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Review Article

Nuts and Bolts of Peripheral Nerve Blocks for Pain After Hip Fracture for Everyday Anesthetist

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Abstract

A range of peripheral nerve blocks is available to treat hip fracture pain, leaving clinicians confused on choice. No single block appears to be outstanding. The article described the relevant anatomy, technical approach, risk associated, and practicability to facilitate a better understanding of the various approaches available. The clinician should be able to make an informed decision based on local requirements and logistics.

Keywords: Hip Fracture, Analgesia, Pain, Regional Anesthesia, Blocks, Preoperative, Emergency Department

1. Context

Hip fractures are one of the most common fragility fractures encountered. In 1990, the worldwide incidence of hip fractures was 1.66 million, projected to reach 6.3 million by 2050 (1). Therefore, there is no doubt that managing patients with hip fractures impose a significant medical and economic burden on healthcare systems. The hip joint has a complex innervation, and the pain following hip fractures or total hip arthroplasties has potentially severe consequences-i.e., delirium, cognitive decline, depression. Inadequate pain control delays mobilization and recovery and is associated with immobility-related complications, such as deep vein thrombosis, pulmonary embolism, atelectasis, pneumonia, increased myocardial demand, and infarction (2), triggered by the sympathetic stress response. The opioid-dependent analgesia may compromise outcomes in frail and elderly populations with hip fractures (3). Central neuraxial analgesia, both epidural and intrathecal, confers excellent analgesia (4-6) but antiplatelet drugs and anticoagulant agents preclude their induction (7, 8).

There is a growing body of data, including randomized controlled trials, observational studies, consensus opinions, national audit initiatives, such as Cochrane systematic reviews (9) and PROSPECT recommendations (10), supporting the use of peripheral nerve blocks (PNB). PNBs effectively reduce pain and quadriceps spasm at rest and on movement, minimize time to remobilization, and reduce opioid requirements. They are not contraindicated in patients taking antiplatelet drugs and anticoagulants, and are especially useful when there is no contraindication to basic analgesics and in those expected with high analgesia requirements.

The use of PNB for pain control after the hip fracture has increased over time; fewer than five out of every 100 patients hospitalized with hip fracture currently receive a PNB, suggesting possible underuse (11). However, there is a lack of clarity in the published literature to unequivocally show which type of PNB is suitable in various locations, settings (emergency department), wards, or operating theatre. Furthermore, the duration of sensory and motor blocks is limited without an adjuvant drug. The use of adjuvant drugs prolongs the duration of analgesia and reduces the dose-dependent side effects of local anesthetics (12, 13).

The review aimed at facilitating a better understanding of various types of peripheral nerve block available in the clinical armamentarium and highlighting the crucial advantages and disadvantages in terms of technical approach, risks associated, and block administration in different locations where anesthesia may be performed. The clinician should be able to utilize a suitable technique based on local requirements and logistics.

2. Search Strategy

Databases, including MEDLINE (Ovid), PubMed, Embase, CINAHL, Google Scholar, and Cochrane, were searched for English language articles published from January 1970 to March 2021. Keywords included “anesthesia” and “analgesia” in different combinations with “hip fracture”. Following the manual search through primary papers, 51 more were retrieved.

3. Regional Anesthesia

A variety of PNBs are utilized for hip fractures: the 3-in-1 block, combined lumbosacral plexus, fascia iliaca compartment, femoral nerve, lumbar plexus plus sacral plexus, posterior lumbar plexus, psoas compartment, obturator nerve, epidural, and combined blocks but the administration of some of them remain controversial (10). The most updated 2020 Cochrane review showed high-quality evidence that nerve blocks reduce pain on movement within 30 minutes by 2.5 points on a Visual Analogue scale (VAS) compared with no nerve block (9). Good quality evidence supported the early (first 48-hour) use of regional analgesia to deliver superior analgesia, spare opioid use, cut delirium, and cognitive dysfunction rates (14).

There was moderate-quality evidence of reduced chest infection and shortened postoperative mobilization (9).

3.1. Anatomy of the Hip Joint and Sensory Innervation

The hip joint, a ball-and-socket articulation of the femur with the acetabulum, is innervated by the femoral, obturator (or accessory obturator) nerves, posteriorly by the sciatic (posterior-superior) and superior gluteal nerve (posterior lateral), and the nerve to quadratus femoris (15). Skin innervation is carried by the lateral femoral cutaneous, genitofemoral nerve, and obturator nerve.

A fibrous capsule encloses the femoral head and most of its neck. The anterior capsule is attached at the intertrochanteric line and innervated by articular branches from the femoral nerve (15). Posteriorly, the lateral half of the femoral neck is extracapsular (EC). Intracapsular (IC) fractures are subcapital, transcervial, or basicervical, while ECs are intertrochanteric or subtrochanteric. Different branches of nerves may be affected depending on IC or EC hip fracture. The femoral nerve is the most dominant nerve supply of the hip joint, which covers the anterior capsule, whilst the obturator nerve covers the inferomedial acetabulum. FNB provides equivalent pain relief in both EC and IC fractures (16).

The sensory nerve supply of bones is limited to A-delta and C sensory nerve fibers, arranged in a fishnet-like pattern under the periosteum. Unlike the skin, which can uniquely sense a multitude of stimuli, bone sensory afferents detect mechanical injury or cortex distortion (stretch and pressure) (17).

The obturator nerve (ON) originates from L2-L4 anterior primary divisions of the lumbar plexus. Articular branches originate either near the obturator canal or from the posterior branch of the obturator nerve. The articular branches of the obturator nerve are known to traverse the infero-medial aspect of the acetabulum before entering the hip joint. In 29% - 54% of individuals, the hip also receives innervation from the accessory obturator nerve, arising directly from the lumbar plexus. When present, it courses over the iliopubic eminence of the hip bone.

The sciatic nerve innervates the posterior and posteromedial areas of the hip joint via articular branches. Two other nerves, the nerve to the quadratus femoris (a direct branch of the sciatic nerve) and the superior gluteal nerve (a component of the sacral plexus), also provide sensory branches to the hip joint. There was scanty information about the frequency of innervation, the exact area of supply, and the clinical relevance of these small nerves.

3.2. Lumbar Plexus Block

Lumbar plexus block (LPB) consists of two separate blocks; the psoas sheath block (PSB) and the psoas compartment block (PCB), and ultimately both block the lumbar plexus (18). It is the most reliable way to block the LFCN, FN, and ON.

The PSB involves an injection into the body of the psoas muscle, which serves as the conduit into the lumbar plexus nerve roots (19). PCB, described by Chayen et al. (20), deposits the LA solution between the psoas and quadratus lumborum muscle. This tissue plane is the lateral extension of and joins the lumbar paravertebral space (21). The lumbar paravertebral region is highly vascular and non-compressible.

The PCB is technically a deeper block, with undesirable effects-i.e., epidural spread, total spinal anesthesia, mild hypotension, plexopathy, systemic toxicity, intraperitoneal injection, retroperitoneal hematoma, renal puncture (22).

In contrast, the lumbar paravertebral block (PVB) deposits LA solution beside the vertebral column near the spinal nerves exit, blocking both somatic and sympathetic (rami communicantes and dorsal root ganglion) fibers

(23). It is a separate entity and not the primary target of the needle when performing an LPB (21). LA solution can find its way into the epidural space via the intervertebral foramen if high injection pressures and volumes are used (19, 24). Anesthesia of the posterior hip would require sacral plexus or parasacral sciatic nerve block. The LPB provides superior analgesia over FICB (25), but it is slightly gone out of favor due to the introduction of safe alternative blocks, such as FICB and FNB.

3.3. The "3 in 1" Block

Made popular by Winnie et al. (26), its premise is that the 3-in-1 (femoral, obturator, and lateral femoral cutaneous nerve block) occurs when a high-volume LA solution streams cranially into the lumbar plexus by blocking the caudal flow. Initial dye and X-ray studies showed that placement of an index finger below the needle insertion point assists LA solution movement into the natural gutter between the quadratus lumborum, psoas, and iliacus muscles but magnetic resonance imaging (MRI) proved otherwise (27). The terminology is under question and needs to be abandoned (28).

The 3-in-1 block is in the best state as a femoral nerve block or a 2-in-1 femoral and lateral femoral cutaneous nerve block (29). Marhofer et al. (30), validated that an infra-inguinal injection of an LA solution does not travel cephalad to reach the obturator nerve in the lumbar plexus. In a recent volunteer-based trial, it was found that a supra-inguinal fascia iliaca block resulted in a more consistent blockade of the obturator nerve than an infra-inguinal approach (80% vs. 10%) (31). Curiously, the infra-inguinal approach reliably blocked the femoral nerve only in 40% of the cases in the same study, using thigh adductor strength as a marker of obturator nerve blockade. The fascia iliaca compartment block or the 3-in-1 block itself is misleading as the pectineus muscle, supplied by the femoral nerve, also adducts the thigh (32).

3.4. Fascia Iliaca Compartment Block

The complexities of LPB were offset by the fascia iliaca compartment block (FICB), which is essentially a field block. LA agent, 30 - 40 mL in a total volume, is deposited into a compartment between the fascia iliaca and the iliacus and psoas muscle, forming an indirect route to the femoral and lateral femoral cutaneous nerve of the thigh. Recent evidence reveals that the ON is not covered (27). There are several variations of the fascia iliaca block, depending on the LA deposition superior or inferior to the inguinal ligament. The blockade of the femoral nerve through this route is assumed to be reliable, given that the femoral nerve lies under the fascia iliaca. However, the LFCN is highly variable in its origin, division, and course (33). Distal injections may not reliably anesthetize the LFCN as it leaves its position under the fascia iliaca to course outwards through the fascia lata. Supra-inguinal approaches deposit the LA agent closer to the LFCN (34, 35).

Its main advantage is that the needle is relatively far from critical vascular structures-the femoral nerve, artery, and vein. Real-time ultrasound-guided FIB increases the efficacy of sensory blockade when compared with landmark technique, where the haptic sensation is not often discernible (36). Bupivacaine concentrations both (0.2% and 0.3%) lowered the pain scores but higher concentration was associated with more motor blockade (37). A meta-analysis by Hong and Ma (38) showed that FICB reduced pain intensity and also had morphine-sparing effect. The optimal injectate volume was not identified. The analgesic effect was superior to that of opioids during movement, with very few adverse effects. There was insufficient evidence to conclude that analgesic consumption, incidence and severity of delirium, and length of stay or mortality are different from other nerve blocks (39).

3.5. Femoral Nerve Block

Femoral nerve block, preferably ultrasound- or nerve stimulator-guided, has long been used for hip fracture analgesia (40) and decreasing the pain of femoral shaft fractures (41) while positioning for spinal anesthesia is evident (42). A meta-analysis of five studies demonstrated a mean difference of -2.13 on a Visual Analogue Scale (VAS) (43).

A systemic review by Riddell et al. (44), demonstrated that the utility of both single and continuous femoral nerve blocks are associated with decreased pain intensity, decreased amount of required rescue analgesia, and fewer adverse events associated with systemic narcotic use in elderly patients aged above 65 presenting to the emergency department with acute hip fracture. Emergency medicine specialists (45) can gain technical proficiency after brief training. The complications associated with femoral nerve blocks are relatively low and usually relate to falls on ambulation due to quadriceps weakness, especially in patients undergoing knee arthroplasty (46). It is unclear if it is a problem for hip fractures, as the timing of block and ambulation needs vary. The key landmarks for femoral nerve block include the inguinal ligament, inguinal crease, and femoral artery. The needle is inserted above the femoral crease and below the inguinal ligament, 1 - 2 cm lateral to the pulse of the femoral artery. For hip fractures, it is prudent to perform the block as close to the inguinal ligament before the nerve splits into an anterior and posterior division.

3.6. Lateral Femoral Cutaneous Nerve Block

Unusual importance is given to the fascia iliaca block to block LFCN. Blockade of this nerve is unwarranted when analgesia is needed before the surgery, such as when the patient has just arrived at the emergency room. Even though LFCN supplies the area where the incision for certain hip interventions may occur, it hardly justifies using an additional 20 mL of LA agent for a small cutaneous nerve. Local infiltration by the surgeon over the incision site should provide the same degree of analgesia without exposing a susceptible patient to large doses of LA solutions. The LFCN does not contribute to hip fracture pain. However, LFCN block would contribute to postoperative analgesia of the incision site.

3.7. Obturator Nerve Block

Blockade of the obturator nerve during the FICB is also highly inconsistent even when large volumes of LA solution are used. Its advantage is that it can be performed without much equipment in challenging environments and is sited a distance from the femoral nerve and vessels. The block is promising but would require clinical trial validation.

3.8. Sacral Plexus Block

A sacral plexus block (SPB) is combined with LPB for complete surgical anesthesia in high-risk patients. There are three ultrasound techniques (47-49). The sacral plexus is imaged within the greater sciatic foramen, the most proximal area where the sciatic nerve can be blocked. Like the lumbar plexus, SPB should be performed in a lateral position. It may cause some discomfort for the patient. Though not overtly deep, the risk of injury to intrapelvic structures is possible if the needle is inserted too anteriorly. The risk-to-benefit ratio for fracture analgesia is concerning and usually reserved for surgical anesthesia in high-risk patients.

3.9. Pericapsular Nerve Group Block

Pericapsular nerve group (PENG) block is a novel inter-fascial plane block used to block the articular branches of the hip joint namely the femoral, obturator, and accessory obturator nerves (AON) between the anterior inferior iliac spine and the ilio-pubic eminence before entering the anterior hip capsule. The benefit of PENG block includes patient positioning for the procedure, no significant motor weakness (potential motor sparing effect), and analgesic efficacy. The anatomic study by Short et al. (50) on the anterior hip capsule with median pain reduction of seven points showed a significant decrease compared with previously reported RA techniques for different types of hip pathologies: intertrochanteric fracture, subcapital fracture, and femoral head metastasis. The procedure is technically simple and quick, requiring small (10 - 15 mL) volumes of LA solution. Ultrasound is used to identify the bony landmarks of the hip bone, including anterior inferior iliac spine (AIIS), pubic ramus, ilio-pubic eminence, and femoral artery. LA solution is deposited between the psoas tendon anteriorly pubic ramus posteriorly. The PENG block can be paired with a separate LFCN block to provide analgesia over the incision site if necessary (51).

3.10. Quadratus Lumborum Block

Quadratus lumborum block (QLB) is an abdominal inter-fascial plane block in which LA solution finds its way into the anterolateral aspect of quadratus lumborum muscle (QLM) between the muscle and the posterior abdominal fascia (52). Spread is into L1-L3 nerve roots in psoas major, QLM, and paravertebral space if a deeper injection is performed. QLB in hip surgery produces a significant reduction in length of stay and intraoperative fentanyl use (53).

3.11. Lumbar Erector Spinae Plane Block

Lumbar erector spinae plane block (L-ESPB) is a paraspinal fascial plane block where an LA agent is injected between the erector spinae muscle and the thoracic transverse process. An indirect route into the paravertebral space is postulated but cadaver dissection and latex dye injections are conflicting (54). When the erector spinae muscles are blocked at a lumbar level, specifically at L4, LA can spread from L2 to S1, giving long-lasting pain relief. This unilateral block avoids the side effects of epidural block. L-ESPB and QLB-T have similar effects; they improve analgesia quality in patients undergoing hip and proximal femoral surgery compared with standard intravenous analgesia regimen (55); however, the actual underlying mechanisms are not clearly understood (54).

4. Advantages and Disadvantages of Peripheral Nerve Block

The distinct advantages and disadvantages of different peripheral nerve blocks are shown in Table 1.

5. Unanswered Questions

The published guidelines usually do not favor a particular block unless the evidence is overwhelming. Does a patient with a hip fracture require a simple or complicated blockade with various combinations and iterations?

Table 1. The Distinct Advantages and Disadvantages of Different Peripheral Nerve Blocks

Type of Block	Approach	Volume Required, mL	Advantages	Disadvantages
Lumbar plexus block/psoas compartment block	Shamrock approach (USG)/PNS	20 - 35	Complete blockade of nerve supply to the anterior hip, using a single injection; the use of ultrasound allows to determine safe depth for needle insertion and guides block needle to target and visualize the spread of injected LA with improved accuracy and success.	Risk of vascular puncture, inadvertent local anesthetic systemic toxicity, and psoas hematoma; risk of unintentional neuraxial spread; risk of renal injury; Need for advanced skill and training, technical difficulty; ultrasound scan is usually performed in lateral, sitting, and prone positions.
Fascia iliaca compartment block	Landmark/Suprainguin (USG)	20 - 40	Easy to perform; done in a supine position; reliably blocks femoral nerve (100%) and LFCN (80% - 100%)	Requiring a large volume of LA for nerve block. Effects are dependent on extent of the spread and the nerves blocked; It does not reliably block the obturator nerve
Femoral nerve block	PNS/USG	10 - 15	Easy to perform (basic block can be done in ED settings); done in a supine position; Reliable with a high success rate	Does not block obturator and lateral femoral cutaneous nerves; risk of inadvertent intravascular injection into the surrounding femoral artery or vein; following hip arthroscopy, landmarks might be displaced by fluid extravasation, with the artery and nerve significantly deeper than their preoperative positions
Sacral plexus block	USG/PNS	Up to 20	Provides additional analgesia to the posterior capsule and cutaneous skin over the buttock	Requires lateral positioning; It does not cover nerve supply to anterior hip
Pericapsular nerve group block	USG	10 - 15	Blocks specific proximal articular branches that innervate the hip joint. The proximal approach potentially provides complete analgesia to the hip joint. Done in a supine position; Potential motoring sparing effect	Relatively a new block since 2018, lack of data on whether it is superior to other blocks; it cannot be used as a sole anesthetic block for hip surgery.
Quadratus lumborum block	USG	15 - 20	Provides both somatic and visceral analgesia; may potentially cover both the lumbar and sacral nerve plexus	Requires an advanced skill level; requires lateral positioning; risk of vascular puncture as the QL region is relatively vascular with lumbar arteries lying posterior to the muscle. risk of puncture to intra-abdominal structure such as kidney, liver, spleen
Lumbar erector spinal block	USG	20	Less risk of nerve, vessel damage, and inadvertent LAST as needle inserted distant to vessels and nerves compared with LPB; neuraxial spread is less likely due to superficial location. A large volume of L-ESPB can potentially provide extended sensorial coverage as LA can spread to L4-L5 nerve roots that are part of the upper portion of the sacral plexus.	Requires an advanced skill level; requires lateral positioning; It cannot be used as a sole anesthetic technique.

In case of hip fractures, all relevant PNBs provide some degrees of analgesia, albeit superior to most opioids. Nerve blocks are included in most protocols and guidelines, not as an option but as a primary mode of analgesia.

6. Timing of Block Administration

Do patients require nerve blocks before surgery or after? An unstable bone causes severe pain in the slightest movement. Temporary immobilization minimizes this discomfort. The ideal time to administer a nerve block is prior to surgical fixation, and efforts must be made to shorten the door-to-block time. When fixed, there is fracture stability and less pain. Of the various surgical approaches, complete joint replacement is less painful over fixation techniques, such as dynamic hip and intramedullary screws (56). The clinician can match the appropriate postoperative regime with drugs or regional anesthesia.

7. Conclusions

The effectiveness of nerve blockade over pharmacological therapy is established. No single peripheral nerve block has a significant advantage over other types.

Given the mythological assumptions on elderly pain and the lack of an assessment tool, the authors believe that nerve blocks should be the first-line approach. The femoral nerve block and FIB appear to have an edge. The FIB has a relatively lower risk of harm in the hands of paramedics, nurses, and ED physicians; nevertheless, the femoral nerve can be missed.

Blocking of the lumbar plexus, paravertebral, or interfacial quadratus plane is technically challenging and requires expertise. Although LPB may provide superior analgesia compared to FICB, however, the authors cannot draw firm conclusions based on low quality evidence and recommend its widespread use. The risk of relative harm prevails over block superiority deliberations. Hitting the lumbar plexus through a femoral block (anterior LPB approach) would be ideal and safe. The authors await a proof-of-concept cadaver or imaging study whereby a femoral perineural catheter threaded into this space extends into the lumbar plexus.

Footnotes

Authors' Contribution: Study concept and design: AM, JM, WAC, and CMK. Analysis and interpretation of data: AM, JM, and WAC. Drafting of the manuscript: AM, JM, WAC, CMK, and FI. Critical revision of the manuscript for important intellectual content: WAC, CMK, FI, and FR. Statistical analysis: AM, JM, and WAC.

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