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Pilot Study

PILOT STUDY

Deep posterior gluteal compartment block for regional anaesthesia of the posterior hip: a proof-of-concept pilot study

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Abstract

Background: Various regional anaesthesia approaches to branches of the anterior lumbar plexus have been proved effective in providing analgesia in hip surgery. However, some patients still experience significant residual posterior hip pain attributed to the posterior nerve supply of the hip. This not only suggests that anterior approaches may not always provide sufficient pain relief, but also that the blocking of major nerves supplying the posterior pericapsular region is needed.

Methods: We present an ultrasound-guided technique to block all major nerves supplying the posterior capsule of the hip joint. The optimal target area was determined by ultrasound imaging, cross-sectional digitised anatomy, and cadaver research, and was found in the deep gluteal compartment. Furthermore, this posterior pericapsular deep-gluteal block was evaluated in two patients.

Results: The spread of dye in the cadaver was observed deep to the gluteus maximus and in between the quadratus femoris and piriformis muscles, and conformed to the presumed location during the ultrasound procedure. It included all major supplying nerves to the posterior hip capsule, that is the superior gluteal nerve, nerve to quadratus femoris and sciatic nerve. In both patients where this posterior pericapsular deep-gluteal block was applied the pain was substantially reduced (numeric rating scale: 4 to 1 and 7 to 1).

Conclusion: We present a successful ultrasound-guided technique targeting the deep gluteal compartment to block all major nerves supplying the hip joint's posterior capsule. This posterior pericapsular deep-gluteal block can be applied as an additional block in hip surgery, with also a possible role in chronic hip pathology.

Keywords: acute pain management; hip surgery; lumbosacral plexus; pericapsular hip block; posterior hip innervation; regional anaesthesia

Hip surgery, whether elective or after hip trauma, is a common procedure in older patients and can result in significant postoperative pain.[1] Several regional anaesthesia techniques have been described to minimise the use of opioids and reduce their adverse effects.[2,3] Classic regional anaesthesia approaches include suprainguinal fascia iliaca compartment block (SFICB) and femoral nerve block (FNB).[4] Novel interfascial plane blocks such as the pericapsular nerve group (PENG) block, quadratus lumborum (QLB), and erector spinae plane (ESP) blocks are now being explored.[5–7]

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These approaches focus on the lumbar, that is primarily anterior, nerve supply of the hip. Support for these approaches is found in anatomical studies, in which the highest levels of mechanoreceptors and sensory fibres are found in the superolateral part of the hip capsule and the anterior part of the labrum.[8–11] However, a substantial supply of sensory fibres from posterior branches of the sacral plexus is also described for the posterior labrum.[12] Intriguingly, the sensory innervation of the hip may vary with sex, age, and pathology,[8–11] and very recently the relation between sensory innervation of the hip joint and pain patterns was highlighted.[12]

We have experienced a number of patients with residual posterior hip pain after an anterior regional anaesthesia technique. This raises questions regarding the role of the generally applied anterior approaches *vs* posterior innervation in post-traumatic pain, post-surgical hip pain, or both, and suggests that additional regional anaesthesia should be focused on posterior articular nerve supply. In this proof-of-concept pilot study, we describe an ultrasound-guided regional anaesthesia technique for posterior hip pain. This approach was evaluated by cadaver research, and was applied and evaluated in two case reports.

Methods

Anatomy of the posterior hip region and the implications for regional anaesthesia

The hip joint comprises a capsular and a pericapsular region and a surrounding compartment. The innervation of the hip is intricate with contributions from both the lumbar and sacral plexus.[12] The anterior and posterior capsule each receive a separate but overlapping nerve supply. The anterosuperior capsule is supplied by the femoral, obturator, and accessory obturator nerves (all branches from the lumbar plexus L2–L4), whereas the posterior capsule is supplied via the sciatic nerve, superior gluteal nerve, and nerve to the quadratus femoris muscle, the latter particularly for the posteroinferior capsule (Fig 1). This posterior supply originates from spinal nerves L4–S1. The course of the nerves supplying the posterior hip joint is as follows. The superior and inferior gluteal nerves emerge cranial and caudal to the piriformis muscle, respectively, to enter the fatty compartment just deep (i.e. anterior) to the gluteus maximus muscle and craniodorsal to the triceps coxae (consisting of superior and inferior gemelli, with the internal obturator muscle in between) and the quadratus femoris muscle (Fig 2). The

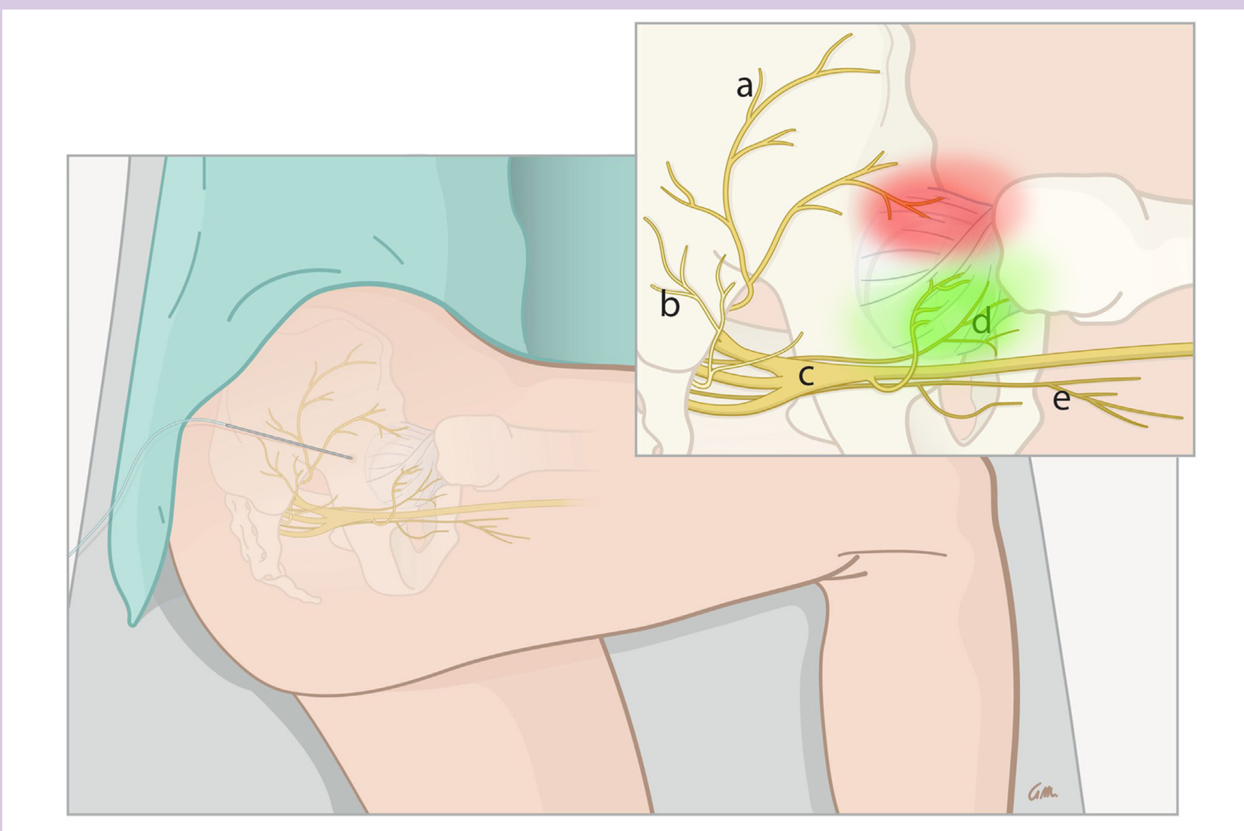

Fig 1. Schematic drawing of the nerves that supply the posterior capsule of the hip. The postero-superior part (red area) is predominantly supplied via the superior gluteal nerve, the posterior and postero-inferior part (green area) of the hip joint via the sciatic nerve and the nerve to the quadratus femoris muscle. a, superior gluteal nerve; b, inferior gluteal nerve; c, sciatic nerve and articular branches; d, nerve to quadratus femoris muscle; e, cutaneous nerve of the thigh. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

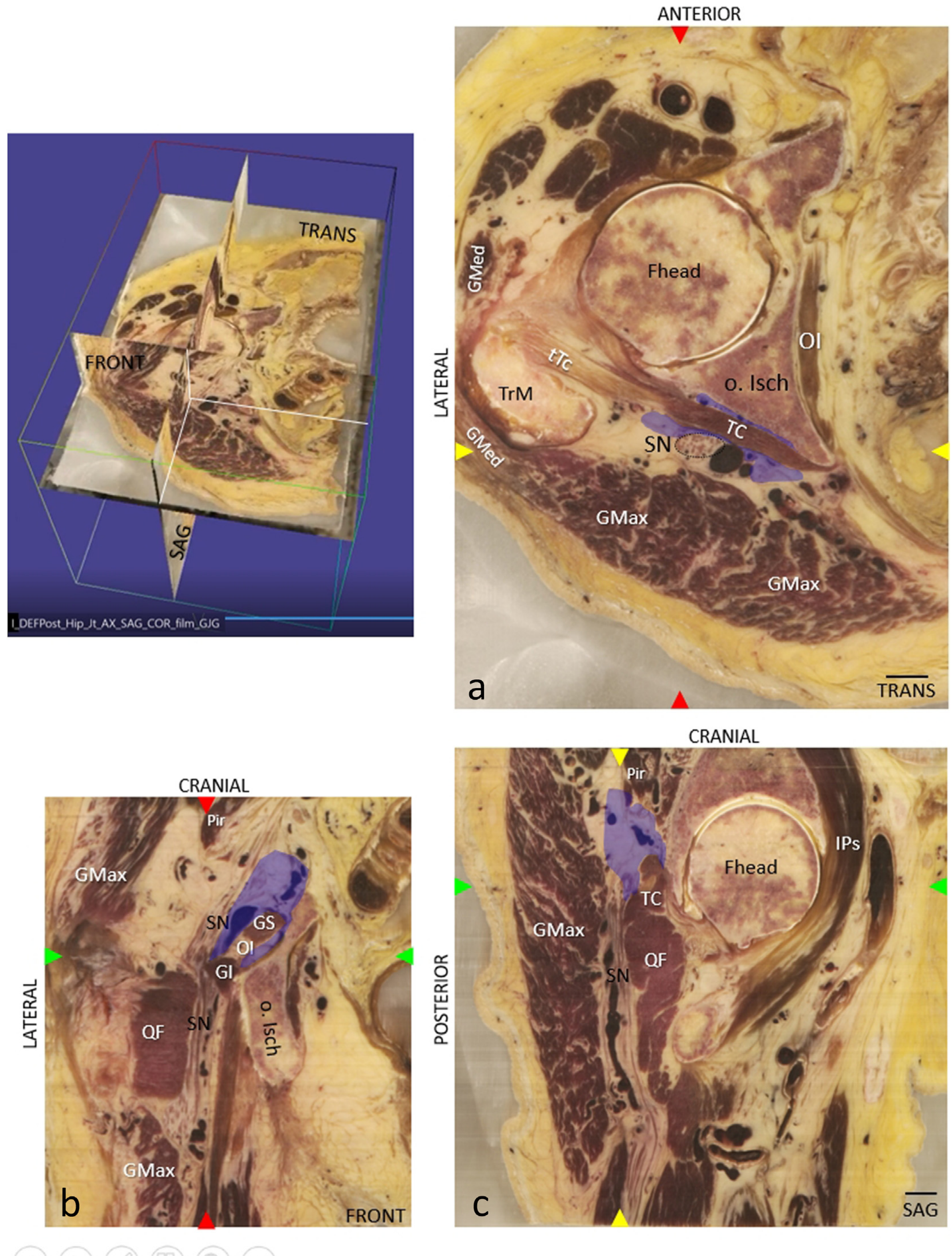

Fig 2. High-resolution anatomical cross sections of the posterior hip region. Upper left: a simultaneous display of the three orthogonal planes (transversal, frontal, and sagittal) in the same specimen, with adjacent enlargements (a–c). The assumed spread of the local anaesthetic in posterior pericapsular deep-gluteal (PPD) block is depicted in each plane, ventral, dorsal, and cranial to the TC, near the posterior rim of the acetabulum cranial to quadratus femoris. (a) Transverse cross section at the level of the femoral head and ischium. The level is depicted in (b) and (c) by the green arrowheads. (b) Frontal cross section at the level of the yellow arrowheads (in a and c) just through the sciatic nerve. (c) Sagittal cross section at the level of the red arrowheads (in a and b). Fhead, femoral head; GI, gemellus inferior; GMax, gluteus maximus; Gmed, gluteus medius; GS, gemellus superior; Ips, iliopsoas; Isch, ischium; OI, internal obturator, o; Pir, piriformis; QF, quadratus femoris; SN, sciatic nerve; TC, triceps coxae (consisting of GS, OI, and GS); TrM, greater trochanter; tTC, tendon TC. Bar represents 10. (Courtesy of Professor Gerbrand J. Groen, Anaesthesiology Pain Centre, University Medical Centre Groningen, University of Groningen, The Netherlands.). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

superior gluteal nerve runs parallel to the superior gluteal vessels to the area between the gluteus medius and gluteus minimus muscle, which it innervates. The nerve to the quadratus femoris muscle generally arises from the upper part of the sciatic nerve. The principal nerves supplying the anterior compartment (femoral and obturator nerves) are separated from the pericapsular space by the iliopsoas muscle and fascia transversalis, respectively,[13] whereas the supplying nerves of the posterior pericapsular space are less compartmentalised. These nerves all pass through the fatty compartment dorsal to the piriformis bordered by the gluteus medius muscle (cranial), gluteus maximus muscle (dorsal), and triceps coxae (caudal), which is open to the pelvic fatty tissue compartment with the contributing lumbosacral nerves (Fig 2). This makes it more difficult to selectively block the terminal posterior capsular branches, in contrast to the anterior blocks in which one can choose between a nerve-oriented block (e.g. a SFICB directed to the femoral nerve, the lateral femoral cutaneous nerve, and possibly obturator nerve) and a target-focused block directed to only the terminal capsular branches (e.g. PENG block).[13]

Ultrasound-guided approach of the posterior hip compartment

To perform this posterior pericapsular deep-gluteal (PPD) block directed to the posterior hip compartment, the patient is positioned in the lateral decubitus position with the target side up, and both hip and knee flexed at a 90° angle (Fig 3a). A curved low-frequency probe is placed on the greater trochanter and aligned parallel with the long femoral axis. The probe is then moved slightly dorsal to visualise the bony landmarks: the greater trochanter, the femoral neck and head, and the posterior acetabular rim (Fig 3b). Superficial to the bony landmarks, the piriformis muscle is identified, deep to the gluteus maximus muscle.

The needle is introduced in-plane from posterolateral to anteromedial until the tip contacts the posterior acetabular rim near the attachment of the ischiofemoral ligament. As the course of the needle is craniolateral to the sciatic nerve and lateral to the superior gluteal nerve, direct nerve injury is unlikely (Fig 1). After negative aspiration, the local anaesthetic solution is injected while observing for adequate fluid spread over the posterior acetabular rim, over the posterior hip capsule and under the piriformis muscle, for a total volume of 20 ml (Fig 3c). Coverage of the superior gluteal nerve and nerve to the quadratus femoris muscle is hereby expected, although the nerves themselves are not visualised. Because of the close vicinity of the sacral plexus, spread to other nerves, such as the posterior femoral cutaneous nerve and the sciatic nerve, is expected with the proposed volume of 20 ml. In case of fracture the full 90° flexion of the hip cannot always be obtained, but the essential landmarks remain identifiable and the PPD block feasible.

Cadaver evaluation of the novel approach

A study of the PPD block was conducted on a fresh male adult cadaver at the Department of Functional Anatomy, University Medical Centre Utrecht, The Netherlands. Written informed consent was obtained during life allowing use of entire body for educational and research purposes, Dutch Nationwide Donation Program.

A unilateral ultrasound-guided PPD block was performed following the above-described technique with methylene blue dye (20 ml) on the periacetabular rim. After injection of the dye with the cadaver in the lateral decubitus, the cadaver was turned to the prone position. Dye had spread to the deep fascia of the gluteus maximus muscle and the deep and superficial part of the gluteus medius muscle, halfway up the ilium bone, 2 cm more cranial than the superior gluteal nerve (Fig 4a). The spread also extended over the entire posterior capsule and the periacetabular rim of the hip joint, where the course of the articular branches is expected. No dye could be seen lateral of the greater trochanter. In the caudal direction the dye spread to the triceps coxae muscles. The medial spread followed the sciatic nerve's course under the piriformis muscle and into the greater sciatic foramen where the sciatic, posterior femoral cutaneous, superior gluteal, and inferior gluteal nerves were completely stained (Fig 4b).

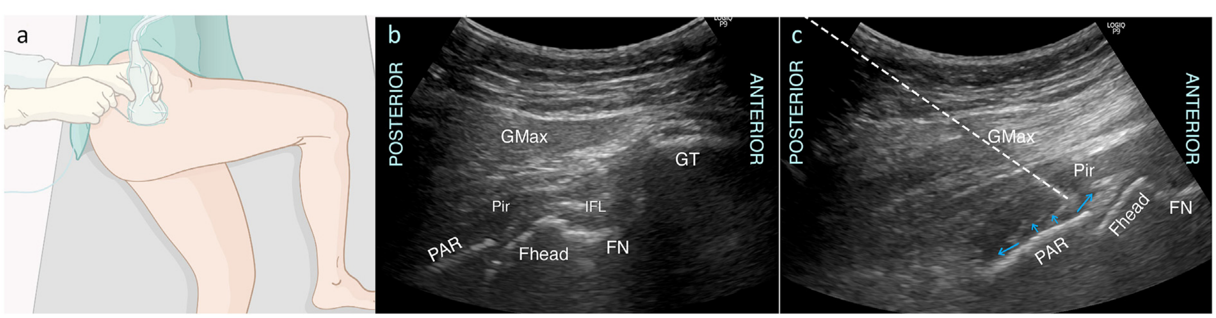

Fig 3. (a) Position of the patient during the posterior pericapsular deep-gluteal block. Ultrasound probe and needle are in line with the axis of the femur, with in-plane needle puncture from the posterior aspect. (b) Corresponding ultrasound image showing the gluteal muscles covering the bony landmarks: Fhead, femoral head; FN, femoral neck; GMax, gluteus maximus; GT, greater trochanter; IFL, ischiofemoral ligament as part of the posterior hip capsule; PAR, posterior acetabular rim; Pir, piriformis muscle. (c) Ultrasound image of the needle trajectory. Blue arrows: spread of local anaesthetic over the posterior acetabular rim and posterior hip capsule, deep to the piriformis muscle. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

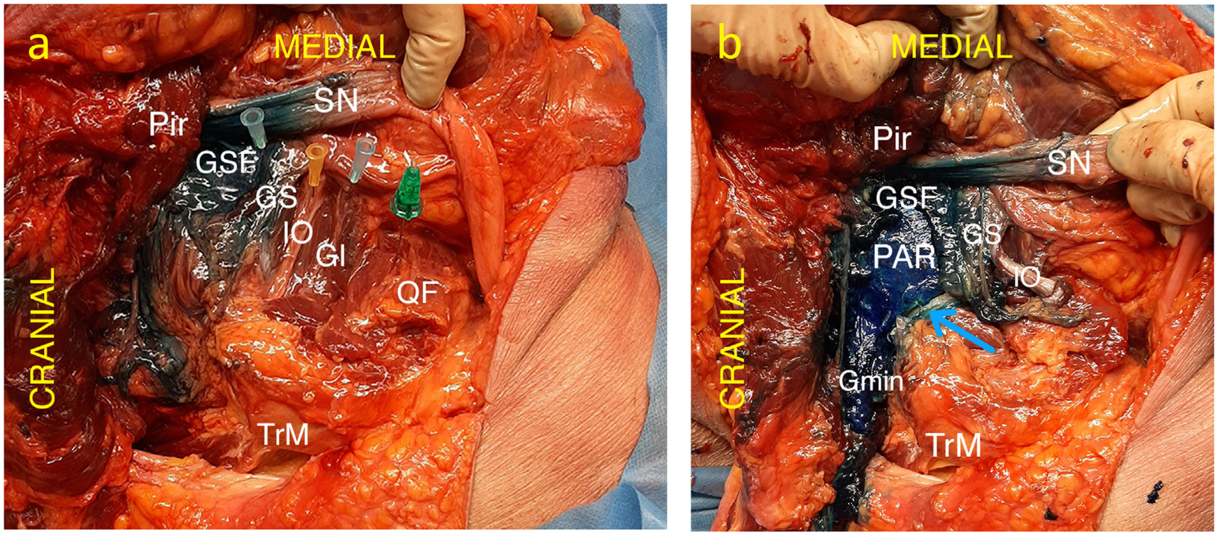

Fig 4. Dissection of the posterior hip region after an ultrasound-guided PPD block with injection of methylene blue 40 mg in NaCl 0.9% (20 ml). (a) View of the infra-piriformis foramen after deflection of gluteus maximus and medius muscle. Medial spread of the dye, up to the greater sciatic foramen (GSF) where staining of the sciatic nerve (SN) can be seen. (b) View of the posterior hip joint and GSF after deflection of gluteus minimus muscle (Gmin) and piriformis muscle (Pir). Dense staining of the entire posterior hip capsule and the posterior acetabular rim (PAR) is visible. The blue arrow indicates the femoral head behind the opened capsule. Heavy staining of the deflected Gmin and deep surface of the Gmax can be observed. GI, gemellus inferior muscle; GS, gemellus superior muscle; IO, internal obturator muscle; Pir, piriformis muscle; PPD, posterior pericapsular deep-gluteal; QF, quadratus femoris muscle; TrM, greater trochanter. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Case reports

After approval of the AZ Klina Ethical comity (OG 146 – EC number 131.200.020), written informed consent was provided by both patients before inclusion of these two case reports.

Case 1

An adult patient, scheduled for total hip replacement after a car accident that caused a comminuted fracture of the femur with acetabular disruption. Preoperatively, he rated his pain 7 on the numeric rating scale (NRS; min 0, max 10). After an SFICB was performed with levobupivacaine 0.25% (40 ml), the patient reported an NRS score of 4 and indicated this pain was localised posteriorly, in the gluteal region. At this time, a PPD block was performed with levobupivacaine 0.25% (20 ml). When positioning the patient for the PPD block, only 45° flexion of the hip was achieved. Despite the suboptimal positioning and the fracture with expected haematoma, the US landmarks were recognisable and the PPD block was performed. After 10 min the patient reported an NRS score of 1, and there was a sensory block of the posterior thigh. The standard pain protocol (acetaminophen and celecoxib) was sufficient for postoperative pain control and, except for piritramide 2 mg i.v. immediately upon awakening, no opioid analgesia was needed in the postoperative period.

Case 2

An adult patient with arthrosis of the hip joint causing persistent debilitating pain presented for total hip replacement. The preoperative pain was mainly localised posteriorly in the gluteal region with an NRS at rest of 7. As we wanted to evaluate the efficacy of our PPD block in such a case of posterior referred pain, we performed a PPD block as described. Fourteen minutes after injection of levobupivacaine 0.25% (20 ml), the patient reported an NRS of 1 and anaesthesia to cold stimulus on the posterior thigh was achieved 20 min after injection. Below the knee there was a mild sensory sciatic block, but no motor weakness. Then, and before the surgery, a SFICB with levobupivacaine 0.25% (40 ml) was performed. During the complete postoperative course, the NRS remained between 0 and 2. Postoperatively, the patient was prescribed a standard pain protocol (acetaminophen and celecoxib) and except for piritramide 20 mg i.v. in the recovery room, no other opioids were needed. Mobilisation on the first postoperative day went smoothly and was uneventful.

Discussion

Anatomical studies attributed postoperative pain mainly to the anterior innervation (lumbar plexus) of the hip joint.[14] In this regard, the choice between a nerve-oriented approach, that is blocking the main anterior supplying lumbar plexus nerves (femoral and obturator nerve), and a target-focused approach of the terminal articular branches of this plexus is still an ongoing and relevant discussion. This is especially true when anterior blocks, although properly conducted, are not able to overcome residual posterior postoperative pain. For this reason, we focused this research on the posterior innervation (sacral plexus) as it is well known that patients with hip pathology may experience posterior gluteal (buttock) pain.[15–17] Birnbaum and colleagues[8] have advocated that blocking the femoral, sciatic, and superior gluteal nerves is crucial for postoperative pain management after hip surgery.

For an optimal regional anaesthesia plan, pain localisation and intensity may be more important than previously considered, especially as pain patterns may differ between the various diseases of the hip joint. For example pain in degenerative osteoarthritis is often characterised mainly by groin pain (via lumbar nerves), whereas hip arthrosis caused by hip dysplasia is more often characterised by posterior buttock pain (via the sacral nerves).[15–17]

In clinical studies on hip joint pain referral patterns, up to 71% of patients report pain in the buttocks or posterior thigh.[16 17] We consider the localisation of the referred pain to be vital in choosing the most appropriate regional anaesthesia technique. This would imply that, with buttock or posterior thigh pain, a posterior regional anaesthesia technique should be included. Only a few other authors have examined the posterior innervation. Ng and colleagues[18] underlined the importance of referred posterior pain on patients with inoperable hip fractures with a partial response to anterior hip neurolysis. They concluded that a posterior hip pericapsular neurolysis could be an effective adjunct and described their technique. Whereas the posterior pericapsular approach of Ng and colleagues[18] is directed to the ischiofemoral ligament, our PPD approach is directed more medially towards the posterior acetabular rim. Gong and colleagues[19] recently published an article focusing on the anterior but also posterior (sacral) innervation. They used an anterior approach in contrast with our posterior approach. Wang and colleagues[20] described a lateral approach to ultrasound-guided sacral plexus block in the supine position but also this approach differs from the approach suggested in this article. They use a more proximal approach to the sacral plexus which may possibly carry an increased risk of nerve damage.

Furthermore, we focused particularly on the pathways and compartments of the contributing posterior nerve supply and on the echogenic visibility of the structures during ultrasonography. It appeared that the focus on the bony posterior acetabular rim, crossing triceps coxae muscles and piriformis muscle, and the fatty compartment between the gluteus maximus and these muscles enabled a fast and easy ultrasound-guided approach for posterior blocks. The posterior pericapsular area, in contrast to the anterior pericapsular area, has no muscular bridge separating the main nerves and the terminal pericapsular nerve branches.[13] A suitable volume of injectate will therefore spread more easily from the pericapsular to the inter-gluteal and deep-gluteal space covering all major contributing posterior nerves.

We have verified this approach not only using cadaver injections, but also in digitised anatomical reconstructions, and in two clinical cases. In general, posterior regional anaesthesia approaches are associated with sciatic motor block.[21,22] Somewhat surprisingly, we did not encounter a sciatic motor block in our two patients although cadaver studies showed a medial spread extending around the piriformis and the outgoing nerves, including the sciatic nerve. Furthermore, we observed spread anterior and posterior to the triceps coxae which would enable a block of the nerve to the quadratus femoris muscle. This extended spread suggests that motor block may occur and impact early mobilisation. Further investigation is warranted to determine if a smaller injected volume could spare the sciatic nerve while preserving adequate spread to the articular branches.

With our PPD approach, nerve damage is not expected because the needle trajectory is lateral to the course of both the sciatic and posterior femoral cutaneous nerves. As the superior gluteal nerve follows the superior gluteal artery, ultrasound facilitates a safe block. In comparison with other posterior regional techniques of the hip, the authors do not think that there are significant risks associated with this block.

The addition of a posterior block to anterior approaches and the importance of using referred pain localisation shows some analogy with the IPACK. For knee pathology, the focus was initially on the anterior innervation with the FNB or the adductor canal block. When either posterior LIA or an IPACK supplements this anterior block, full postoperative analgesia is achieved.

Although the findings from the cadaver study and digitised anatomical reconstructions appear robust, our research is limited by the small number of patients. Effects on sciatic motor block and mobility need to be further elucidated, and optimal volume, concentration, drug combination, and restriction to only the posterior articular branches of the hip joint.

Further research should focus on whether blocking the hip's posterior compartment reduces postsurgical pain, enhances recovery after hip surgery, and may be useful in chronic hip pain syndromes.

Conclusions

In case of residual posterior hip pain, despite properly conducted anterior approaches an additional PPD block is of benefit, as demonstrated in two patients. Cadaver and digitised anatomical reconstructions confirmed a PPD spread in the compartments containing the major contributing posterior hip supplying nerves (superior gluteal nerve, nerve to the quadratus femoris muscle, and sciatic nerve). We suggest that an additional PPD block next to a PENG block or a SFICB might result in a complete and accurate pericapsular block in hip pathology and or surgery.

Authors' contributions

Study design: KV, DVA
Literature search: KV, DVA, BV, SC
Dissection: DVA, BV
Anatomical insights: RB
Radiographic and anatomical interpretations and insights: PB
Anatomical and pathophysiological insights: GG
Writing of the manuscript: KV, DVA
Contribution to different drafts of the manuscript: GG
Writing of initial and revised versions of the manuscript: SC
Critical appraisal of the different drafts: KV, DVA, BV, SC, GG
Final approval of the version to be published: KV, DVA, SC, RB, PB, GG

Declaration of interest

The authors declare no conflicts of interest.

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