pump: 0.2% Naropin® Basal rate: 3-5 ml/h - Bolus: 5 ml - lockout: 20 min. Infusion pump: 0.2% Naropin® at 5-15 ml/h
For access through medial distal lower leg or medial ankle joint	If necessary, adjuvant femoral nerve block or saphenous nerve block/Ringwall	No catheter	

For amputations above and below the knee, we usually use continuous spinal anaesthesia (spinal anaesthesia via spinal catheter). If there are any contraindications to a spinal approach, our preferred choice is peripheral blockade with a "double catheter": Sciatic and femoral catheter.

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