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Fascia iliaca compartment blocks: Different techniques and review of the literature

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The fascia iliaca compartment block has been promoted as a valuable regional anesthesia and analgesia technique for lower limb surgery. Numerous studies have been performed, but the evidence on the true benefits of the fascia iliaca compartment block is still limited. Recent anatomical, radiological, and clinical research has demonstrated the limitations of the landmark infrainguinal technique. Nevertheless, this technique is still valuable in situations where ultrasound cannot be used because of lack of equipment or training. With the introduction of ultrasound, a new suprainguinal approach of the fascia iliaca has been described. Research has demonstrated that this technique leads to a more reliable block of the target nerves than the infrainguinal techniques. However, more research is needed to determine the place of this technique in clinical practice.

Anatomy of the lumbar plexus and implications for regional anesthesia

The lumbar plexus consists of the ventral rami of the L1-L4 spinal nerves and commonly a small contribution of the subcostal nerve from T12. Besides ilioinguinal, iliohypogastric, and genitofemoral nerves, it also forms the femoral, obturator, and lateral femoral cutaneous nerves (Fig. 1).

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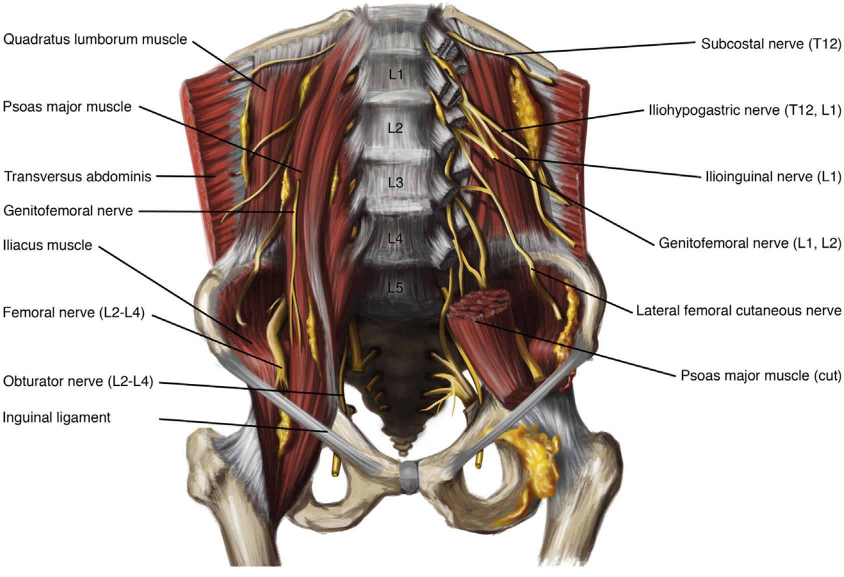

Fig. 1. The anatomy of the lumbar plexus.

The femoral nerve (FN) is formed in the psoas muscle by the dorsal divisions of the L2-L4 nerve roots. At the level of the fifth lumbar vertebral body, the FN exits the psoas muscle in a medial to lateral direction deep to the iliac fascia. It continues caudally posterior to the inguinal ligament, anterior of the iliopsoas muscle, and lateral of the femoral artery and vein. The FN innervates the quadriceps and sartorius muscles and inconsistently innervates the pectineus muscle. The sensory distribution of the FN is located in the anterior and medial portion of the thigh.

The lateral femoral cutaneous nerve (LFCN) is formed in the psoas muscle by the dorsal divisions of the L2-L3 nerve roots. The LFCN will also exit the psoas muscle laterally deep to the iliac fascia. At the level of the anterior superior iliac spine, it dives under the inguinal ligament and further continues anterior to the sartorius muscle. The LFCN is a purely sensory nerve innervating the lateral aspect of the thigh.

The obturator nerve (ON) is formed by the ventral divisions of the L2-L4 nerve roots. It exits the psoas muscle medially at the level of S1 and continues outside the fascia iliaca compartment toward the obturator canal, where it leaves the pelvis. The ON divides into an anterior branch and a posterior branch ventrally and dorsally of the adductor brevis muscle. The ON innervates the adductor muscles of the lower limb with the exception of the internal obturator muscle and an inconsistent innervation of the pectineal muscle. The ON has also an inconsistent sensory distribution on the medial aspect of the thigh [1].

As these three nerves innervate, an important portion of the lower limb, a lumbar plexus block, targeting the nerves with a single injection, could result in anesthesia and analgesia after lower limb surgery.

Numerous posterior approaches of the lumbar plexus, both landmark-based and ultrasound-guided (USG), have been described. However, posterior approaches require the lateral position, are technically challenging, and have inherent risks such as spinal and epidural spread, intravascular injection, hematoma formation, and infection [2]. Because of the difficulties associated with the posterior approach of the lumbar plexus, anesthesiologists have since long attempted anterior approaches for lumbar plexus blockade.

Anterior approaches of the lumbar plexus: evolution from “3-in-1 block” to ultrasound-guided supra-inguinal fascia iliaca compartment block

In 1973, Alon Winnie described the inguinal paravascular technique for lumbar plexus blockade, the so-called “3-in-1 block.” [3] For this landmark technique, the femoral artery was palpated in the inguinal crease; using a paresthesia technique, the needle was positioned close to the FN. Local anesthetics (LA) were injected while applying firm distal pressure promoting cephalad spread. Where his initial report demonstrated a consistent block of the three target nerves with volumes exceeding 20 mL, it could not be confirmed by subsequent clinical and radiological trials [4]. Using magnetic resonance imaging, Marhofer et al. demonstrated that there is consistent lateral, caudal, and slightly medial spread of local anesthetics after a "3-in-1 block," but that cephalad spread could not be observed [5]. In conclusion, with a "3-in-1 block," only the femoral and lateral cutaneous nerves can be reliably blocked, whereas the ON is often spared.

In 1989, after anatomical review of the relationship between the different branches of the lumbar plexus and the iliac fascia, Dalens et al. described a new approach to the lumbar plexus: the fascia iliaca compartment block (FICB). The fascia iliaca compartment is the virtual space formed by the iliac fascia and the psoas and iliacus muscles which it covers. As the nerves of the lumbar plexus are situated posteriorly of the iliac fascia, it was hypothesized that an injection of a large enough volume of LA under the iliac fascia would lead to a subsequent blockade of the branches of the lumbar plexus. The authors described a landmark-based FICB. For this technique, a needle is introduced 0.5 cm caudal to the point between the middle and lateral third of the line between the pubic tubercle and the anterior superior iliac spine. During needle passage of the fascia lata and the iliac fascia, a loss of resistance is felt after which LA are injected and firm digital pressure immediately caudal to the needle was exerted to promote cranial spread. The efficacy of this new approach was compared with the "3-in-1 block" in 120 children. With an FICB, a 90% success rate, defined as a complete block of the three target nerves (FN, LFCN, and ON), was obtained, where this was only 12% in the "3-in-1 block" group [6]. After these positive results, subsequent studies exploring the benefits of the FICB were performed in different patient populations and for different indications (Fig. 2).

With the introduction of ultrasound (US) to regional anesthesia, a USG technique for the FICB was developed. For this technique, a transverse infrainguinal US image is obtained with the femoral artery, FN, and iliac and sartorius muscles as important US landmarks. The needle is introduced using a lateral-to-medial in-line approach and penetrates the fascia iliaca at the junction of the iliac and sartorius muscles. Adequate spread both medially and laterally is essential to obtain a successful block (Fig. 3). Dolan et al. compared the efficacy of the landmark and the USG technique in 80 patients undergoing hip or knee replacement surgery. With US, the proportion of patients with complete loss of sensation in all parts of the thigh was 82% compared to 47% in the landmark group. Moreover, the incidence of motor block was significantly higher in the US group [7]. Nevertheless, even with a USG approach, a

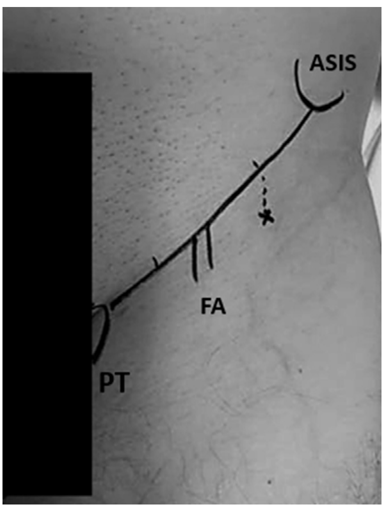

Fig. 2. Landmark FICB; anatomical landmarks. PT: Pubic Tubercle, ASIS: Anterior Superior Iliac Spine, FA: Femoral Artery, *: injection point.

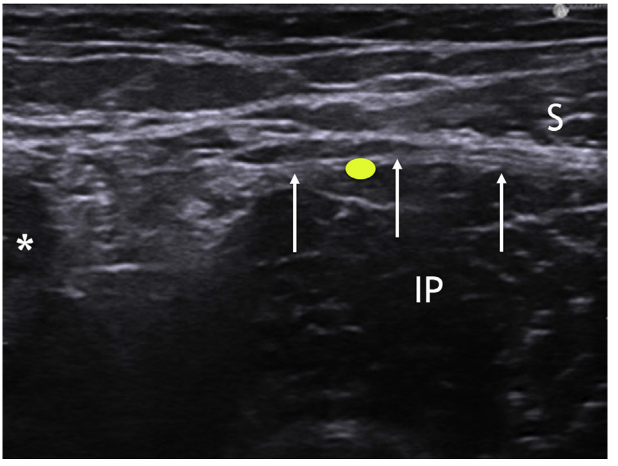

Fig. 3. Ultrasound landmarks for infra-inguinal FICB. White asterisk: Femoral artery, White arrows: Iliac fascia, IP: Iliopsoas muscle, S: Sartorius muscle, Yellow dot: needle injection point.

motor block of the ON was present in only 44% of the patients. The evaluation of the motor block is essential to assess the effect of an FICB on the ON. The ON has an inconsistent sensory distribution, where only in 43% of the patients the ON innervates the inner side of the thigh [8]. As such, an assessment only evaluating the sensory component of the ON is unreliable. An MRI study conducted by Swenson et al. evaluated spread of LA after a USG infra-inguinal FICB. The FN and LFCN were consistently blocked, but there was no evidence of spread medially or cranially that could lead to a reliable block of the ON [9].

A new approach to the iliac fascia was described by Hebbard in 2011 [10]. For this longitudinal, supra-inguinal approach, the patient lying in supine position, a linear high-frequency probe (6–14 MHz), is placed in the sagittal plane to obtain an image of the anterior inferior iliac spine. The fascia iliaca and sartorius, iliopsoas, and internal oblique muscles can be identified by sliding the probe medially. One can identify the “bow-tie sign” formed by the muscle fascias of the sartorius muscle and abdominal muscles. Using an in-plane approach, an 80-mm needle is introduced 1-cm cephalad to the inguinal ligament. Using hydro-dissection, the fascia iliaca is separated from the iliac muscle to create a space where the needle can be advanced cranially. An injection can be considered successful if spread of LA is observed cranial to the point where the iliac muscle dives under the abdominal muscles (Fig. 4).

The rationale of the longitudinal supra-inguinal FICB is that a more cranial deposition of LA would lead to a better spread under the fascia iliaca with a concomitant spread toward the ON located medially of the psoas muscle. Unfortunately, the cadaver study of Hebbard et al. did not investigate spread toward the ON. The authors briefly described that they used the block in more than 150 patients with good results and no complications.

As described before, the interpretation of an ON block is difficult, especially in the postoperative setting where motor function can be impaired because of pain or transient nerve palsy due to traction- or tourniquet-related ischemia. Therefore, anatomical and radiological research performed on volunteers is essential to determine whether or not the supra-inguinal approach is effective in blocking the ON. Vermeylen et al. performed a cadaver study investigating the ideal volume necessary to block the three target nerves (FN, LFCN, and ON). Both CT imaging and dissection techniques were used to determine that at least 40 mL of LA is necessary to consistently block the three target nerves [11]. The same research group has investigated the spread of LA of both the infra-inguinal and supra-inguinal approach in healthy volunteers using a clinical and MRI evaluation of the spread of LA. The results confirmed that a supra-inguinal FICB leads to a more consistent block of the three target nerves (Personal communication, Dr. Vermeylen K, paper accepted for publication in RAPM).

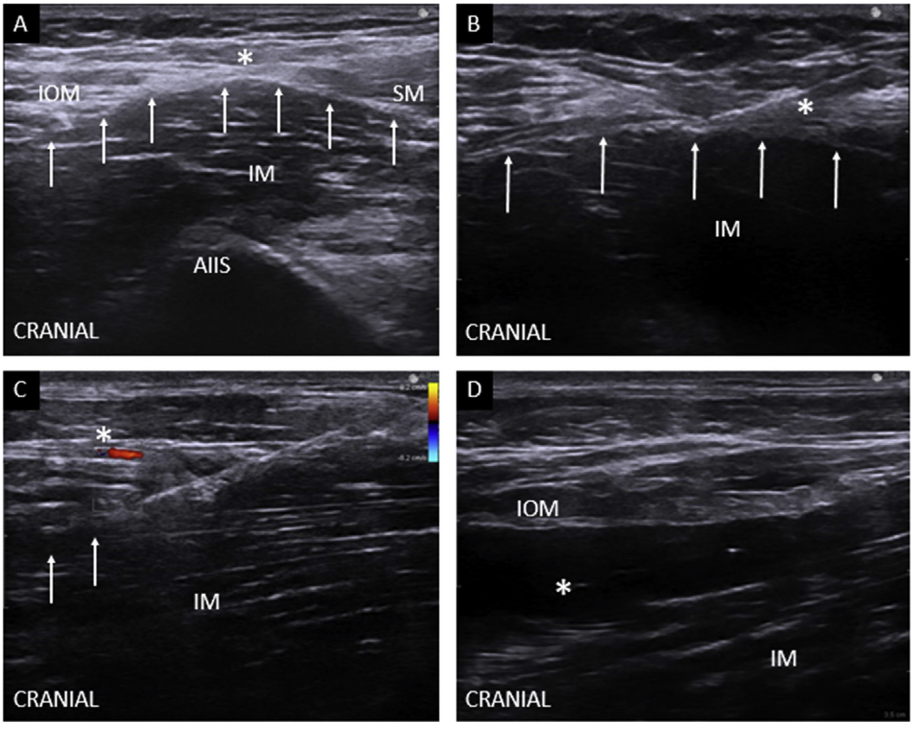

Fig. 4. Ultrasound landmarks and injection for supra-inguinal FICB. A) IOM: Internal oblique muscle, SM: Sartorius muscle, AIIS: Anterior inferior Iliac spine, IM: Iliacus muscle, White asterisk: Bow tie sign of iliac fascia, White arrows: Iliac fascia. B) IM: Iliac muscle, White asterisk: needle. C) IM: Iliac muscle, White asterisk: Deep circumflex artery, White arrows: injection of LA. D) IOM: Internal oblique muscle, IM: Iliac muscle, White asterisk: LA.

Fascia iliaca compartment block in clinical practice

Fascia iliaca block for hip fractures

Numerous studies have been performed regarding the clinical efficacy of an FICB for patients with hip fractures. A recent meta-analysis regarding the role of preoperative FICB demonstrated that the FICB resulted in lower pain scores with movement than opioids, reduced time to first opioid request, and reduced the total opioid consumption. Furthermore, an FICB reduces the time to perform spinal anesthesia. However, no benefit could be demonstrated regarding postoperative analgesic consumption for preoperatively placed FICB compared to opioids, NSAIDS, or other PNBs. Furthermore, no effect was observed on mortality or on the incidence of delirium. However, only 11 clinical trials could be included in this meta-analysis adding up to only 538 patients receiving an FICB. Also, all studies used a landmark (loss of resistance) technique, as the clinical relevance of this meta-analysis in the era of US is questionable. Finally, many studies suffered from methodological issues with high heterogeneity, prohibiting firm conclusions to be drawn from this meta-analysis [12].

Although Dolan et al. demonstrated that a USG approach of the FICB is superior to a landmark technique, US is not always readily available to clinicians [7], especially in the prehospital setting, where nonmedical practitioners, who may lack the necessary training and equipment, rely on adequate analgesia for transportation of patient with hip fractures. In these circumstances, the landmark technique might still be a valuable addition to the analgesic armamentarium. Indeed, Dochez et al. demonstrated in a feasibility study that a prehospital-administered landmark FICB performed by emergency medical service nurses decreased initial pain scores from 8 to 3 on a numerical rating scale

(NRS: 0 = no pain, 10 = most extreme pain). Furthermore, during mobilization and transportation, NRS pain scores remained below 4 [13]. A recent systematic review addressed the efficacy of prehospital-administered FICB. In 90% of the patients included in this review, the FICB was considered successful with a reduction of pain scores with only one minor adverse event in 254 patients. The authors conclude that an FICB is a safe and effective technique to provide analgesia in the prehospital setting. Unfortunately, the difference in study designs, patient populations, FICB techniques, and clinical endpoints makes it again difficult to draw firm conclusions from this review [14].

With the knowledge based on anatomical and radiological studies, one can argue that the effects of an FICB can be largely attributed to the block of the FN. Indeed, according to Hilton's law, the neck of the femur is primarily innervated by the FN, questioning the need for an additional block of the ON and LFCN for preoperative analgesia in these patients. Numerous studies have been published regarding the efficacy of femoral nerve blocks (FNB) for patients with hip fractures. Similar to the literature regarding FICB for hip fracture patients, interpretation of the data regarding the efficacy of FNB is difficult because of the differences in study design and studied outcome parameters. A systematic review by Riddell et al. based on 7 RCTs including only 224 patients demonstrated a reduction in pain scores and morphine consumption and a lower incidence of adverse events [15].

Thus, based on the currently available literature, both FICB and FNB have similar clinical benefits for patients with a fractured neck of the femur. To the best of our knowledge, only two studies directly compared an FNB with an FICB for preoperative analgesia in patients with hip fracture. Newman et al. compared an FNB with an FICB for pain relief in patients with fractured neck of femur. The results were in favor of an FNB block, which provided a significantly larger reduction of initial pain scores and reduced overall morphine consumption. This study can be criticized as the landmark-based FICB was compared with a nerve-stimulator-guided FNB. As previously described, the landmark approach for an FICB has a higher incidence of failed blocks than the USG approach [7]. Unfortunately, Newman et al. did not perform a sensory or motor evaluation; therefore, the results of this study must be interpreted with caution [16]. Cooper et al. performed a randomized controlled trial to compare a USG FICB with a USG FNB for preoperative analgesia in patients with fractured neck of femur. The study demonstrated an equal reduction of visual analog scale (VAS) scores in both groups [17]. To conclude, based on the available literature, there is insufficient evidence that an FICB with its inherent unreliable block of the ON is superior to a “simple” FNB. This conclusion is also reflected in the National Institute of Health and Care Excellence (NICE) guidelines on hip fracture management (https://www.nice.org.uk/guidance/cg124, Update may 2017), where nerve blocks are recommended in the management of acute pain, but without a specific recommendation for a specific block.

Fascia iliaca block for total hip arthroplasty

The hip joint capsula is innervated by branches of both the lumbar and sacral plexus. The antero-lateral portion is innervated by the FN, and the anteromedial portion by the ON. The posterior portion is innervated by direct branches of the sacral plexus, branches of the sciatic nerve, the nerve to the quadratus femoris muscle, and superior gluteal nerve. Nociceptive fibers are predominantly situated in the anterior portions whereas mechanoreceptors are predominantly situated in the posterior portions [18]. Depending on the surgical approach, the lateral femoral cutaneous nerve innervates the area of the skin incision. As such, it seems reasonable to focus on the lumbar plexus to target postoperative pain after total hip arthroplasty (THA).

The evidence regarding the efficacy of an FICB for postoperative analgesia after THA is conflicting. In 2007, Stevens et al. used a modified landmark approach, with an introduction of the needle 1 cm cranial of the inguinal ligament in a small RCT in patients undergoing THA. There was a significant morphine sparing effect in the first 24 h [19]. Shariat et al. could not demonstrate a clinical benefit of an FICB in patients with insufficient analgesia after undergoing THA [20]. Kearns et al. demonstrated that spinal morphine was superior to an FICB in terms of postoperative opioid consumption [21]. This is in contrast to the study by Desmet et al. where an FICB decreased morphine consumption with approximately 45% in the first 48 h postoperatively in patients after undergoing THA [22]. These contrasting results might be explained because of the different approaches of the fascia iliaca. Desmet et al. used a longitudinal, supra-inguinal approach, whereas in the other studies, an infra-inguinal approach was used. As described before, an infrainguinal approach leads to an inconsistent block of the ON. Indeed, in the study by Shariat et al., only 25% of patients had an ON block, opposed to 76% of the patients in Desmet's study. Given the important role of the ON in the innervation of the hip capsula, it is not surprising that the approach with the most consistent ON block had favorable clinical results. More research is needed to determine the role of a suprainguinal FICB as part of a multimodal analgesia protocol for patients after undergoing THA surgery.

Fascia iliaca compartment block for other indications

It is clear that most research has focused on the role of an FICB in patients receiving hip surgery. However, other indications have been described in the literature.

Cuignet et al. used continuous FICBs in burn patients requiring lower limb skin-grafting procedures. There was a reduction in VAS pain scores and a cumulative morphine reduction from 88 mg to 23 mg in the first three postoperative days [23].

An FICB can be used as an analgesic modality after total knee arthroplasty (TKA). In a direct comparison between periarticular infiltration and landmark FICB, Bali et al. could not demonstrate a difference in VAS pain scores and morphine consumption in the first 24 h after surgery [24]. A landmark FICB had similar effect on VAS pain scores and overall analgesic consumption as a nerve-stimulator-guided FNB in patients receiving a TKA. However, in this study, 60 mL of LA were injected in both groups as a loading dose. With these large volumes, it is highly unlikely to detect a clinical difference between the blocks as both blocks have similar injection points [25]. A small study in children scheduled for anterior cruciate ligament repair could not demonstrate a difference between FICB and FNB in terms of VAS scores and morphine consumption [26]. One can criticize this study as it was probably underpowered to detect a clinical difference. Furthermore, no sensory or motor tests were performed to evaluate whether the block was performed successfully.

While there is not enough data to support an evidence-based recommendation for patients with hip fracture and hip surgery, data supporting the use of FICB for other types of lower limb surgery are even scarcer. It is clear that more research is needed to establish the place of an FICB for these types of surgery.

Clinical pearls

An FICB is a fascial plane block, a regional anesthesia technique, where LA are not injected in the vicinity of the nerve but in the intermuscular plane where the targeted nerves have their anatomical course. As such, fascial plane blocks will cover multiple nerves and dermatomes with a single injection. There are two important factors needed to be considered regarding the success of a fascial plane block. First, volume is of paramount importance as large volumes of LA are necessary to obtain sufficient spread necessary to block the targeted nerves [11]. Thus, regardless of the technique, an adequate volume is necessary to achieve clinical success. For the landmark and USG infrainguinal approach, 30–40 mL of LA is recommended, and for the USG supra-inguinal approach, at least 40 mL of LA is required to consistently block the FN, ON, and LFCN [9,11]. Second, needle placement in the correct intermuscular plane is equally important to obtain a successful block. Intramuscular injections will not result in adequate spread, and LA will remain contained in the muscle with the potential of myotoxicity. However, even with a volume of 40 mL of LA, the infra-inguinal transverse approach will be unreliable in clinical practice. Increasing the volume will not improve the quality of the block and only increase the risk of LAST. With a transverse approach, cranial spread of LA is limited, and the spread medially toward the ON is also limited due to the barrier formed by the iliopectineal fascia. The supra-inguinal approach to the iliac fascia, with a more cranial deposition of LA, is further gaining interest as cadaver, radiological and clinical pieces of evidence are now slowly starting to appear demonstrating its potential [10,11,22].

As discussed above, volume is important to achieve a clinical benefit. Long-acting LA such as ropivacaine and bupivacaine are commonly used to extend analgesia, but decreasing the concentration of the LA will be necessary to avoid systemic toxicity. Reassuringly, in a study comparing longitudinal supra-inguinal FICB with no block in patients undergoing THA, plasma ropivacaine levels after injection of 40 mL ropivacaine (0.5%) were within the maximal tolerated plasma concentrations in all patients. Time to maximum concentration was 45 min, indicating that patients should be monitored and observed for at least 45–60 min after block performance [22]. This is slightly longer than current ASRA guidelines that recommend 30–45 min of observation after the performance of a truncal block. However, the ASRA guidelines are a general recommendation for all truncal blocks and not specific for a supra-inguinal FICB; furthermore, the level of evidence for this recommendation is only grade 1C [27].

To further extend the duration of analgesia, practitioners can use additives such as dexamethasone and dexmedetomidine. Although the evidence is limited, both seem to prolong the duration of analgesia after single shot FICB [28,29]. As with other peripheral nerve blocks, duration of analgesia can be prolonged with the use of a catheter. However, data regarding the use of catheters is non-existant. It is currently unclear if a catheter technique should use a fixed infusion rate or rather use an intermittent bolus regimen. It seems logical to use an intermittent bolus regimen with rapid injection of sufficient amounts of LA, as a fixed infusion rate will less likely lead to an adequate spread of LA.

Critical considerations

Although the supra-inguinal approach of the fascia iliaca compartment definitely has the potential to play an important role in clinical practice, certain questions are still unresolved. As with all fascial plane blocks, clinicians cannot visualize spread of local anesthetics around the targeted nerves and therefore must rely on an adequate spread of LA in the intermuscular plane. This is at the same time the strength and weakness of all fascial plane blocks. As the needle remains far away from the targeted nerves, the potential of nerve block induced injury decreases dramatically. Unfortunately, as spread of LA is sometimes unreliable, one can argue that an approach specifically targeting the nerves separately might be more successful in clinical practice. More research is needed to establish the efficacy and safety of an FICB compared with a specific nerve block approach of the FN, ON, and LFCN for a variety of surgical procedures.

Conclusion

In the last decades, regional anesthesiologists have explored different anterior techniques to approach the lumbar plexus. Currently, based on both basic science and clinical research, the supra-inguinal FICB is the most promising technique. Further research is needed to determine the precise role of a supra-inguinal FICB in clinical practice with attention to the possible advantages and disadvantages of an FICB compared to more selective blocks. Furthermore, in circumstances where US is not available, the landmark-guided approach remains a valuable option to provide better analgesia to patients with hip fractures.

Practice points

- The FICB should be considered in patient with hip fractures as part of a multimodal analgesia protocol.
- An USG approach is preferred over the landmark method. However, when US cannot be performed, the landmark technique remains a valuable alternative.
- The supra-inguinal approach is a promising technique as it more reliably blocks the FN, ON, and LFCN.
- As with all fascial plane blocks an adequate volume is of paramount importance for block success.
- Reducing the concentration of LA must be considered to reduce risk of LA systemic toxicity, when injecting these large volumes.

Research agenda

- Large well-performed RCTs are required to increase the evidence on the use of an FICB for hip surgery.
- We need evidence on the clinical benefits of a supra-inguinal FICB compared to an infra-inguinal FICB.
- Further evidence is required on the clinical benefits of a supra-inguinal FICB over more selective blocks.
- Research on the use of additives and continuous techniques is needed to establish the most effective method to obtain prolonged analgesia.

Conflicts of interest

No conflict of interest or funding declared for the authors.

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