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ULTRASOUND GUIDED TECHNIQUES FOR PERIOPERATIVE PAIN MANAGEMENT IN TOTAL KNEE ARTHOPLASTY

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CONTENTS

INTRODUCTION

ULTRASOUND GUIDED TECHNIQUES FOR PERIOPERATIVE PAIN MANAGEMENT IN TOTAL KNEE ARTHOPLASTY

Optimal analgesia remains challenging for total knee arthroplasty. Over 50% of patients report postoperative pain as a major concern as shown by many studies that leads to a serious complications such as myocardial infarction, pulmonary infection, paralytic ileus, urinary retention anxiety, prolonged hospitalizations, patient dissatisfaction, impaired patient rehabilitation[1,2,3].

Ultrasound guidance considered as the golden standard for regional anaesthesia and analgesia where it improves safety, efficacy helped to promote its use and role in perioperative pain management comparing with general anaesthesia. Furthermore, it provides a superior analgesic effect with lower cost-effective and a decreased mortality and morbidity with better postoperative course and fewer complications [1, 2, 4].

Studies have shown that blocking multiple nerves was superior to any single nerve block, epidural analgesia or peri- articular infiltration. For decreasing opioid requirements, the best options were femoral/sciatic/obturator/femoral/obturator/ lumbar plexus/sciatic, lumbar plexus, femoral/sciatic blocks. In terms of high quality studies, sciatic/femoral provide a better modality of range of motion and considered overall best approach [1, 3, 4, 5, 6, 7].

Ultrasound

Non-invasive visualization structures of the tissue and operator dependent procedure that gives a real time imagining as a reflection for organ surfaces and scattering within different tissues [8]
In 1880 piezoelectric effect in crystal discovered by Pierre and Jacques Curie, and in 1978 an application of needle placement for nerves block done with ultrasound by P. La Grange.
Also in 1989 P. Ting and V. Sivagnanaratnam used ultrasound to visualize the anatomy of the axilla with observation local anaesthetic spread. Furthermore, in 1994 B mode used to explore brachial plexus block by Steven Kapral. [10]

Definition of ultrasound:

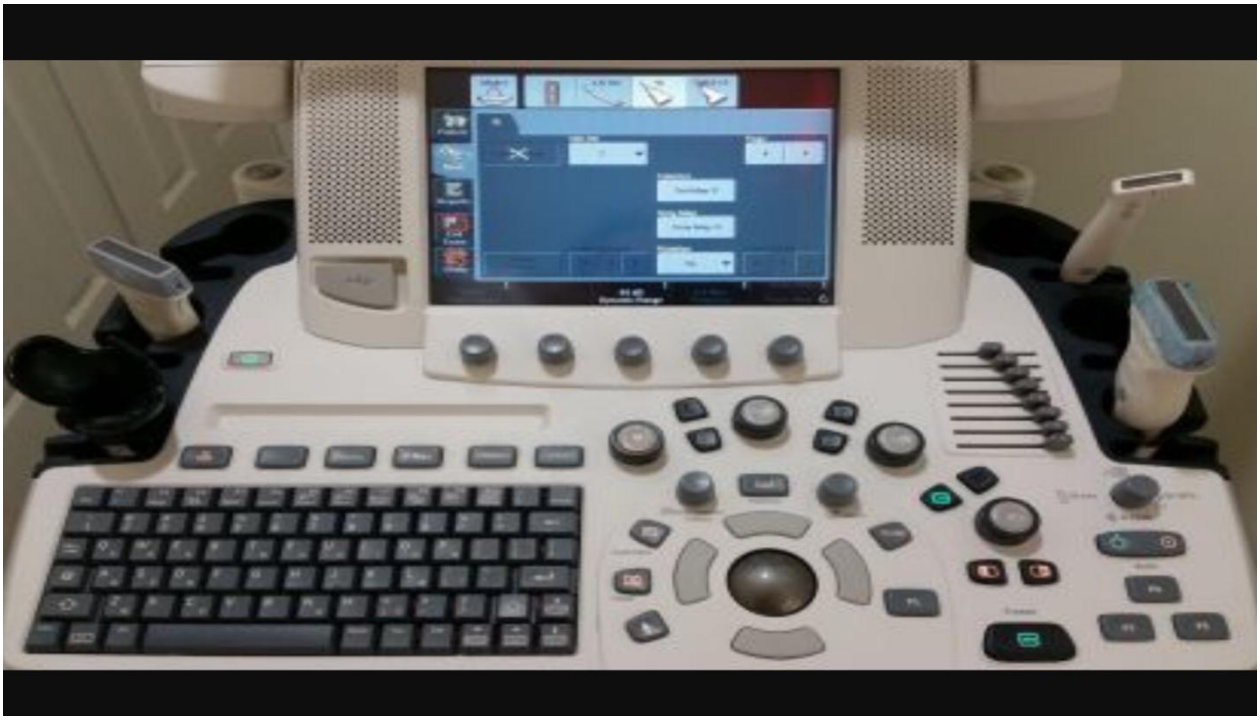
High frequency sound waves (mechanical longitudinal waves) that generated with a specific frequency ranges and sent through tissues. The lower frequencies penetrate deeper structures compared to high frequencies that considered for superficial structures [12]. The upper limit of the normal human hearing ranged between (20 Hz to 20 kHz). The frequencies that can be used for clinical imaging (1-50 MHz).
As the sounds passing through tissues it is either reflected, absorbed or allowed to pass through, depending on the tissue echo-density. Substances with higher water contents (e.g. Cerebrospinal fluid, blood) transmits and conducts the waves very well with poor reflection and thus are called as echo lucent. These appear as a dark areas because of very little reflection of the sound waves [8, 10, 12].
On the other hand, materials with low water content or containing substances that are poor sound conductor (air, bone) appears very bright due reflection almost all the sound waves. Peripheral nerves ideally looks like a bundle of drinking straws end-on viewed.”10”

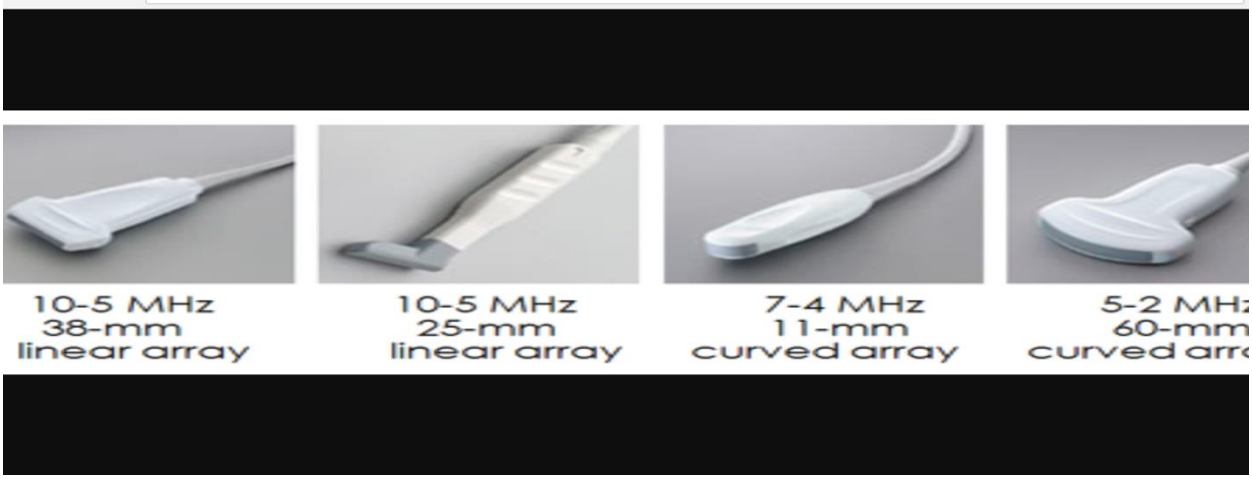
Modes of ultrasound

1. A- Mode (amplitude): measuring the depth by displaying a single signal of echo against time e.g. Eye dimensions measurements.
2. B-Mode (brightness): most common mode with multiple beams e.g. 2D image.
3. M-Mode: (motion mode): examines the moving structures [8].

Controls of ultrasound

- Probe selection (Frequency): High frequency for superficial structures and low frequency for deep structures.
- Depth: Should be adjusted for location of the target to be in the screen centre.
- Gain: This control the brightness of the image, where signals can be amplified equally from different depth to be displayed.[8,10].





Advantages of ultrasound guided regional anaesthesia include

1. Anatomical variation detection.
2. Overall safety of ultrasound techniques.
3. Safely identifying neural tissues.
4. Adjacent anatomical structures identification.
5. Observation of spreading of local anaesthetic and exact administration.
6. Longer duration and faster onset of the blocks.
7. Needle observations.
8. Amount of local anaesthetic much reduced.
9. Lessen the number of attempts with needle at nerve location and potentially the risk for nerve injuries decreased.
10. Very high successful rate with fewer complications [12,10,11].

Nerve supply of the knee joint [9]

1. Femoral nerve: (L2,3,4)
   Gives twigs from the nerve to the three vasti “9”
2. Obturator :(L2,3,4)
   Gives genicular branch from its posterior division.
3. Tibial nerve :
   Superior medial genicular nerve
   Inferior medial genicular branch
   Middle genicular branch
4. Peroneal nerve.
   Superior lateral genicular
   Inferior lateral genicular
   Recurrent genicular branch

Lumbar Plexus

- Ventral rami of L1-L4

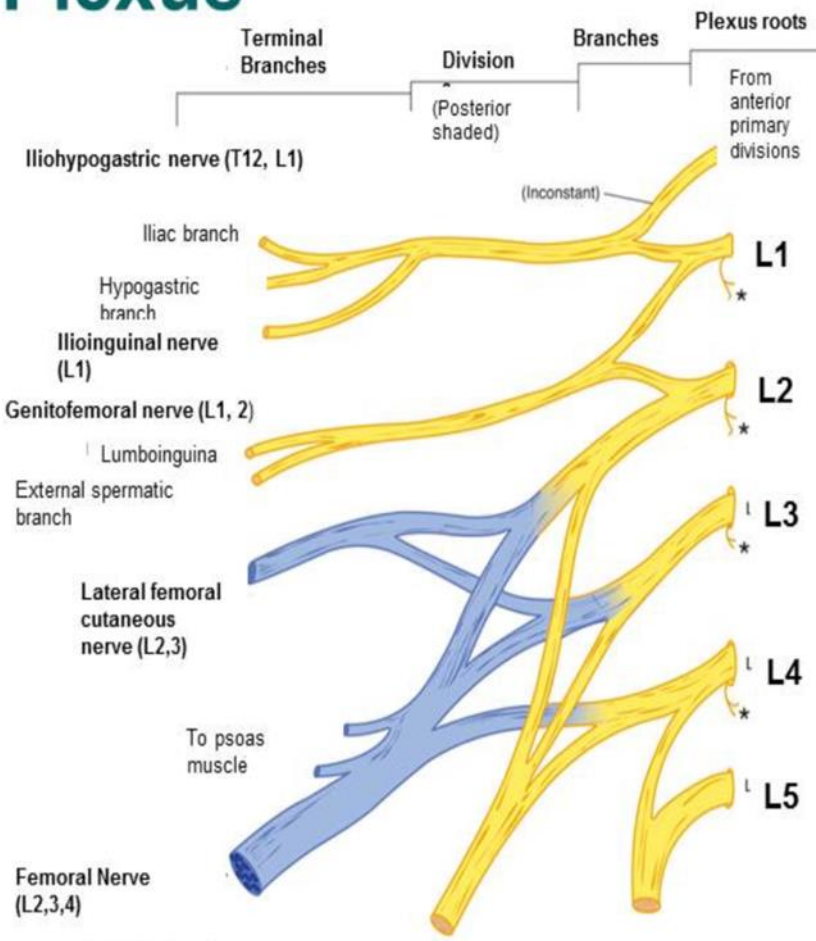


Figure 28-10. Lumbar Plexus. In: Waxman SG. *Clinical Neuroanatomy*. 26th ed. New York, NY: McGraw-Hill; 2010. http://www.accessphysiotherapy.com. Accessed March 22, 2012.

Femoral nerve block

Anatomy:
Originates from the ventral rami (L 2, 3, 4) of the lumbar plexus and considered as its largest branch, as it descends through the lateral border of psoas major muscle and enter the thigh behind the midpoint of the inguinal ligament via the groove between psoas and iliacus muscle to deep to them to enter the femoral triangle where it will be bounded medially by femoral artery, and covered by fascia lata and fascia iliaca [9,10].

Femoral nerve gives its branches after passing under the inguinal ligament which are anterior branch (superficial) and posterior branch (deep).

Anterior branch (superficial) gives the following branches
1. Nerve to sartorius muscle
2. Nerve to pectinneus muscle
3. Sensory innervation to the acetabulum (the articular surface).
4 .Anterior and medial aspect of the thigh (skin) [12,11,10].

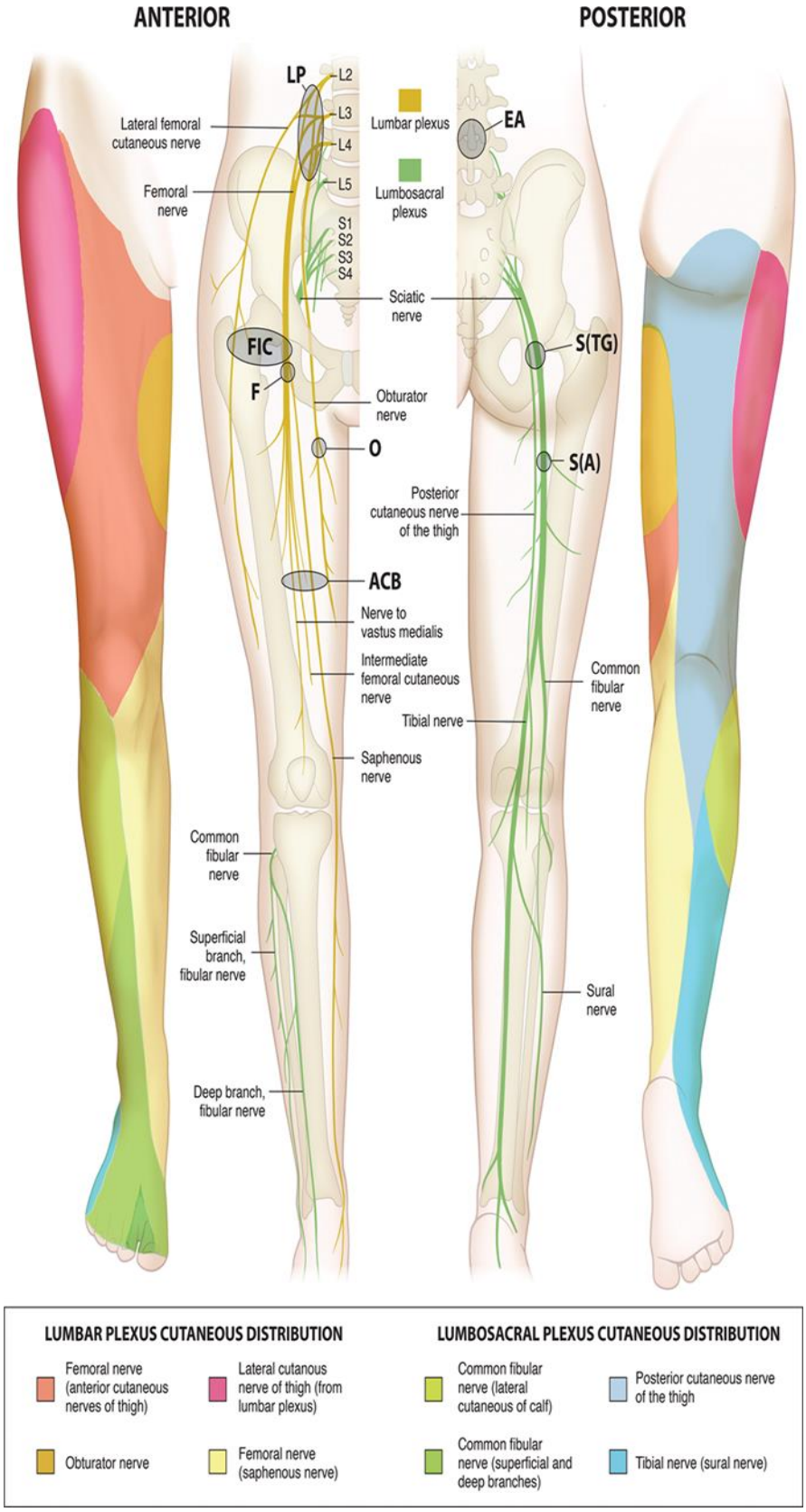
Posterior branch (deep) gives the following divisions

1. Motor branch to the quadriceps muscle.
2. Sensory (saphenous nerve).

Dermatomal innervations

Skin over the anterior aspect of the thigh and knee joint.
Saphenous nerve cover the medial aspect of the leg including medial malleolus

Osteotomal supply:
Femur (anterior aspect).
Knee joint (anterior-medial aspect).
Hip joint (anterior wall) [9,10,12].



Indications

1. Femur fracture (neck and shaft).
2. For knee operations e.g. total knee arthroplasty +_ sciatic nerve.
3. Knee amputation (above and below the joint), with sciatic nerve.
4. Hip surgery as adjuvant analgesia.
5. Procedures for lower leg and foot (medial aspect) [9,10,11].

Contraindications

Absolute

1. Refusal of the patient.
2. Local infection (injection site).

Relative

1. Patient with compartment syndrome (leg).
2. Patient with peripheral neuropathy.
3. Bleeding diathesis or patient on anticoagulant drugs.
4. Femoral artery prosthetic graft.[9,10].

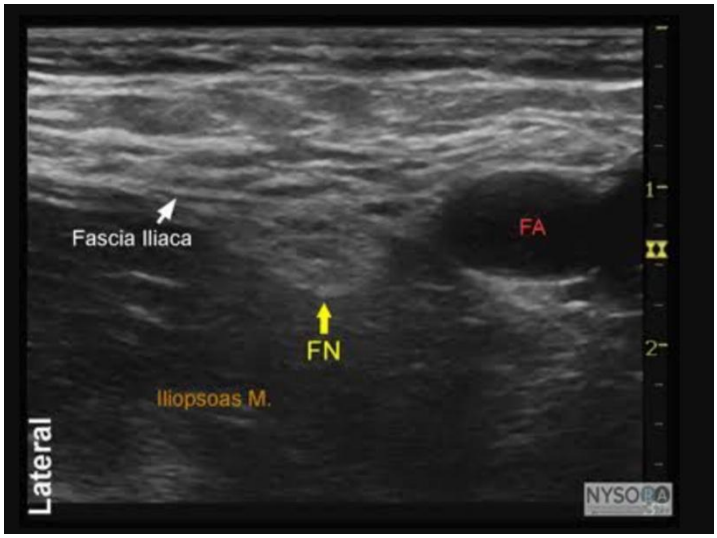
General preparation and equipment:

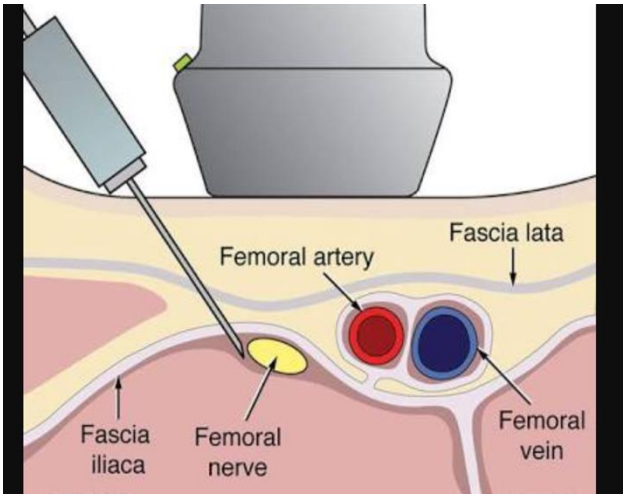
1. Patient consent.
2. Ultrasound machine (linear probe) 8-14 MHz
3. Sterile Probe cover and gel.
4. 22 G Echogenic stimulating needle 50-100 mm.
5. Peripheral Nerve stimulator.
6. Local anaesthetic.
7. Sterile gloves.
8. Syringe 10 ml x2.

Procedure

Patient in supine position with exposed thigh and patella, and the skin over the inguinal area should be cleaned with antiseptic solution. After that try to identify the femoral artery with transducer by traversing the inguinal crease with slow movement medial or lateral, also with tilting the transducer cranially and caudally help to localize the nerve which appears as a hyperechoic oval structure with identifying the iliopsoas muscle and its fascia [10,11,12].

A wheel of local anaesthetic infiltrated to the skin at needle insertion site, then advance the needle from lateral to medial side of the thigh around 0.5-1 cm lateral to transducer in-plain technique directed toward the femoral nerve, with using the nerve stimulator at the same time at 0.5 mA, 0.1 msec.
Watching the penetration of fascia iliaca and advancing the needle tip either below or above the nerve with needle, it leads to contraction of the quadriceps muscle (dancing patella sign), with careful aspiration injection of 1-2 ml of local anaesthetic helps to identify the tip of the needle. Then injection of 10-20 ml of local anaesthetic with multiple aspiration will be adequate [10,11,12].

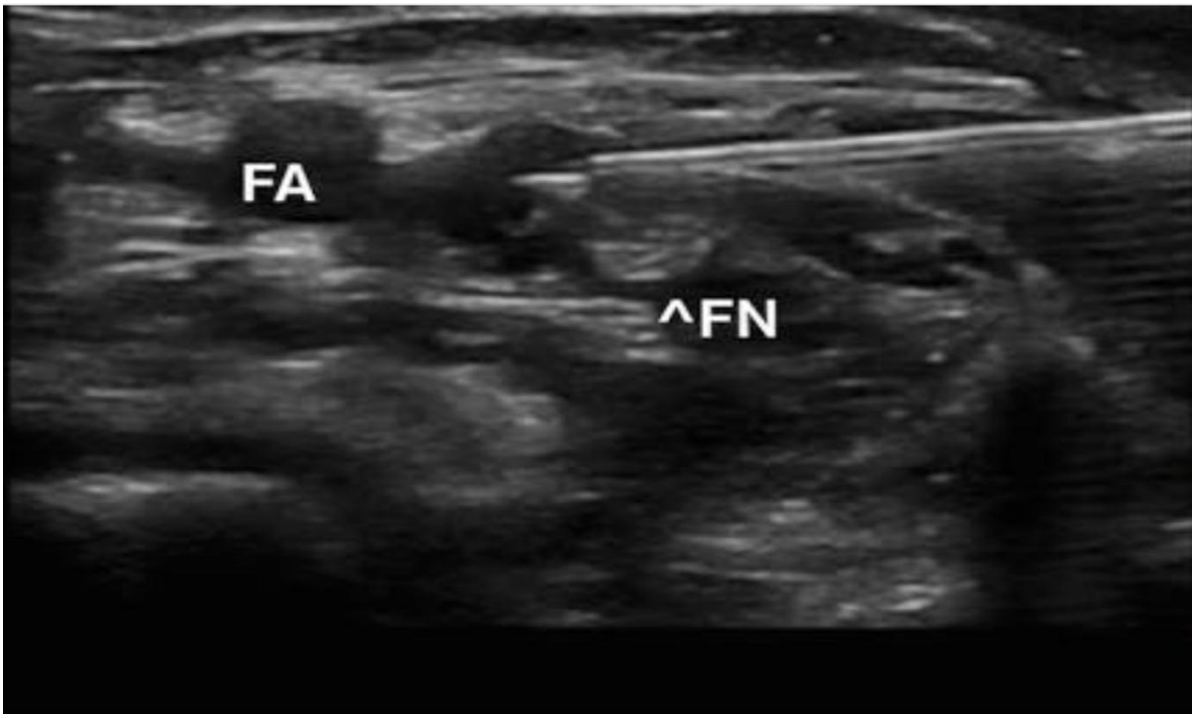




Continuous Ultrasound-Guided femoral nerve block:[10]

The aim to leave a catheter close to the femoral nerve which enables continues supply of local anaesthetic. Considered in three phases:

Phase one: placement of the needle.
Phase two: advancement of the catheter.
Phase three: catheter fixation and securing.



Sciatic nerve
Considered as the largest nerve in body and one of the major nerves that supply the lower limb. It is around 2 cm in width, the sciatic nerve originate from the lumbosacral plexus L4, S3) nerve roots. It gives a motor and sensory supply to the lower limb [10, 11].

Motor supply
Supplies the muscle of the posterior aspect of the thigh including hamstring part of the adductor Magnus, and supplies muscle of the leg and foot.

Sensory: skin over the lateral aspect of the leg, plantar and dorsal surfaces of the foot, heel.

Indications of sciatic nerve block:

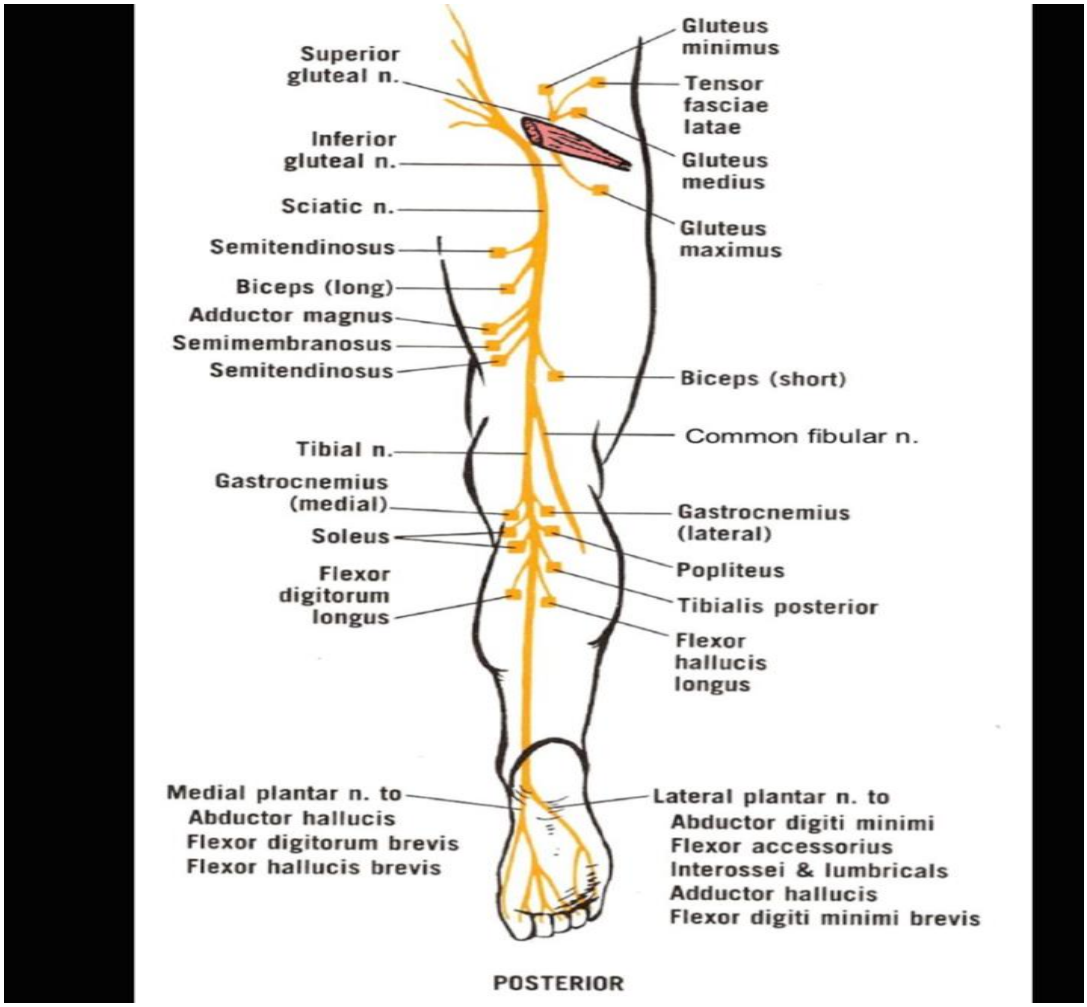
1. Hip surgery.
2. Leg surgery in combination with femoral nerve or lumbar plexus block.
3. Analgesia for above or below knee operations.
4. Ankle and foot surgeries.
5. Complex regional pain syndrome [10, 11, 12].

Many approaches can be used to sciatic nerve block including:
Anterior approach (when patient cannot be mobilizing due to trauma or pain), sub gluteal and trans gluteal also considered. It depends on personal preference and anatomical characteristics.

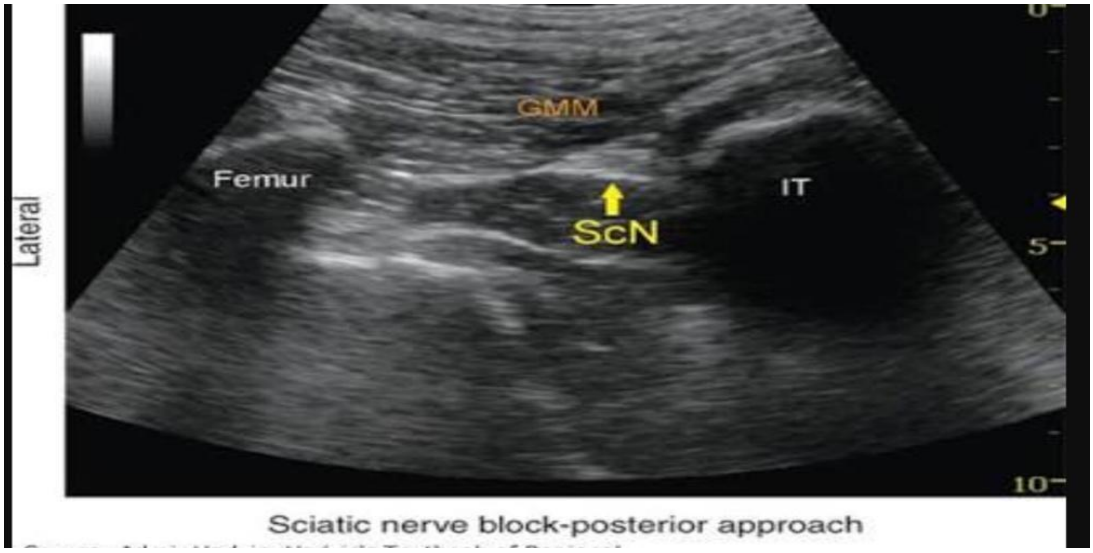
Posterior approach (transgluteal)

Preparation

1. Ultrasound machine with curvilinear probe (2- 6 MHz), with probe cover.
2. Local anaesthetic 20 to 30 ml.
3. Short bevel insulated stimulating needle 21G -22G, 100mm.
4. Peripheral nerve stimulator.
5. Sterile set and sterile gloves.



A. **Patient position:** patient can be in lateral or semi-prone position considering the limb to be blocked is the uppermost with flexed both hips and knees joints.
B. **Landmarks:** Ischial tuberosity, greater trochanter and femur**.**
C. **Ultrasound anatomy:** This block considered to be a quite difficult with ultrasound-guided blocks because of the depth the nerve and anisotropic effect from the triangular shape of sciatic nerve.
   At this level, visualization of the sciatic nerve in short axis between the greater trochanter and ischial tuberosity.
   The most superficial structure is gluteus Maximus muscle and sciatic nerve will be just deeper to it and superficial to quadriceps femoris muscle, more closer to ischial tuberosity side.
   Where it appears as triangular hyperechoic structure [10, 11, 12].



Sciatic nerve block-posterior approach

Conclusion

Ultrasound-guided regional anaesthesia are very useful adjuncts for perioperative pain management for total knee arthroplasty surgery, where it improves the outcome, decreases the hospital stay and more patient satisfaction.

Also blocking multiple nerves founded much better than single nerve, epidural analgesia, or peri-articular infiltration. The femoral and sciatic nerve block combination seemed to be the overall best technique [1, 2, 3, 4 ,5,6,7].

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