

Applications of Ultrasound in Anesthesia A Handbook



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Foreword
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FOREWORD

Ultrasound technology is a rapidly emerging science with wide applications in the field of medicine. It is a safe, reliable, relatively inexpensive and portable imaging modality. It plays an important role in identifying the correct anatomy of underlying structures and has therefore served as a very good diagnostic tool in medical science.



Practice of anesthesia also requires the correct identification of anatomical landmarks for proper placement of drugs in regional anesthesia blocks given for anesthesia or analgesia purpose. In emergencies as well as in cases with difficult anatomy to locate the required landmarks, ultrasound serves as a rescue device. Current and future applications of ultrasound in the field of anesthesia include regional anesthesia, epidural space identification in cases of difficult anatomy, delineating nerve plexuses for chronic pain procedures, vascular access, airway assessment, lung ultrasound, ultrasound neuro-monitoring, gastric ultrasound, focused transthoracic echo (TTE), transesophageal echo (TEE) and Doppler. Airway assessment applications do include identification of cricothyroid membrane for cricothyrotomy in emergency as well as assessing the tracheal diameter for selecting the proper sized endotracheal tube particularly in small kids. Practice of ultrasound is gradually becoming routine in daily practice of anesthesia and pain management in many

of the centers of India and is going to become common application everywhere. It is therefore a perfect time when young anesthesia postgraduate residents be made familiar with practice of ultrasound.

Applications of Ultrasound in Anesthesia: A Handbook has been written by Dr Kavita S Lalchandani with the purpose to explain the basics of ultrasound and its applications to young budding anesthesiologists in a very simple understandable language with diagrams and ultrasound photographs wherever required.

The initial chapters in this book deal with the knowledge of ultrasound which includes parts of ultrasound, terminologies and how to do scanning, while in other chapters the author has discussed ultrasound-guided procedures like central venous access and various regional blocks.

I am sure that the book will be appreciated by the anesthesia fraternity—both consultants and young students of anesthesiology and I wish it to become a regular handbook for them while carrying out a procedure in operation theater or in intensive care under ultrasound guidance.

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PREFACE

Future is all about advancement and ultrasound is one such advancement in medical practice. It is rapidly emerging science with wide applications in the field of medicine. It is a safe, reliable, relatively inexpensive and portable imaging modality. It plays an important role in identifying the correct anatomy of underlying structures and has therefore served as a very good diagnostic tool in medical science.

The book describes the basics of ultrasound, different terminologies used in ultrasound and simplified way of performing anesthetic procedures under ultrasound guidance.

Kavita S Lalchandani

ACKNOWLEDGMENTS

It is most appropriate that I begin by expressing my gratitude to the Almighty for having blessed me to write this book.

Any accomplishment requires the whole-hearted efforts (cooperation) of many people and this work is not different. This has been the result of teamwork put together by certain people without their support, encouragement and motivation this would not have seen the light of the day.

It gives me immense pleasure to express my deep gratitude, respect and sincere thanks to Dr MR Upadhyay, Senior Professor and Head, Department of Anesthesiology, SSG Hospital and Government Medical College, Vadodara, Gujarat for his advice and guidance and sharing his extraordinary experiences and unflinching encouragement throughout the work. His insight, high calibre and personal qualities have been profoundly inspirational to me.

I would like to thank Dr Neha Shah, Assistant Professor in Anesthesiology for her support in writing chapter 8: Transversus Abdominis Plane Block.

Above all, my sincere most appreciation goes to my husband Dr Shyam Lalchandani and my children for their unfailing motivation in all my academic endeavors and for their understanding, patience and encouragement during the long tedious hours of hard work amidst piles of papers and the glow of the computer screen.

My sincere thanks to Mr Sharad Patel whose dynamism to publish this book by M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India, is a constant driving force for me to come out with this new book.

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Lower Extremity Nerve Blocks

In this chapter we will discuss about femoral nerve block and popliteal sciatic nerve block under ultrasound guidance.

ULTRASOUND-GUIDED FEMORAL NERVE BLOCK

Anatomy (Fig. 1)

The femoral nerve (L_2-L_4) runs down the posterolateral wall of the pelvis behind the fascia iliaca. The femoral artery and vein lie anterior to the fascia iliaca. As the vessels pass behind the inguinal ligament they become invested in a fascial sheath. The femoral nerve lies behind and lateral to this sheath but is not within it. All three are deep to the fascia lata, but unfortunately the exact position of the nerve in relation to the artery is inconsistent. It may be close to the sheath or several centimeters lateral to it, as well as being more deeply placed. Because of these femoral nerve block is not easy by anatomical landmark technique rather ultrasound is very much helpful to locate the nerve. Ultrasound application helps to monitor the spread of local anesthetic and needle placement and make appropriate adjustments, should the initial spread be deemed inadequate. Also, because of the proximity to the relatively large femoral artery, ultrasound may

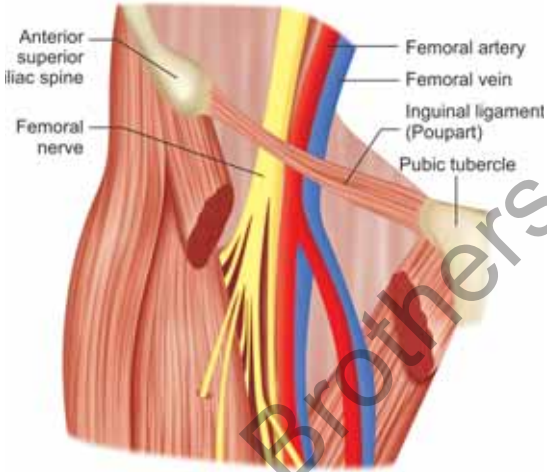


Fig. 1: Anatomy of femoral nerve

reduce the risk of arterial puncture that often occurs with this block with the use of non-ultrasound techniques.

Femoral nerve block results in anesthesia of the anterior and medial thigh down to the knee (the knee included), as well as a variable strip of skin on the medial leg.

Sonoanatomy

The main structure to visualize for femoral nerve block are femoral artery, femoral vein, and fascia iliaca. The femoral artery should be located first using color Doppler and pulse wave Doppler. The femoral vein can be seen medially while femoral nerve will be seen laterally as hyperechoic round or oval rim (Fig. 2).

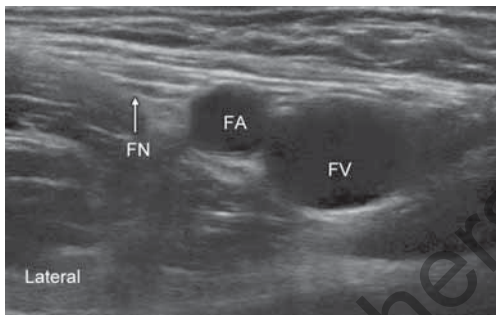


Fig. 2: Sonoanatomy of femoral nerve

Abbreviations: FV, femoral vein; FA, femoral artery; FN, femoral nerve

Indications

- Femoral nerve block is indicated for surgeries on anterior thigh and knee
- For providing postoperative analgesia for surgeries on anterior thigh and knee
- Along with lateral cutaneous nerve of thigh it is indicated for surgeries on thigh and knee
- The total volume required is 20 to 30 mL of local anesthetic.

Patient position: Supine.

Transducer position: Transducer should be placed transversely close to the inguinal crease.

Technique: After proper positioning and sterile precaution place the transducer as mentioned above and start scanning. First of all locate the femoral artery using color Doppler, just above it fascia iliaca can be seen. The femoral nerve lies lateral to artery as hyperechoic rim. If femoral nerve is not visualized tilting and sliding of transducer helps to locate the nerve.

Insert the needle in-plane from lateral to medial side. Once needle tip reaches up to the nerve confirm by injecting 1 to 2 mL of local anesthetic. After that inject rest of the local anesthetic volume that is 10–20 mL of local anesthetic.

Important Note

When in doubt, the nerve stimulator can also be used along with ultrasound.

Never inject against high resistance to injection because this may signal an intr fascicular needle placement.

ULTRASOUND-GUIDED POPLITEAL SCIATIC NERVE BLOCK

Anatomy of Sciatic Nerve (Fig. 3)

- The sciatic nerve is the largest nerve supplying the leg. It is formed by the fusion of Lumbar fourth, fifth nerves and 3 sacral spinal nerves. It leaves the pelvis through the greater sciatic foramen and runs toward the posterior aspect of the thigh between the greater trochanter and the ischial tuberosity.
- Then it divides into two major branches: (1) Tibial nerve and (2) common peroneal nerve. The tibial nerve supplies the heel and the sole of the foot. The common peroneal, also known as the common fibular nerve, innervates the lateral aspect of the leg and dorsum of the foot.
- At the popliteal crease, the nerves are midway between skin and bone. They are lateral and superficial to the popliteal artery and vein in a separate sheath.
- The tibial nerve is the larger of the two divisions and runs in the middle of popliteal fossa passing inferiorly through the two heads of the gastrocnemius. The common peroneal nerve is more lateral and superficial than the tibial nerve.

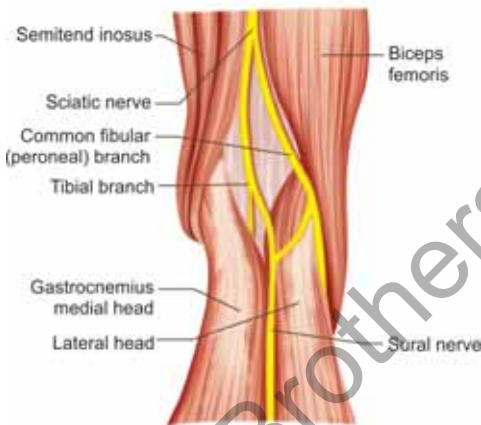


Fig. 3: Popliteal sciatic nerve anatomy

General Considerations

As mentioned above the two branches of sciatic nerve lies deep it is difficult to locate the nerve using anatomical blind technique. So, the ultrasound along with nerve locator is the best way to locate the sciatic popliteal nerve.

There are two approaches for popliteal sciatic block, lateral approach and posterior approach. In both position ultrasound image remains same but the patient position differs.

Position of the Patient

In lateral approach patient position is right or left lateral (more commonly, oblique position) and in posterior approach patient should lie in prone position.

Indications

For operations and postoperative analgesia on lower limb below knee.

Ultrasound Anatomy

The structure of interest are popliteal artery, popliteal vein, biceps femoris muscle and semimembranosus and semitendinosus muscles. The biceps femoris muscle lies lateral to the artery and semi-membranosus and semitendinosus muscles lie medial to the artery. The tibial nerve is seen as a hyperechoic, oval, or round structure with a stippled or honeycomb pattern just superficial and lateral to the artery, while common peroneal nerve is located even more superficial and lateral to the tibial nerve (Fig. 4).

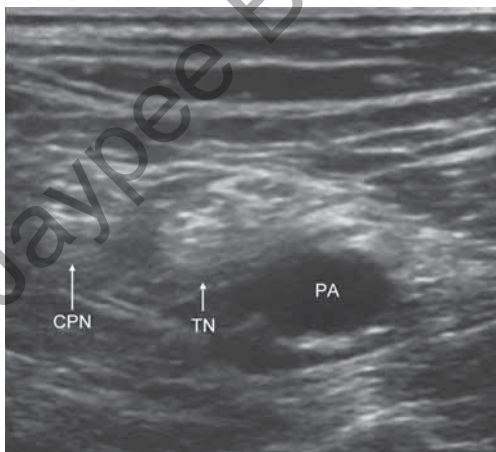


Fig. 4: Sonoanatomy of popliteal sciatic nerve

Abbreviations: PA, popliteal artery; TN, tibial nerve; CPN, common peroneal nerve

Patient's Position

Prone position with the legs slightly abducted. A small footrest is useful to facilitate identification of a motor response if nerve stimulation is used. Also, it relaxes the hamstring tendons, making transducer placement and manipulation easier.

Transducer Position

Transversely at the popliteal crease on the lateral aspect of thigh or over popliteal fossa.

Technique

First of all try to identify popliteal artery, aided with the color Doppler ultrasound when necessary, at a depth of approximately 3–4 cm. The popliteal vein also accompanies the artery.

On either side of the artery are the biceps femoris muscles (lateral) and the semi-membranosus and semitendinosus muscles (medial). Superficially (i.e. toward the skin surface) and lateral to the artery is the tibial nerve, seen as a hyperechoic, oval, or round structure with a stippled or honeycomb pattern on the interior.

If difficulty in identifying the nerve is encountered, the patient can be asked to dorsiflex and plantar flex the ankle, which makes the nerve rotate or move in relation to its surroundings.

Once the tibial nerve is identified, an attempt should be made to visualize the common peroneal nerve, which is located even more superficial and lateral to the tibial nerve. Then move the transducer proximally until the tibial and peroneal nerves are visualized coming together to form the sciatic nerve before its division. This is usually seen at a distance between 5 cm and 10 cm from the popliteal crease, but this may occur very close to the

crease or (less commonly) more proximally in the thigh.

As the transducer is moved proximally, the popliteal vessels move anteriorly and therefore become less visible. At all the times keep adjusting depth, gain, and direction of the ultrasound beam to keep the nerve visible. The sciatic nerve typically is visualized at a depth of 2–4 cm.

Once identified, a skin wheal is made immediately lateral or medial to the transducer. Then insert the needle in-plane toward the sciatic nerve.

If nerve stimulation is used (0.5 mA, 0.1 msec), the contact of the needle tip with the sciatic nerve often is associated with a motor response of the calf or foot. Once the needle tip is confirmed to be adjacent to the nerve, inject the local anesthetic after negative aspiration.

Needle repositioning and injection of small aliquots is frequently required to ensure adequate circumferential spread of the local anesthetic.

When injection of the local anesthetic does not appear to result in a spread around the sciatic nerve, additional needle repositions and injections may be necessary. When injecting into the epineurium, correct injection is recognized as local anesthetic spread proximally and distally to the site of the injection around both divisions of the nerve. This typically results in separation of TN and CPN during and after the injection.

Important Note

The nerve stimulator can be useful to confirm the proper placement of needle.

Never inject against high resistance to injection because this may signal an intraneural injection.

BIBLIOGRAPHY

1. Beach ML, Chinn C, et al. A comparison of sensory and motor loss after a femoral nerve block conducted with ultrasound versus ultrasound and nerve stimulation. *Reg Anesth Pain Med.* 2009;34:508-13.
2. Beaudoin FL, Nagdev A, Merchant RC, Becker BM. Ultrasound-guided femoral nerve blocks in elderly patients with hip fractures. *Am J Emerg Med.* 2010;28(1):76-81.
3. Gray AT, Huczko EL, Schafhalter-Zoppoth I. Lateral popliteal nerve block with ultrasound guidance. *Reg Anesth Pain Med.* 2004;29:507-9.
4. McQuay HJ, Carroll D, Moore RA. Postoperative orthopaedic pain: the effect of opiate premedication and local anesthetic blocks. *Pain.* 1988;33(3):29-5.
5. Schafhalter-Zoppoth I. The "see-saw" sign: improved sonographic identification of the sciatic nerve. *Anesthesiology.* 2004;101:808-9.
6. Sinha A, Chan VW. Ultrasound imaging for popliteal sciatic nerve block. *Reg Anesth Pain Med.* 2004;29:130-4.
7. Sites BD, Gallagher JD, Tomek I, Cheung Y, Beach ML. The use of magnetic resonance imaging to evaluate the accuracy of a handheld ultrasound machine in locating the sciatic nerve in the popliteal fossa. *Reg Anesth Pain Med.* 2004;29:413-6.
8. Ultrasound guided Ankle block: New York Society of Regional Anaesthesia : 3268 September :2013.
9. Ultrasound guided femoral nerve block: New York Society of Regional Anaesthesia: 2013;3267.
10. Ultrasound guided popliteal sciatic nerve block: New York Society of Regional Anaesthesia : 3416 October :2013.
11. Wildsmith JAW, Armitage EN, McClure JH. Principles and practice of regional anaesthesia, 3rd edition. pp. 216-25.