9 Inguinal Paravascular Lumbar Plexus Anesthesia
(“3-in-1 Technique” according to Winnie, Femoral Nerve Block)

9.1 Anatomical Overview

The femoral nerve arises within the psoas muscle, usually from the anterior divisions of the four large roots L1–L4 but sometimes only from L2–L4, and is the largest nerve of the lumbar plexus (Fig. 9.1). It passes to the thigh in the fascial space between psoas major and iliacus through the muscular lacuna (Fig. 9.2). The iliopectineal fascia separates the muscular lacuna and thus the femoral nerve from the vascular lacuna through which the lymphatic vessels and the femoral artery and vein run. After giving off a few superficial cutaneous branches (anterior cutaneous branches) it lies under the fascia lata and the iliac fascia in the femoral trigone (Hahn et al. 1996; Platzer 1999; Woodburne 1983), (Figs. 9.3, 9.4). In the region of the inguinal ligament, the femoral nerve is ca. 1 cm lateral to the artery, where it soon branches (Figs. 9.5, 9.6). The femoral nerve provides the sensory innervation of the anterior thigh and is involved in the innervation of the hip and knee and of the femur. It is the motor supply to the knee extensors and hip flexors (see Fig. 7.7).

Fig. 9.1 Anatomical overview of the lumbar plexus and the femoral nerve.
1 Obturator nerve
2 Femoral nerve
3 Lateral cutaneous nerve of the thigh
4 Inguinal ligament

Fig. 9.2 Lumbar plexus with femoral nerve and obturator nerve. Note the arcus iliopectineus, a sheet of connective tissue that separates the vascular lacuna from the muscular lacuna. In femoral nerve block, the psoas muscle may prevent spread of the local anesthetic to the obturator nerve proximal to the inguinal ligament. Distal to the inguinal ligament, the spatial distance and separation by the iliac fascia make inclusion of the obturator nerve by a femoral nerve block almost impossible.
1 Psoas
2 Femoral nerve
3 Arcus iliopectineus
4 Obturator nerve
5 Femoral artery
6 Inguinal ligament
Fig. 9.3 Cranial view of the right inguinal region. Note that the fascia lata and the iliac fascia have to be penetrated to block the femoral nerve ("double-click").

1 Femoral artery
2 Fascia lata
3 Iliac fascia with arcus iliopectineus
4 Genitofemoral nerve
5 Femoral nerve
6 Psoas major

A Anterior superior iliac spine
B Symphysis

Fig. 9.4 Cranial view of the right inguinal region. Note that the fascia lata and the iliac fascia have to be penetrated to block the femoral nerve ("double-click," see also Fig. 9.3).

1 Femoral vein
2 Femoral artery
3 Femoral nerve
4 Iliac fascia
5 Fascia lata
Fig. 9.5  Anatomical overview of the inguinal region: note IVAN (Inside Vein, Artery, Nerve).

1  Lateral cutaneous nerve of the thigh
2  Femoral nerve
3  Femoral artery
4  Femoral vein
5  Obturator nerve

Fig. 9.6  Anatomical overview of the inguinal region: note IVAN (Inside Vein, Artery, Nerve). The femoral nerve has a cauda equina-like division after passing through the inguinal ligament.

1  Sartorius
2  Femoral nerve (looped)
3  Femoral artery
4  Femoral vein
5  Branch of the obturator nerve
9.2 Femoral Nerve Block (“3-in-1 Technique”) 

Landmarks
Anterior superior iliac spine, pubic tubercle. The anterior superior iliac spine and the pubic tubercle are marked and joined by a line. This connecting line corresponds to the inguinal ligament. The classically described puncture site is 1 cm below the inguinal ligament and ca. 1.5 cm lateral to the femoral artery (note: IVAN = Inside Vein, Artery, Nerve) (Figs. 9.7, 9.8).

Divergence from the original technique is recommended, selecting the injection site ca. 1 cm below the inguinal crease, that is, markedly further distally (Figs. 9.9–9.12).

Fig. 9.7 Classical injection site according to Winnie and Labat just below the inguinal ligament. The nerve is here at a greater distance from the skin and is encountered at an angle of almost 90° (see Fig. 9.8). It is advisable to seek orientation further distally just below the inguinal crease (see Fig. 9.9).

1 Anterior superior iliac spine
2 Pubic tubercle
3 Injection site according to Winnie and Labat
4 Femoral artery

Fig. 9.8 The femoral nerve emerges from beneath anteriorly, crosses the iliopubic eminence, and then divides into the individual branches. The shortest skin–nerve distance is at about the level of the inguinal crease. If puncture is performed in the region of the inguinal ligament, a greater skin–nerve distance must be anticipated.

1 Femoral nerve
2 Femoral artery
3 Inguinal ligament
4 Sartorius
5 Note the skin–femoral nerve distance at the level of the inguinal ligament
6 The femoral nerve crosses the iliopubic eminence
Fig. 9.9 Recommended technique for femoral nerve block: puncture site about 1.5 cm lateral to the femoral artery, which can be palpated, and ca. 1 cm below the inguinal crease. Note that the needle is directed tangentially and proximally.

1 Inguinal ligament
2 Inguinal crease
3 Femoral artery
4 Puncture site
A Anterior superior iliac spine
B Greater trochanter

Fig. 9.10 See Fig. 9.9; here, medial view. Right thigh

1 Inguinal ligament
2 Inguinal crease
3 Femoral artery

Position
The patient lies supine and the leg is slightly abducted and externally rotated. In difficult anatomical situations, a flat pad can be placed under the patient’s buttocks in order to show the topography of the inguinal region better.

Method
The landmarks are marked and the femoral artery is palpated. If the artery is impalpable, a Doppler probe can be used for orientation (Fig. 9.13).

After skin disinfection and intracutaneous or superficial subcutaneous local anesthesia ca. 3 cm (Härtel 1916; Moore 1969) below the inguinal ligament (or 1 cm below the inguinal crease) and ca. 1.5 cm lateral to the artery, the skin is incised with a small lancet. An 18G, 45° short-bevel needle with a surrounding plastic cannula is advanced cranially and dorsally at an angle of 30° to the skin and parallel to the artery until the tough resistance of the fascia lata is felt. The
Fig. 9.11  When the index and middle fingers are on the femoral artery, the injection site is laterally located at the level of the distal interphalangeal joints.

Right thigh

Fig. 9.12  Recommended puncture site for femoral nerve block. The nerve is relatively superficial just below the inguinal crease. Note the tangential needle direction. When the finger palpates the femoral artery from the lateral aspect, the injection site is at the level of the distal interphalangeal joint.

Right inguinal region
1 Puncture site
2 Sartorius
3 Femoral nerve
4 Femoral artery
5 Inguinal ligament

Fig. 9.13  In difficult anatomical situations, use of a Doppler probe can facilitate finding the femoral artery.
resistance is overcome by slightly increasing pressure (Figs. 9.14, 9.15). While cautiously advancing the needle further, there is often a second “loss of resistance” when the tip of the needle passes through the iliac fascia (so-called “double-click”). The end of the needle should then be lowered, and it is advanced further proximally parallel to the artery under stimulation (PNS) (Figs. 9.16, 9.17). Contractions in the quadriceps femoris and “dancing” of the patella at 0.3 mA with a pulse duration of 0.1 ms indicate that the tip of the needle is in the correct position in the immediate vicinity of the femoral nerve. Following negative aspiration, 20–40 ml of a medium-acting or long-acting local anesthetic (LA) is injected. Digital pressure distal to the needle can promote distribution of the LA in a cranial direction (Figs. 9.18–9.20). If a continuous technique is planned, a flexible 20G catheter is advanced 5 cm beyond the end of the cannula after injection of the LA (Figs. 9.21, 9.22). Before connecting the catheter to a bacterial filter, the catheter should be aspirated again to exclude an intravascular position (Fig. 9.23).

**Local Anesthetic, Dosages**

*Initially:* 30–50 ml of a medium-acting LA (e.g., 1% [10 mg/ml] mepivacaine, lidocaine) or a long-acting LA (e.g., ropivacaine 0.75% [7.5 mg/ml]).

*Continuous:* 8–10 ml/h ropivacaine 0.2–0.375% (2–3.75 mg/ml)

Combination block with the sciatic nerve: see below.

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**Fig. 9.14** Puncture of the femoral nerve. The fascia lata and iliac fascia have to be penetrated.

Right inguinal region

1. Fascia lata
2. Iliac fascia with iliopectineal fascia
Fig. 9.15 Puncture for femoral nerve block. The needle is advanced proximally in the surrounding sheath using electrostimulation. It must not be forced against resistance. If the response is lost, it can be useful to direct the needle tip somewhat anteriorly by lowering the hub of the needle.

Right thigh

Fig. 9.16 Advancing proximally beneath the iliac fascia using nerve stimulation.

Right inguinal region

Fig. 9.17 After crossing the iliopubic eminence as the highest point, the femoral nerve goes deeper again further peripherally. With a more peripheral puncture below the inguinal ligament, advancing the needle in the cranial direction (under nerve stimulation) within the surrounding sheath may necessitate lowering the hub of the needle in order to advance it virtually “uphill.”

1 Femoral nerve
Fig. 9.18  After aspiration, 30–40 ml of LA is injected slowly and with repeated aspiration. Digital compression distal to the needle can be helpful.

Right inguinal region

Fig. 9.19  Backflow of drops of the LA after injection of 30–40 ml indicates correct injection into the nerve compartment.

Right inguinal region

Fig. 9.20  Spread of the LA, shown radiologically using contrast. Note the spread laterally; contrary to what is imagined of a “3-in-1 block” there is not always central spread toward the lumbar plexus.
Fig. 9.21  Introduction of a flexible catheter through the needle. The catheter should not be advanced more than 3–4 cm beyond the needle tip.

Fig. 9.22  Removal of the cannula after advancing the catheter.

Fig. 9.23  Aspiration through the catheter before connecting a bacterial filter.
9.3 Sensory and Motor Effects

The femoral nerve provides the sensory innervation of the front of the thigh and is involved in the innervation of the hip, knee, and femur. It is the motor supply to the knee extensors and hip flexors. The saphenous nerve is the sensory terminal branch of the femoral nerve and supplies the inside of the lower leg. The anesthesia can include the great toe in a few cases (Clara 1959).

9.4 Indications and Contraindications

**Indications**
- In combination with a block of the sciatic nerve (sacral plexus), all operations on the leg (including total joint replacement of the knee and ankle) can be performed.
- Wound management and skin grafts on the anterior and lateral thigh and on the inside of the lower leg.
- Pain therapy after operations on the knee and femur (e.g., arthroscopic operations, anterior cruciate ligament repair, knee replacement, etc.) and pain reduction after hip operations or thigh amputation.
- Pain therapy (e.g., in femoral shaft fracture [Tobias 1994]; patellar fracture; positioning for spinal anesthesia, e.g., before surgery of femoral neck fractures; mobilization; physiotherapy).

**Contraindications**
- General contraindications (see Chapter 15).
- Tumor in the groin (relative: painful lymph nodes in the groin).
- Previous inguinal vascular surgery (relative).

9.5 Complications, Side Effects, Method-Specific Problems

Vascular puncture with subsequent hematoma is possible. Femoral nerve lesions have been described in case reports.

**Practical Notes**
- Identification of the perineural space is possible in principle without a nerve stimulator and with the loss-of-resistance technique only. However, the nerve stimulator should not be omitted as the femoral nerve is primarily a motor nerve and therefore paresthesia is not produced in every case in the event of (unintentional) puncture of the nerve (Urmey 1997).
- The femoral nerve is separated from the artery by the iliac fascia (Figs. 9.2–9.4). A transarterial technique, such as that described for the brachial plexus, is therefore not possible (Rosenquist and Lederhaas 1999; Urmey 1997).
- Misinterpretation due to muscle contractions on direct intramuscular stimulation of the sartorius muscle or stimulation of superficially situated motor branches innervating sartorius muscle can lead to failures (Fig. 9.24). So-called “dancing” of the patella should therefore always be achieved.
- The classical technique was described in 1924 by Labat. In this technique the puncture site was 1 cm below the inguinal

Fig. 9.24 A motor response in the region of the sartorius muscle can be caused by direct stimulation of the muscle or by stimulation of the motor branch of the femoral nerve, which supplies the sartorius. In both cases, the needle position must be corrected, medially in the first case and slightly laterally and a little deeper in the second case. Only a “dancing patella” or response from the different quadriceps muscles produced by slight “wobbling” movements of the needle is secure evidence that the needle is in the correct position (at appropriate stimulation intensity).

1 Sartorius
2 Motor branch to sartorius
ligament. Compared to a puncture site in the region of the inguinal ligament, the femoral nerve 1 cm below the inguinal crease is wider and markedly closer under the fascia lata (Figs. 9.8, 9.12). Puncture somewhat distal to the inguinal crease is therefore recommended and not, as in the classical technique of femoral nerve block, at the level of the inguinal ligament.

- The quality of anesthesia is not improved by advancing the catheter further forward and/or using greater injection volume than stated (Singelyn et al. 1996) (Fig. 9.25).
- The anesthesia may, in a few cases, include the great toe through the saphenous nerve (sensory terminal branch of the femoral nerve) (Clara 1959).
- Persistent pain in the region of the knee with otherwise complete anesthesia on the front of the thigh and a good motor block of the hip flexors and knee extensors can indicate insufficient obturator nerve block (Paul 1999).

9.6 Remarks on the Technique

Cranial to the inguinal ligament, the femoral nerve passes in a fascial sheath that is formed posterolaterally by the iliac fascia, medially by the psoas fascia, and anteriorly by the transversalis fascia. When it passes under the inguinal ligament, the nerve begins to split underneath and soon comes closer to the surface, dividing into its terminal branches. Immediately below the inguinal ligament, the femoral nerve is separated from the artery by the iliopectineal fascia, which now forms the fascial sheath that continues to surround the medial part of the nerve, which is composed posterolaterally of the merged iliopsoas fascia and anteriorly of the fascia lata.

Alon Winnie postulated in 1973 that this fascial sheath should be understood as a sheath surrounding the nerveplexus throughout from the proximal psoas compartment to its distal branching. According to Winnie, this fascial tube can be “filled” with local anesthetic by an appropriate injection technique not only from above as a psoas compartment block but also from the groin. According to Winnie, the femoral, obturator, and lateral cutaneous nerves of the lumbar plexus should be reached with 20 ml of local anesthetic. This technique is also described as the anterior approach to the psoas compartment (Hahn et al. 1996). Winnie called the method the “3-in-1 technique” (Winnie et al. 1973, 1974). Winnie’s classic concept is currently under discussion on the basis of recent information. The shared and continuous fascial sheath he described was not always
Lang found in a prospective study that when the Winnie technique was used, the femoral nerve was anesthetized in 81% and the lateral cutaneous nerve of the thigh in 96%, but that the obturator nerve was blocked in only 4% (Lang et al. 1993). The area of sensory innervation of this nerve on the inside of the thigh is very inconstant and is not suitable for investigation (Bergmann 1994). Demonstration of the degree to which the obturator nerve is involved in the block is therefore very difficult. Paul and Drechsler
(1993) found a completely anesthetized area of skin in only 5% of cases in isolated obturator nerve blocks despite the fact that there was obvious motor block of the adductors. On the basis of these observations, the obturator nerve appears to be of subordinate importance for the innervation of the knee in most cases. That would explain the very effective use of the so-called “3-in-1 technique,” even if this probably leads only to a “2-in-1 block” (Rosenquist and Lederhaas 1999). The extent and significance of block of the lateral cutaneous nerve of the thigh have not yet been conclusively elucidated. In the technique described by Winnie, the puncture site selected was 1 cm below the inguinal ligament with the needle directed vertically toward the nerve. At this point, the femoral nerve is still relatively deep. Löfström mentions a depth of 3.5–4 cm (Löfström 1980) (Fig. 9.8). For this reason, Härtel (1916) and later Moore (1976) recommended a puncture site 2–3 cm further distal. In its further course, the nerve very quickly becomes more superficial and divides. Vloka et al. (1999) found that a puncture site at the level of the inguinal crease and directly lateral to the artery led most frequently (in 71%) to contact between the needle and the nerve. The nerve was significantly wider at this point (1.4 cm vs. 0.98 cm) and was closer to the fascia lata (0.68 cm vs. 2.64 cm) than at the level of the inguinal ligament (Vloka et al. 1999) (Fig. 9.12). Because of the branching of the nerve, however, a puncture site even further distally might be problematic and might also make placement of a catheter more difficult (Urmey 1997). Good anatomical orientation is possible even without producing paresthesia. The “double-click,” a loss of resistance that can be felt on penetrating the fascia lata and the iliac fascia, especially when short-bevel needles are used, is a very reliable indication that the tip of the needle is in the correct position. Whether the success rate can be improved by peripheral nerve stimulation during femoral nerve block is controversial. However, as the femoral nerve in the majority of cases has motor fibers, an intraneural injection might remain unnoticed on the basis of absent paresthesia if the nerve is approached too closely. With pure motor neurons, an overproportionate incidence of intraneural injection can be anticipated (Gentili and Wargnier 1993; Graf and Martin 2001; Urmey 1997). For safety reasons, the use of peripheral nerve stimulation is strongly recommended. The indications for inguinal paravascular femoral nerve block for intraoperative anesthesia are very limited. Femoral nerve block, when performed on admission to hospital in the case of femoral neck or femoral shaft fractures, can allow pain-free examination and also administration of spinal anesthesia for surgery. Complete analgesia in the hip cannot be achieved as the hip is also supplied by the sacral plexus, but a clear reduction in pain is obtained (Esteve et al. 1990; Fournier et al. 1998). A combination of spinal anesthesia and the “3-in-1 block” in transurethral operations on the bladder wall to eliminate the obturator reflex seldom leads to the desired effect. By blocking the obturator nerve, contractions of the adductor muscles due to unintentional stimulation by electroresection should be prevented. However, the “3-in-1 block” not only leads to an inadequate obturator nerve block but is also cranial to the site of stimulation. In order to obtain an effective block of the obturator nerve for this purpose, a selective obturator nerve block must be performed distal to the bladder. Femoral nerve block can be combined very successfully with sciatic nerve block for operations on the leg (Anke-Moller et al. 1990; Elmas and Atanassoff 1993; Geiger et al. 1989, 1995; Kaiser et al. 1986; Mackenzie 1997; Sprotte 1981). For surgery requiring a thigh tourniquet and operations on the knee, where dorsal parts of the knee are also involved, combination with a proximal sciatic nerve block is almost necessary. 20–40 ml of a 1% (10 mg/ml) medium-acting amide for the femoral nerve block (“3-in-1 block”) plus 20–30 ml for the sciatic block is recommended (Büttner and Meier 1999; Meier and Büttner 2001). Sufficient anesthesia of the femoral nerve (“3-in-1 block”) can also be obtained with 20 ml of ropivacaine 0.5% (5 mg/ml) or 20 ml of bupivacaine 0.5% (5 mg/ml) (Marhofer et al. 2000a, 2000b). The technique of femoral nerve block is easy to learn, simple to perform, and safe. In combination with a proximal sciatic block, it enables operations to be performed on the lower limb. As continuous pain therapy, femoral nerve block provides sufficient analgesia for operations on the femur and patella and reduces pain in operations on the hip or knee. In rehabilitation after knee operations, continuous femoral nerve block provides effective pain relief and leads to shorter hospitalization and better functional results compared to general anesthesia (Capdevila 1999).