Review Article

Regional Anesthesia for Hip Surgery Patients: Review Article

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Successful postoperative pain control is one of the keys on the patients' recovery after surgery, especially in the hip fracture and hip reconstruction surgery. Currently, the concept on pain management with multimodal analgesia and regional anesthesia plays a key role for postoperative analgesia and has demonstrated the ability of enhancing postoperative recovery, reducing opioids consumption, and decreasing the time to mobilization. Nonetheless, the development of new regional analgesic techniques has evolved in the past four decades and can be intimidating to the general anesthesiologists. Therefore, the present article aimed to provide a concise review of the hip innervation and the current regional analgesic techniques as a practical guide for the perioperative pain management after hip surgery.

Keywords: Total hip replacement; Hip fracture; Hip nerve innervation; Lumbar plexus block; Femoral nerve block; Fascia iliaca block; Pericapsular nerve group block; Quadratus lumborum block; Erector spinae plane block; Local infiltration analgesia; Postoperative analgesia

Received 29 October 2021 | Revised 21 December 2021 | Accepted 21 December 2021

J Med Assoc Thai 2022;105(2):152-9

Website: http://www.jmatonline.com

Effective postoperative analgesia has a significant impact on patient's outcomes and recovery function after surgery. Current concepts of postoperative pain management are based on multimodal analgesia, with regional anesthesia playing a key role for postoperative pain control. Regional analgesic technique has been shown to achieve the goals of enhanced recovery after surgery, by minimizing opioid consumption and shortening time to mobilization. However, the recent expansion in the number and types of regional analgesic technique can be daunting for general anesthesiologists. Therefore, the present review article aimed to provide a concise overview of hip innervation and regional analgesic technique as a practical guide for the perioperative pain management after hip surgery.

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How to cite this article:

Chalacheewa T, Termpornlert S, Sa-ngasoongsong P, Sangkum L. Regional Anesthesia for Hip Surgery Patients: Review Article. J Med Assoc Thai 2022;105:152-9.

DOI: 10.35755/jmedassocthai.2022.02.13263

Nerve innervation of hip

Cutaneous innervation

The skin dermatomes relevant for hip surgery come from the lumbosacral plexus. The iliohypogastric nerve innervates the inferior abdominal wall and the upper lateral quadrant of the buttock. The ilioinguinal nerve innervates the inferior to medial aspect of the inguinal ligament. The genitofemoral nerve supplies inferior to mid portion of the inguinal ligament and spermatic cord. The femoral nerve (FN) innervates the anterior aspect of the thigh, and the obturator nerve (ON) innervates the anteromedial aspect of the thigh. The lateral cutaneous nerve of the thigh innervates the lateral aspect. The posterior aspect is innervated by the sacral plexus[1,2] (Figure 1).

Muscles and nerve innervation

The hip muscles can be divided into three main groups as shown in Table 1[1,2].

Hip joint and nerve innervation

The hip joint is a ball-and-socket synovial joint. The ball is the femoral head, and the socket is the acetabulum. The circumference of the acetabulum is encompassed by the fibrocartilaginous rim called labrum. The labral innervation is from a branch of the nerve to the quadratus femoris and ON. Free nerve endings were seen in all parts of the acetabular labrum; however, they were more numerous in the

Table 1. Muscle and nerve innervation around the hip

Muscle	Nerve
Iliopsoas group (Iliacus, psoas major, and psoas minor)	Anterior rami of spinal nerves L1 to L3 and femoral nerve (L2 to L4) (iliacus only)
Gluteal muscles	Superior (L4 to S1) and inferior (L5 to S2) gluteal nerves
• Superficial (Gluteus maximus, gluteus medius, gluteus minimus, and tensor fasciae latae)	Nerve to piriformis (S1 to S2), nerve to obturator internus (L5 to S2), nerve to quadratus femoris (L4 to S1), obturator nerve (L3 to L4)
• Deep (Piriformis, gemellus superior, obturator internus, gemellus inferior, obturator externus, and quadratus femoris)	
Hip adductors (Gracilis, pectineus, adductor longus, adductor brevis, adductor magnus, and adductor minimus)	Obturator nerve (L2 to L4) and femoral nerve (L2 to L3) (pectineus only)

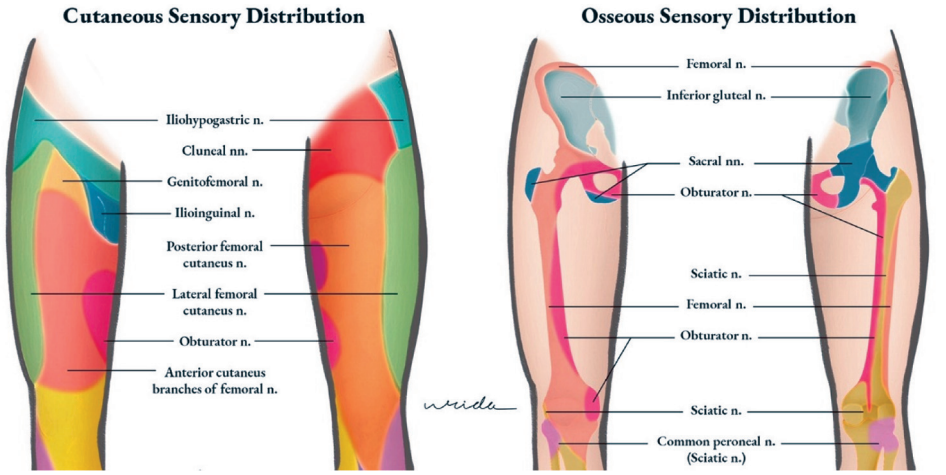

Figure 1. Skin and hip joint and nerve innervation.

superior and anterior quarters[3]. An understanding of the osteotomal innervation of the femur and hip joint is important in block planning (Figure 1).

Hip capsule and nerve innervation

The hip capsule receives innervation from a variety of nerves of the lumbosacral plexus and their articular branches (ABs). The ABs innervating the hip joint were found to arise from the FN, accessory FN, ON, accessory obturator nerve (AON), sciatic nerve, superior gluteal nerve (SGN), and inferior gluteal nerve (IGN), as well as the nerve to the quadratus femoris (NQF)[4-6].

• Anterior section of the hip joint capsule was supplied by the ABs of the FN, ON, and AON. The FN was mostly responsible for the sensory innervation of the anterior and anterolateral region and ON and AON were mostly supplied anteromedial section of the hip joint capsule. The accessory ON is inconsistently present. Gardner[7] was able to identify it in 25% of cases, whereas Kampa et al[8] and Short et al[9] observed it in 5% and 54% of specimens, respectively (Figure 2).

• Posterior section of the hip joint capsule was supplied by the ABs from the nerve to the quadratus femoris muscle, as well as by ABs from the SGN, IGN, and directly by the sciatic nerve. Kampa et al(8) is the only one who described an AB of the IGN. The branch was identified in 10% of specimens and was described as entering the posterior capsule inferolaterally (Figure 3).

Surgical approaches to hip surgery had an impact on soft tissue injuries from skin to bone. Table 2 summarizes the soft tissues that were affected by the common surgical approach to the hip joint (Figure 4, 5)[10].

Regional analgesic techniques for hip surgery

Epidural analgesia

Epidural technique can cover nerve innervation around the hip in term of lumbosacral plexus. Epidural analgesia may be useful for postoperative pain relief following major lower limb joint replacements. Choi et al in 2003 reported that an epidural infusion of local anesthetic or local anesthetic-narcotic mixture may be better than epidural narcotic alone in postoperative

Table 2. Surgical approaches and affected tissues

Total hip arthroplasty and bipolar hemiarthroplasty				
Operation	Skin incision	Muscle	Ligament	Bone
Antero-lateral approach	Start at a point 2 to 3 cm posterior to the ASIS and direct toward the mid portion of the GT. It then continues 10 to 15 cm along the axis of the femur.	Tensor fascia lata Gluteus medius Gluteus minimus	Anterior joint capsule	Acetabulum, femoral neck, and shaft of femur
Direct anterior approach	Start 2 to 4 cm lateral to the ASIS then direct distally and laterally for about 8 to 12 cm at 20° from the sagittal plane of the patient toward the lateral aspect of the patient's ipsilateral knee.	Tensor fascia lata Rectus femoris Gluteus medius	Anterior joint capsule	Acetabulum, femoral neck, and femoral shaft
Direct lateral approach	A longitudinal incision from 3 to 5 cm proximal and about 5 to 8 cm distal to the tip of the GT.	Tensor fascia lata Gluteus maximus Gluteus medius Gluteus minimus Vastus lateralis	Anterior joint capsule	Acetabulum, femoral neck, and femoral shaft
Posterior approach	Start 5 cm distal to the greater trochanter and centred on the femoral diaphysis. The incision continues proximal to the GT, and then curves toward the PSIS for 6 cm.	Tensor fascia lata Gluteus maximus Piriformis	Posterior joint capsule	Acetabulum, femoral neck, and femoral shaft
ORIF with cephallomedullry nail e.g., PFNA	A 5-cm incision proximal from the tip of the GT.	Tensor fascia lata Gluteus medius	-	Femoral head, neck, and shaft

ORIF=open reduction and internal fixation; PFNA=proximal femoral nail antirotation; ASIS=anterior superior iliac spine; GT=greater trochanter; PSIS=posterior superior iliac spine

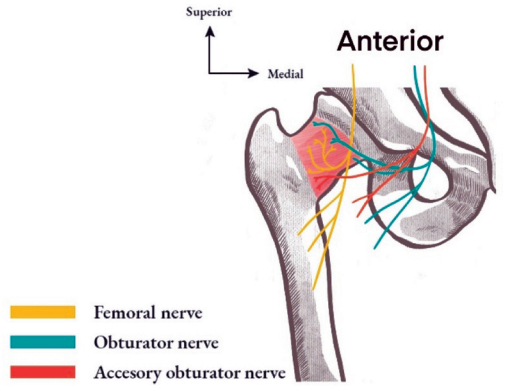

Figure 2. Innervation of the anterior hip joint capsule.

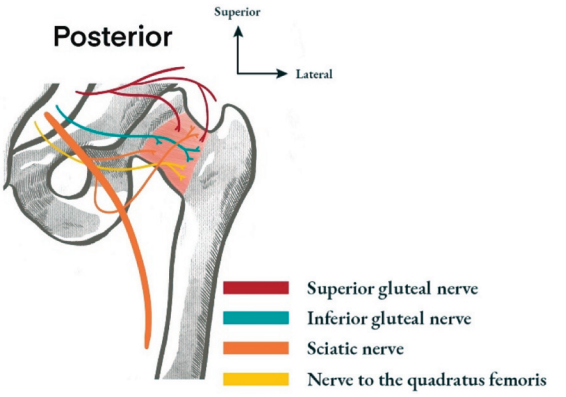

Figure 3. Innervation of the posterior hip joint capsule.

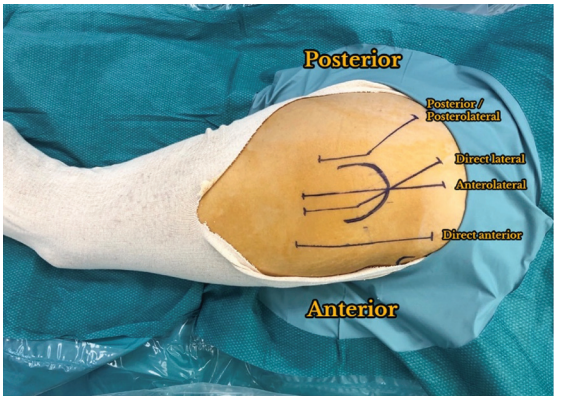

Figure 4. Surgical approaches for total hip arthroplasty.

Figure 5. Incision in proximal femoral nail antirotation (PFNA).

pain relief following hip and knee replacement. However, the magnitude of pain relief must be weighed against the frequency of adverse events[11], especially in the hip fracture patients who almost occurred in complicated elderly patients. In this age group, long-term drug intake and comorbidities caused by chronic underlying diseases such as hypertension, diabetes mellitus, and cardiovascular diseases lead to hemodynamic instability as a major concern in postoperative epidural analgesia.

Lumbar plexus block (LPB)

LPB targets the FN, LFCN, and ON. LPB is one of the anesthetic options in the elderly patients undergoing hip surgeries. Effectiveness of LPB is attributed to the sufficient analgesia provided intraoperatively as well as postoperatively. LPB results in less hypotension and improved analgesia in elderly patients undergoing hip fracture repair and is as effective as epidural block for analgesia after THA, with less nausea, urinary retention, motor block, and hypotension[12-16]. LPB has been associated with potentially serious complications by difficult technique such as total spinal anesthesia, psoas hematoma or abscess, LA spread to epidural, and renal trauma. Another concern, LPB is a deep block and should be avoided in patients with abnormal clotting or platelet dysfunction.

Fascia iliaca compartment block (FICB)

FICB relies on proximal spread of local anesthetic beneath the fascia iliaca providing an anterior approach to the FN, LFCN, and ON. Supra-inguinal approach with 40 mL of LA[17-20] produces a more complete sensory block of the medial, anterior, and lateral region of the thigh, compared with an Infra-inguinal approach[19]. FICB with multimodal analgesia could be used to effectively reduce pain intensity up to 24 hours, total morphine consumption, and length of hospital stay in THA patients[20,21]. Nowadays, FICB has been used preoperative and postoperative for hip fractures and is widely believed to offer fast and adequate pain relief with fewer adverse effects than the systemic analgesia, especially in the elderly[22-27]. The hip fracture outside capsule such as intertrochanteric fracture might not require the volume of LA spreading to ON. This is because only FN and LFCN are affected from the surgical technique.

Femoral nerve block (FNB)

FNB has a high success rate and carries a low risk of complications. However, proximal spread of local anesthetic to the other branches of the lumbar plexus is unreliable. A single shot, low volume FNB is not useful after hip arthroplasty as this approach is too distal to provide clinically useful anesthesia or analgesia of the hip. Another study showed continuous FNB was compared with LPB[28] and with epidural analgesia[29]. Similar pain and analgesic requirements were reported. When FNB was compared with fascia iliaca block, pain scores were higher in the FNB group[30]. FNB may also be useful when positioning patients for neuraxial anesthesia when compared with intravenous fentanyl in hip fracture[31]. The authors prefer FICB over FNB in THA and hip fracture surgeries.

Pericapsular nerve group (PENG) block

The PENG block is firstly described by Girón-Arango et al for the blockade of the ABs of the femoral, obturator and accessory ONs that provide sensory innervation to the anterior hip capsule[32,33]. It has been successfully used as an alternative regional anesthesia technique for the management of acute pain after hip fracture[34,35]. Currently, the PENG with LFCN block has been shown to be effective in total hip replacement surgery[36]. The PENG block provided optimal postoperative analgesia, fast motor recovery, and reduced opioid consumption as recommended by enhanced recovery after surgery protocols. For this reason, PENG block may be a useful regional anesthesia technique to manage postoperative pain in the context of modern fast-track hip surgery. More prospective studies are still needed.

Quadratus lumborum (QL) block

The QL block is a regional anesthesia technique originally described in 2007 to provide analgesia for abdominal surgery. Multiple approaches are described in the literature and incudes lateral, posterior, and anterior or transmuscular. Different approaches determine different spread patterns of injectate with affected dermatomes ranging from thoracic T6 to lumbar L2[37]. This block could also provide analgesia to the hip, and various reports have demonstrated efficacy in the setting of femoral neck fracture[38,39] and hip arthroplasty[40-43]. Cadaveric studies of the transmuscular QL block showed direct dye spread to the roots and branches of the lumbar plexus[44,45]. Nassar et al[46], reported both FICB and QL block had comparable durations of analgesia. Postoperative visual analog scale values, both static and dynamic, were comparable between the two groups. FICB showed slightly lower 24

hours morphine consumption, while QL block showed two additional advantages, a lower pain score during positioning for subarachnoid block and a more preserved postoperative motor power. However, Sophia et al[47], found no reduction of morphine consumption or pain scores in first 24 hours postoperatively, and no advantages in terms of time to first standing, ambulation, or hospital stay in posterior QL block with multimodal analgesia. Because there were still mixed results in terms of reduction of morphine consumption and pain scores, which correspond with functional outcome between various QL block techniques, more outcome data based on prospective studies are needed.

Erector spinae plane block (ESPB)

Ultrasound-guided ESPB is an interfascial plane block, first described by Forero et al[48] in 2016, which is used in the treatment of thoracic neuropathic pain. The plausible mechanism of action is proposed by the local anesthesia was distributed in paravertebral foramina, partially epidural area, and lumbar nerves[49]. In clinical studies, ESPB was reported in the treatment of postoperative pain from surgical procedures, ranging from shoulder to hip surgery[50-54]. However, currently the evidence for lumbar ESP block for hip surgery is limited to case reports, while randomized control trial is scarce. More data are required to determine the efficacy of this novel technique.

Local infiltration analgesia (LIA)

LIA is a simple, surgeon administered technique for pain relief after THA and TKA and little adverse events[55-57]. LIA for THA requires systematic, extensive, and meticulous multilayer tissue injection before surgical wound closure, encompassing both capsular and soft tissues[58]. Injectate typically contains local anesthetics, as well as other analgesic adjuncts such as ketorolac, dexamethasone or adrenaline[59]. There have been randomized controlled trials that compared the efficacy of LIA with intrathecal morphine or epidural analgesia in patients after THA[60]. In a recent meta-analysis, no difference was observed between LIA and peripheral nerve blocks such as LPB, FNB, or FIB, in terms of cumulative opioid use and pain scores at 24 hours after hip surgery[61]. PROSPECT recommended LIA as a part of analgesia and enhanced recovery (ERAS) after surgery for THA[21]. There were still no RCTs of LIA recommended for ORIF with intramedullary nail.

The possible advantages and disadvantages of each regional anesthetic technique are given in Table 3.

Conclusion

The hip is a complex joint that is innervated by branches of lumbar and sacral plexus. An understanding of the dermatome, myotome, and osteotome innervation of hip area from skin to joint is important in block planning. Hip surgery can be performed by regional anesthesia/analgesia techniques. Epidural analgesia provides analgesia in both anterior and posterior side of hip but must be weighed against the adverse events. Alternative nerve and interfascial plane blocks may have a role in analgesia for patients undergoing hip surgery. There is supportive evidence for lumbar plexus, FN, and fascia iliaca block but rigorous studies of PENG block, QL block, and erector spinae plane (ESP) block are lacking. However, the blocks that cannot provide analgesia of both side of hip, multimodal analgesic in the perioperative period are mandatory.

What is already known on this topic?

Many regional anesthesia techniques are available for hip surgery analgesia. Ideal block technique for hip surgery is not yet defined.

What this study adds?

An understanding of the dermatomal, myotomal, and osteotomal innervation of hip joint is important in block planning. Epidural analgesia provides good analgesia but must be weighed against the adverse events. Alternative nerve and interfascial plane blocks may have a role in analgesia for patients undergoing hip surgery. There is supportive evidence for lumbar plexus, FN, and fascia iliaca block but rigorous studies of PENG block, QL block, and ESP block are lacking. However, the blocks that cannot provide analgesia of both side of hip, multimodal analgesic in the perioperative period are mandatory.

Conflicts of interest

The authors declare no conflict of interest.

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Table 3. Comparison advantages and disadvantages of regional anesthetic techniques on analgesic efficacy

	Possible advantage	Possible disadvantages
Epidural analgesia	• Provide the best pain relief when compare to other techniques by covering lumbar and sacral plexus that are the nerve innervation around the hip[11]	• Epidural related side-effects[11] • Hypotension • Nausea/vomiting • Itching • Urinary retention • Muscle weakness that may limit ambulation after surgery • Limit in patients with abnormal clotting or platelet dysfunction • Risk of block related side-effects (e.g., hematoma, infection)
Lumbar plexus block	• Target the lumbar plexus but not sacral plexus • Provide good pain relief and decrease postoperative morphine consumption after hip surgery[12-16]	• Less hypotension when compare with epidural analgesia[13] • Risk of block related side-effects (e.g., hematoma, infection, LAST, epidural spreading) • Limit in patients with abnormal clotting or platelet dysfunction • Quadricep weakness • Difficult technique
Fascia iliaca compartment block	• Target the femoral, lateral femoral cutaneous, and obturator nerve[20] • Provide good pain relief and decrease postoperative morphine consumption after hip surgery[20,21] • No effect on hemodynamics	• Risk of block related side-effects (e.g., hematomas, infection, LAST, nerve injury, perforation of intraperitoneal) • Quadricep weakness
Femoral nerve block	• Provide good pain relief and decrease postoperative morphine consumption after hip surgery • No effect on hemodynamics	• Risk of block related side-effects (e.g., hematomas, infection, LAST, nerve injury) • Quadricep weakness • When femoral nerve block was compared with fascia iliaca block, pain scores were higher in the femoral nerve block group[30]
Pericapsular nerve group block	• Target the articular branches of femoral, obturator and accessory obturator nerves that innervate to the anterior of hip capsule • Provide good pain relief and decrease postoperative morphine consumption after hip surgery • No effect on hemodynamics	• Risk of block related side-effects (e.g., hematomas, infection, LAST, nerve injury) • Less quadricep weakness compare with epidural analgesia, FICB, and femoral nerve block
Quadratus lumborum block	• Target at roots or branches of the lumbar plexus[44,45] • Controversial results in term of decrease 24 hours morphine consumption and pain score[46,47]	• Risk of block related side-effects (e.g., hematomas, infection, LAST, nerve injury) • Quadricep weakness has been reported, especially anterior QL approach
Lumbar erector spinae plane block	• Local anesthesia was observed in paravertebral foramina, partially epidural area, and lumbar nerves[49] • Benefit in clinical use is still controversy. Level of evidence has been reported in case report or case series studies[53,54]	• Risk of block related side-effects (e.g., hematomas, infection, LAST, nerve injury)
Local infiltration analgesia	• Easy to perform • Recent meta-analysis showed that LIA had comparable pain score and 24 hours morphine consumption with peripheral nerve blocks after hip surgery[61]	• Risk of LAST, infection, and hematomas • Operator dependent

LIA=local infiltration analgesia; LAST=local anesthetic systemic toxicity; FICB=fascia iliaca compartment block; QL=quadratus lumborum

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