

Review Articles/Brief Reviews

A review of approaches and techniques for lower extremity nerve blocks

[Un bilan des approches et techniques pour les blocs nerveux du membre inférieur]

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Purpose: The purpose of this narrative review is to summarize the evidence derived from randomized controlled trials (RCTs) regarding approaches and techniques for lower extremity nerve blocks.

Source: Using the MEDLINE (January 1966 to April 2007) and EMBASE (January 1980 to April 2007) databases, medical subject heading (MeSH) terms “lumbosacral plexus”, “femoral nerve”, “obturator nerve”, “saphenous nerve”, “sciatic nerve”, “peroneal nerve” and “tibial nerve” were searched and combined with the MESH term “nerve block” using the operator “and”. Keywords “lumbar plexus”, “psoas compartment”, “psoas sheath”, “sacral plexus”, “fascia iliaca”, “three-in-one”, “3-in-1”, “lateral femoral cutaneous”, “posterior femoral cutaneous”, “ankle” and “ankle block” were also queried and combined with the MESH term “nerve block”. The search was limited to RCTs involving human subjects and published in the English language. Forty-six RCTs were identified.

Principal findings: Compared to its anterior counterpart (3-in-1 block), the posterior approach to the lumbar plexus is more reliable when anesthesia of the obturator nerve is required. The fascia iliaca compartment block may also represent a better alternative than the 3-in-1 block because of improved efficacy and efficiency (quicker performance time, lower cost). For blockade of the sciatic nerve, the classic transgluteal approach constitutes a reliable method. Due to a potentially shorter time for sciatic nerve electrolocation and catheter placement than for the transgluteal approach, the subgluteal approach should also be considered. Compared to electrolocation of the peroneal nerve, electrostimulation of the tibial nerve may offer a higher success rate especially with the transgluteal and lateral popliteal approaches. Furthermore, when performing sciatic and femoral blocks with low volumes of local anesthetics, a multiple-injection technique should be used.

Conclusions: Published reports of RCTs provide evidence to formulate limited recommendations regarding optimal approaches and techniques for lower limb anesthesia. Further well-designed and meticulously executed RCTs are warranted, particularly in light of new techniques involving ultrasonographic guidance.

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Objectif: L'objectif de cet examen narratif est de résumer les données probantes dérivées d'études randomisées contrôlées (ERC) concernant les approches et techniques pour les blocs nerveux du membre inférieur.

Source: A l'aide des bases de données MEDLINE (janvier 1966 à avril 2007) et EMBASE (janvier 1980 à avril 2007), les termes MeSH (vedette-matière médicale) « lumbosacral plexus », « femoral nerve », « obturator nerve », « saphenous nerve », « sciatic nerve », « peroneal nerve » et « tibial nerve » ont été recherchés et combinés au terme MeSH « nerve block » à l'aide de l'opérateur « and ». Les mots clés « lumbar plexus », « psoas compartment », « psoas sheath », « sacral plexus », « fascia iliaca », « three-in-one », « 3-in-1 », « lateral femoral cutaneous », « posterior femoral cutaneous », « ankle » et « ankle block » ont également été recherchés et combinés au terme MeSH « nerve block ». La recherche a été limitée aux ERC impliquant des sujets humains et publiées en langue anglaise. Quarante-six ERC ont été identifiées.

Constatations principales: Par rapport à son équivalent antérieur (bloc 3-en-1), l'approche postérieure du plexus lombaire est plus fiable quand une anesthésie du nerf obturateur est requise. Le bloc du compartiment de l'aponévrose iliaque pourrait également représenter une meilleure alternative que le bloc 3-en-1 à cause d'une efficacité et d'une efficience améliorées (temps de perfor-

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mance plus court, coût moindre). Pour un bloc du nerf sciatique, l'approche transglutéeale constitue une méthode fiable. En raison d'un temps potentiellement plus court pour l'électrolocation du nerf sciatique et le positionnement du cathéter que par la voie transglutéeale, l'approche subglutéeale devrait également être prise en considération. Par rapport à l'électrolocation du nerf péronier, l'électrostimulation du nerf tibial pourrait offrir un taux de réussite plus élevé, particulièrement avec les abord transglutéal et latéral poplité. De plus, lors de la mise en place de blocs sciatique ou fémoral avec de petits volumes d'anesthésiques locaux, une technique d'injection multiple devrait être utilisée.

Conclusion : Les comptes rendus publiés d'ERC fournissent des données probantes qui permettent de formuler des recommandations limitées en ce qui concerne les approches et techniques optimales pour l'anesthésie du membre inférieur. Des ERC bien conçues et exécutées avec soin sont requises, particulièrement à la lumière de nouvelles techniques d'écho-guidage.

HISTORICALLY, lower extremity nerve blocks have not been as widely used as brachial plexus blocks. This may be due to the fact that regional anesthesia of the lower limb requires blockade of several different nerves whereas neuraxial blocks reliably provide intraoperative anesthesia and postoperative analgesia with one puncture site. However, over the past decade, the increased use of low molecular weight heparins and the proven rehabilitative benefits associated with continuous femoral nerve blocks have led to a renewed interest amongst anesthesiologists to perform regional anesthesia for the lower limb.¹⁻⁴ Despite this enthusiasm, there still persist many variances in clinical methods for lower extremity nerve blocks. Accordingly, a literature search of randomized clinical trials was undertaken to determine the best available approaches and techniques for regional anesthesia of the lower limb. For the purposes of this narrative review, the term “approach” refers to the site where a neural structure can be accessed (anterior and posterior approaches for the lumbar plexus; pubic tubercle and inguinal approaches for the obturator nerve; perifemoral injection, transsartorial injection, paracondylar injection, infiltration around the medial tibial tuberosity, paravenous injection below the knee and infiltration around the medial malleolus for the saphenous nerve; parasacral approach for the sacral plexus; anterior, posterior transgluteal, posterior subgluteal, lateral midfemoral, lateral popliteal and posterior popliteal approaches for the sciatic nerve). On the other hand, the term “technique” refers to the modality (loss of resistance, neurostimulation, echoguidance) or endpoints (type of neurostimulation, single

or multiple injections) needed to identify and anesthetize the nerve for a given approach.

Methods

Search strategy and selection criteria

The literature search for this review was conducted during the first week of May 2007, using the MEDLINE (January 1966 to April 2007) and EMBASE (January 1980 to April 2007) databases. Medical subject heading (MeSH) terms “lumbosacral plexus”, “femoral nerve”, “obturator nerve”, “saphenous nerve”, “sciatic nerve”, “peroneal nerve” and “tibial nerve” were searched and combined with the MESH term “nerve block” using the operator “and”. Since “lumbar plexus”, “psoas compartment”, “psoas sheath”, “sacral plexus”, “fascia iliaca”, “three-in-one”, “3-in-1”, “lateral femoral cutaneous”, “posterior femoral cutaneous”, “ankle” and “ankle block” do not exist as MESH terms, they were queried as keywords and combined with the MESH term “nerve block”. Furthermore, the results were limited to peer-reviewed reports of human studies published in the English language. From this initial search, only randomized controlled trials (RCTs) comparing different approaches or techniques of lower limb anesthesia were retained. After selecting the initial articles, we examined the respective reference lists, as well as our personal files, for additional material. All studies containing an appropriately identified randomization process and active control groups were retained. No RCTs were excluded based on factors such as sample size justification, statistical power, blinding, definition of intervention allocation or primary and secondary outcomes. However, non-randomized studies, observational case reports and cohort studies were excluded to avoid potential biases introduced by institutional practices. Furthermore, only articles pertaining to approaches and techniques were retained. Dose finding studies and studies comparing local anesthetic agents (LA) or dealing with local anesthetic manipulation (thermoalteration, alkalization, addition of adjuncts, mixing, dose fractionation) exceeded the scope of this review. Articles pertaining to equipment (stimulating vs non stimulating perineural catheters) were also excluded. Finally, in RCTs comparing pain control provided by different nerve blocks in the setting of a specific surgical procedure, only the data pertaining to the sensory and motor distributions provided by the blocks was retained for analysis.

Results

Our search criteria yielded 46 RCTs. Of these studies (average sample size = 62 subjects), 54% provided

sample size justification and 57% blinded assessment. Only 28% provided data about allocation concealment. Primary endpoints varied greatly: for instance, definitions of block success included surgical anesthesia, sensory analgesia (patient cannot feel cold or pinprick) as well as combined sensory analgesia and motor block.

I LUMBAR PLEXUS, FEMORAL, LATERAL FEMORAL CUTANEOUS, OBTURATOR AND SAPHENOUS NERVE BLOCKS

Lumbar plexus block

APPROACHES

The lumbar plexus can be blocked with a posterior approach by injecting LA in a lumbar paravertebral location.⁵⁻⁸ Alternately Winnie *et al.*⁹ have suggested that an inguinal, paravascular injection in the femoral perineural sheath (with concomitant distal manual compression and cephalad angulation of the needle) will lead to retrograde LA migration towards the lumbar plexus. Since the three main terminal branches (femoral, lateral femoral cutaneous and obturator nerves) of the lumbar plexus can be anesthetized with a single injection, this anterior approach is also called “3-in-1 block”.

Four RCTs (combined $n = 250$) have compared single shot anterior and posterior approaches with highly consistent results.^{7,10-12} At 30 min, both methods produced similar rates of sensory and motor block of the femoral nerve (93–100 and 73–100% of patients respectively).^{7,10,12} Two RCTs have reported a higher success rate for blockade of the lateral femoral cutaneous nerve with the posterior approach (90–97 *vs* 50–53%; $P < 0.05$)^{10,12} whereas another study found no difference (85–95%).⁷ All four RCTs reported significantly better obturator block with the posterior approach: three RCTs noted an improved sensory block (77–80 *vs* 47–50%; $P < 0.05$)¹⁰⁻¹² while two studies also found a higher rate of motor block (63–100 *vs* 0–30%; $P < 0.05$).^{7,10} However, in 45 patients undergoing total hip replacement, one study compared single shot lumbar plexus and 3-in-1 blocks and failed to detect any difference in nerve block distribution.¹³

Two RCTs (combined $n = 119$) have compared continuous posterior and anterior approaches for patients undergoing total knee replacement. While Morin *et al.*¹⁴ reported similar performance time, onset and success of obturator sensory blockade, Kaloul *et al.*¹⁵ found a better sensory block of the obturator nerve at 24 hr ($P = 0.02$). However both studies reported a significantly quicker onset ($P = 0.0017$) and better motor block of the obturator nerve at six hours ($P = 0.006$) with posterior lumbar plexus catheters.^{14,15}

The unreliability of the anterior approach to block the obturator nerve may stem from the fact that LAs do not anesthetize the lateral femoral cutaneous and obturator nerves by proximal migration, but by lateral and medial diffusion respectively.¹ Thus, with the 3-in-1 method, LA spread may occur preferentially in a lateral direction and spare the obturator nerve.¹² Some authors have even advocated renaming the anterior approach “2-in-1 block”.¹⁶ This contention seems to be supported by a RCT comparing 3-in-1 to direct obturator block: in 44 patients, Atanassof *et al.*¹⁷ observed that the latter method resulted in a denser motor block of the obturator nerve, as evidenced by a greater mean decrease from baseline in adductor compound muscle action potential testing (88.8 ± 21 *vs* $7.4 \pm 19\%$; $P < 0.05$).

Techniques

In their original description of the anterior approach, Winnie *et al.*⁹ advocated using paresthesiae to locate the femoral nerve. Seven subsequent RCTs have proposed modifications to this technique. In one study, compared to elicitation of paresthesiae, neurostimulation did not lead to an increased success rate.⁷ In two RCTs (combined $n = 100$), compared to neurostimulation, ultrasonography provided a quicker onset ($13-16 \pm 6-14$ *vs* $26-27 \pm 12-16$ min; $P < 0.05$) and a denser combined sensory block of the femoral, lateral femoral cutaneous and obturator nerves ($4-15 \pm 5-10$ *vs* $21-27 \pm 11-19\%$ of sensation to pinprick compared to the unanesthetized contralateral limb; $P < 0.05$).^{18,19} A recent study has also reported better blockade of all three nerves with echoguidance.¹¹ In 1988, to improve obturator nerve block seen with the 3-in-1 technique, Dalens *et al.*²⁰ introduced the fascia iliaca compartment block, a method by which LA was injected immediately posterior to the fascia iliaca while firm compression was applied distal to the puncture site. In 120 children randomized to a (neurostimulation-guided) 3-in-1 or a (loss of resistance-guided) fascia iliaca compartment block, these authors reported a similar rate of complete sensory block for the femoral nerve (100%); however the fascia iliaca block resulted in improved blockade of the lateral femoral cutaneous and obturator nerves (92 *vs* 15% and 88 *vs* 13% of patients respectively; both $P < 0.05$).²⁰ The same comparison was carried out in 100 adults. Again, despite a similar rate of femoral block (88–90%), the lateral femoral cutaneous nerve was more frequently anesthetized with the fascia iliaca compartment technique (90 *vs* 62%; $P < 0.05$). However, sensory blockade of the obturator nerve showed no difference (38–52%).²¹ In a follow-up study, the same group of authors com-

pared perineural catheters inserted with the 3-in-1 and fascia iliaca techniques. The latter method resulted in a faster performance time ($P < 0.05$) and a lower material cost ($\$11 \pm \2 vs $\$22 \pm \3 ; $P < 0.05$). Despite similar blockade of the femoral and lateral femoral cutaneous nerves, the 3-in-1 technique produced a better sensory block of the obturator nerve at one, 24 and 48 hr.²² In 2006, using Winnie's technique,⁹ Pham Dang *et al.*²³ investigated the role of femoral perineural sheath expansion for the insertion of stimulating catheters. In 60 patients randomly allocated to a bolus of 10 mL D5W through the needle or no bolus, they found that sheath expansion reduced the number of attempts ($P = 0.007$) and the resistance encountered ($P = 0.01$) during successful perineural catheter placement. However, no differences in spread were found when contrast was injected through the catheters.²³

Different surface landmarks have been advocated for the posterior approach to the lumbar plexus.⁵⁻⁸ In a RCT comparing Winnie's⁵ and Chayen's⁶ landmarks using neurostimulation, Dalens *et al.*²⁴ reported that, in children, while both techniques achieved similarly successful block of the lumbar and sacral plexi (88–92% of patients), Chayen's landmarks also led in 88% of cases to contralateral lumbar and sacral plexic anesthesia (through epidural LA spread). Comparing Winnie's⁵ and Capdevila's⁸ landmarks with neurostimulation in 60 adults, Mannion *et al.*²⁵ found similar performance times ($2.3-2.5 \pm 1.5$ min), similar patterns of block and comparable rates of epidural spread (33–40% of patients). Comparing Winnie's⁵ or Chayen's⁶ landmarks at the L4–5 level to Dekrey's landmarks⁷ at the L3 level, Parkinson *et al.*⁷ reported similar blockade of the femoral, lateral femoral cutaneous and obturator nerves at 30 min (95–100%). The incidence of epidural spread ranged from 4 to 25%. Interestingly, none of the 40 patients in this study presented a complete block of a nerve originating from the sacral plexus.⁷

It must be noted that, while both Winnie⁵ and Chayen⁶ advocated using loss of resistance to locate the lumbar plexus in their original descriptions, all subsequent RCTs have employed neurostimulation for its identification.^{7,24,25} A formal study comparing these two modalities or ultrasonography has not been undertaken. Furthermore, while preliminary imaging studies on volunteers seem to suggest a similar spread of contrast with Winnie's⁵ and Chayen's⁶ techniques, the comparative efficacy of catheters placed according to these different landmarks has not been investigated with RCTs.²⁶ Finally, the optimal location for placement of the needle (or catheter) tip

also requires further elucidation with RCTs: while Winnie's⁵ and Chayen's⁶ techniques (termed psoas compartment blocks) aimed to position the needle tip in a fascial plane between the quadratus lumborum and psoas muscles, recent descriptions by Dekrey⁷ and Capdevila⁸ (termed psoas sheath block) advocated anesthetizing the roots of the lumbar plexus in the substance of the psoas muscle.

FEMORAL NERVE BLOCK

Some confusion exists in the literature regarding the terminology pertaining to femoral nerve blockade: despite specifically using Winnie's description for the 3-in-1 block,⁹ some studies have nonetheless labelled their technique "femoral nerve block".^{13,14,23} Thus we decided to include the results of these RCTs in the previous section. A review of the literature yielded only one RCT corresponding to our search criteria. When using a small dose of LA (12 mL of ropivacaine 0.75%), Casati *et al.*²⁷ showed that, compared to a single injection-technique, a triple-injection method (with electrolocation and anesthesia of the branches to the vastus medialis, intermedius and lateralis muscles) was preferable. Although block placement took less time with the single-injection technique (3.4 ± 1.2 vs 4.7 ± 1.7 min; $P = 0.02$), total preoperative time was significantly shorter in patients receiving multiple injections because of a quicker onset time (10.0 ± 3.7 vs 30 ± 11 min; $P < 0.001$).

Femoral nerve block can be carried out either at the inguinal ligament or at the inguinal skin crease. Although cadaveric studies seem to suggest that the nerve is easier to locate at the crease, these two landmarks have not been compared with RCTs in humans.²⁸ During electrolocation of the femoral nerve, two responses are often encountered: sartorius muscle contraction (stimulation of the anterior branch of the femoral nerve) and quadriceps muscle contraction or "dancing patella" sign (stimulation of the posterior branch of the femoral nerve). Most authors advocate preferentially searching for the latter response as articular branches derive from the posterior branch.¹ Although sensible and anatomically sound, this contention has not been confirmed with RCTs. Loss of resistance, elicitation of paresthesiae, neurostimulation and ultrasonography have all been investigated as adjunctive modalities for nerve localization in 3-in-1 block:^{7,11,18-22} although the results of these studies can be extrapolated to femoral blockade, further RCTs are nonetheless required to investigate their use in the context of a specific femoral nerve block technique. Finally, as evidenced by the confusion in terminology, the difference between 3-in-1

and femoral nerve block requires elucidation. In other words, despite the unreliable block of the obturator nerve, it is not clearly established whether the 3-in-1 method is a different entity from the isolated femoral nerve block because of improved blockade of the lateral femoral cutaneous nerve.

LATERAL FEMORAL CUTANEOUS NERVE BLOCK

In 20 volunteers randomized in a crossover study, Shannon *et al.*²⁹ evaluated two techniques for lateral femoral cutaneous nerve blockade: fan infiltration and sensory neurostimulation (aiming to elicit a paresthesia on the lateral thigh). The latter method achieved a higher success rate (100 *vs* 40%; $P < 0.001$). Furthermore electrolocation resulted in a quicker onset time (0.6 ± 0.2 *vs* 6.9 ± 6.1 min; $P < 0.02$) and a decreased rate of incidental femoral nerve block (5 *vs* 35% of patients; $P = 0.02$). No differences in the extent of the block, performance time and procedural discomfort were noted.

OBTURATOR NERVE BLOCK

In 50 patients requiring an obturator block for knee arthroscopy, Choquet *et al.*³⁰ compared the classic approach (at the level of the pubic tubercle) to a new approach (at the level of the inguinal crease) and found that the latter method resulted in a decreased performance time (80 *vs* 120 sec; $P < 0.05$), less procedural discomfort (visual analogue score = 2 ± 1.4 *vs* 4 ± 1.7 ; $P < 0.001$) and a lower incidence of minor complications such as vascular puncture and persistent groin pain ($P < 0.05$). Twenty minutes after application of the block, adductor strength decrease and cutaneous distributions of the obturator nerve block were not significantly different between the two groups.

SAPHENOUS NERVE BLOCK

Several approaches for blockade of the saphenous nerve have been described: perifemoral injection, transsartorial injection, infiltration around the medial femoral condyle, infiltration around the medial tibial tuberosity, paravenous injection below the knee and infiltration around the medial malleolus. Techniques have included field blocks, loss of resistance and (sensory) neurostimulation. Four RCTs were reviewed, of which three compared approaches and one compared techniques.

In one RCT ($n = 60$) reported by Van der Wal *et al.*,³¹ a transsartorial approach (using loss of resistance) was compared to infiltrations around the medial femoral condyle and around the medial tibial tuberosity below the knee. The transsartorial approach achieved a higher success rate than infiltration below

the knee (80 *vs* 40% of patients; $P < 0.05$); it was also more successful than paracondylar infiltration (80 *vs* 65% of patients) but this failed to reach statistical significance. In an effort to refine the transsartorial method, Comfort *et al.*³² compared loss of resistance to (sensory) neurostimulation in a group of 25 volunteers. The latter produced a higher success rate (100 *vs* 72% of patients; $P < 0.05$). However, procedural pain scores, performance times and anesthesia-related times were also more elevated (1 *vs* 2 on a ten-point scale, 11 ± 5 *vs* 4 ± 1 min and 13 ± 7 *vs* 8 ± 2 min respectively; all $P < 0.05$). In a recent RCT, Benzon *et al.*³³ compared a neurostimulation-guided perifemoral approach (4 cm below the inguinal crease) seeking a motor response in the vastus medialis or rectus femoris muscles, to a neurostimulation-guided transsartorial approach and three field blocks: paracondylar, below the knee and around the medial malleolus. These authors observed the following rates of blockade for the medial leg (above the ankle): 100% for the transsartorial approach, 70% for the perifemoral approach, 10% for paracondylar injection and 70% for below the knee infiltration. Because of the small number of subjects in the study ($n = 10$), statistical significance was only achieved when comparing paracondylar injection with the other groups. Assessment of the block below the ankle was more difficult because of the variable contribution of the superficial peroneal nerve. Interestingly, in the perifemoral group, despite approaching the saphenous nerve 4 cm below the inguinal crease, 70% of subjects still presented some degree of femoral motor blockade.

In 20 volunteers, De Mey *et al.*³⁴ compared a blind injection lateral and medial to the saphenous vein with one made below the knee (between the tibial tuberosity and the medial head of the gastrocnemius). The paravenous approach yielded a higher success rate (100% *vs* 33.3% of patients; $P < 0.05$). Performance time and procedural discomfort were not reported.

INTERPRETATION

Compared to its anterior counterpart (3-in-1 block), the posterior approach to the lumbar plexus offers a higher success rate for single shot and continuous blocks because of improved anesthesia of the obturator nerve. In children, Chayen's technique for the posterior approach can lead to an increased incidence of epidural spread. In adults, no differences have been found between Winnie's, Chayen's, Dekrey's and Capdevila's landmarks. For the 3-in-1 block, ultrasonography may be a superior technique to elicitation of paresthesiae and nerve stimulation. The fascia iliaca compartment block represents an interesting alterna-

tive to the 3-in-1 block: while providing a similarly efficacious block of the femoral nerve, it is associated with better anesthesia of the lateral femoral cutaneous and possibly of the obturator nerves. Furthermore, perineural catheters inserted with the fascia iliaca technique may result in a quicker performance time and a lower material cost. Perineural sheath expansion with 10 mL D5W can reduce the resistance and attempts needed for successful catheter placement. For low volume femoral nerve blocks, a multiple-injection technique provides a shorter onset time.

Block of the lateral femoral cutaneous nerve can be carried out using sensory neurostimulation. Compared to the traditional fan infiltration technique, it leads to an improved onset time and success rate coupled with a reduced risk of incidental femoral nerve block.

A new inguinal approach for obturator nerve block has recently been described and compared to the traditional method at the pubic tubercle. It was found to decrease the performance time, procedural discomfort and side effects.

The transsartorial and paravenous approaches represent the best options for blockade of the saphenous nerve. Although sensory neurostimulation increases the efficacy of the transsartorial approach, it also results in increased pain scores as well as performance and anesthesia-related times.

II SACRAL PLEXUS, SCIATIC, TIBIAL, PERONEAL, POSTERIOR FEMORAL CUTANEOUS AND ANKLE NERVE BLOCKS

Sacral plexus

As described by Mansour,³⁵ the parasacral approach to the sacral plexus aims to anesthetize the latter just caudal to the posterior inferior iliac spine. In 150 patients undergoing lower limb surgery, using 20 mL of ropivacaine 0.75%, Cuvillon *et al.*³⁶ compared this method to a (double-injection) transgluteal sciatic nerve block: although the parasacral approach resulted in a quicker performance time (2 *vs* 5.5 min; $P < 0.001$), because of a slower onset (25 *vs* 15 min; $P < 0.017$), total anesthesia-related times (20–25 min) were similar between the two groups. No differences were noted in the success rates of sciatic and posterior femoral cutaneous nerve block.

Sciatic nerve

APPROACHES

Two RCTs (combined $n = 178$) have compared the transgluteal and subgluteal approaches for sciatic nerve block and reached similar conclusions: while no differences in success rates, onset and offset times were noted,^{37,38} the subgluteal approach was associ-

ated with quicker sciatic nerve electrolocation (32 *vs* 60 sec; $P < 0.001$) and less procedural pain ($P < 0.001$).³⁷

Two RCTs (combined $n = 158$) have compared the transgluteal and posterior popliteal approaches for blockade of the sciatic nerve and found no differences in onset, offset and performance times. However, the procedure was significantly less painful with the popliteal approach.^{39,40} While Kilpatrick *et al.*³⁹ reported a better success rate with the transgluteal approach (95 *vs* 45% of patients; $P < 0.01$), Fuzier *et al.*⁴⁰ found no difference between the two groups (94–98%).

Two RCTs (combined $n = 100$) have compared the transgluteal and lateral popliteal approaches: both studies found a longer onset for sensory and motor block with the latter.^{38,41} Taboada *et al.*⁴¹ also reported a lower success rate with the lateral popliteal approach (68 *vs* 96% of patients; $P < 0.05$).

One RCT ($n = 63$) compared the lateral midfemoral and lateral popliteal approaches and reported no differences in performance time, procedural discomfort and quality as well as duration of sensory and motor blockade. The lateral midfemoral approach was associated with shorter onset times for sensory block of the tibial nerve (5 *vs* 10 min; $P = 0.016$) and for motor block of the tibial and peroneal nerves (5 *vs* 15 min; $P = 0.03$ and 6 *vs* 15 min; $P = 0.009$ respectively).⁴²

One RCT ($n = 59$) compared the lateral midfemoral and anterior approaches and reported no differences in performance time (4.9–6.1 min), success rate (77–79%), onset time (18–19 min) and block duration (373–506 min).⁴³ Another RCT ($n = 50$) compared the posterior popliteal and lateral popliteal approaches and found similar success rates. The posterior approach required fewer attempts to localize the sciatic nerve.⁴⁴

Of all the studies evaluated, only one compared different approaches for sciatic nerve block in a pediatric population. Dalens *et al.*⁴⁵ randomized 180 children undergoing lower extremity surgery to an anterior, a posterior transgluteal and a lateral midfemoral approach. No differences in overall success rate (82–97%) and block duration were noted. The distribution of anesthesia in the lower extremity was similar and included not only territories supplied by the sciatic nerve but also those supplied by the posterior femoral cutaneous nerve. However, the posterior approach was associated with a higher success rate on the first attempt compared to the lateral and anterior approaches (88 *vs* 78 and 62% respectively; both $P < 0.05$). In turn, the lateral approach also achieved a higher first-pass success rate than the anterior approach ($P < 0.05$).

Two RCTs (combined $n = 116$) compared sciatic

perineural catheter placement using the subgluteal and posterior popliteal approaches. In one study, more attempts were necessary to achieve successful catheter placement with the latter method.⁴⁶ The rate of catheter occlusion or dislodgement did not differ between groups.⁴⁷ In the literature, no other RCTs were found comparing approaches for placement of sciatic perineural catheters.

TECHNIQUES

In 20 patients, using new landmarks for the anterior approach (puncture site 2.5 cm medial to the femoral artery and 2.5 cm distal to the inguinal crease), Van Elstraete *et al.*⁴⁸ compared placement of the patient's leg in a neutral position or in external rotation. These authors found that, with the latter approach, the sciatic nerve was more quickly electrolocated (46 ± 25 vs 79 ± 53 sec; $P < 0.006$). However success rates, distances from skin to nerve, numbers of attempts required and side effects were similar.

Two RCTs (combined $n = 150$) using the posterior transgluteal approach compared a single to a double-injection technique, in which the tibial and peroneal components of the sciatic nerve were independently electrostimulated and anesthetized. In both studies, 20 mL of LA (ropivacaine 0.75% or a mix of lidocaine 1% and tetracaine 0.2%) were used for the two groups. The findings were consistent. A double-injection technique produced a higher success rate at 45 min (75–100 vs 55–80% of patients; $P < 0.05$).^{36,49} Although associated with a longer performance time (5.5 vs 3 min; $P = 0.001$), it also resulted in a quicker onset (15 vs 25 min; $P < 0.017$). Thus the total anesthesia-related times were not different between the two groups (20–25 min).⁴⁹ In 80 patients undergoing hallux valgus surgery, Taboada *et al.*⁵⁰ compared plantar flexion (tibial nerve stimulation) to dorsiflexion (peroneal nerve stimulation) as the stimulatory response guiding a single-injection technique. These authors observed a higher success rate with plantar flexion (87.5 vs 55%; $P < 0.05$). Furthermore, the latter also produced shorter onset times for complete sensory and motor block (10 ± 10 vs 20 ± 11 min and 13 ± 10 vs 24 ± 12 min respectively; both $P < 0.05$). Taboada *et al.*⁵⁰ attributed the improved success and onset seen with plantar flexion to the fact that the tibial nerve is the larger of the two sciatic neural components and thus requires more LA to be deposited in its vicinity.

It must be noted that the landmarks used for the transgluteal approach in all the preceding studies originate either from Labat's⁵¹ or Winnie's⁵ descriptions; despite their widespread use and popularity, these two methods have never been formally com-

pared with RCTs, nor have they been determined to be interchangeable.

One RCT ($n = 50$) has compared single and double-injection techniques for the posterior subgluteal approach. In both groups, 30 mL of ropivacaine 0.75% were used. Despite a similar success rate (92–96%), performance time (2.4–3.1 min) and block duration, Taboada *et al.*⁵² reported that the double-injection technique produced a faster onset of complete sensory and motor blockade (7.4 vs 12.5 min and 12.3 vs 18.8 min respectively; both $P < 0.001$). However, the single-injection method caused less procedural discomfort ($P = 0.013$). Although preliminary works suggest that inversion constitutes the best neurostimulatory response for the subgluteal approach, this finding has not been validated with RCTs.⁵³

Two studies have attempted to determine the best technique for the lateral midfemoral approach. In one RCT ($n = 50$), a proximal (20 cm distal to the greater trochanter) and distal puncture site (30 cm distal to the greater trochanter) were compared in patients receiving 20 mL of mepivacaine 1.5%.⁵⁴ Taboada *et al.*⁵⁴ observed, with the proximal method, a higher success rate (88 vs 56%; $P < 0.05$) and a faster onset of complete sensory and motor blockade (12 ± 7 vs 19 ± 9 min and 15 ± 8 vs 23 ± 9 min respectively; both $P < 0.05$) because of a quicker sensory and motor block of the peroneal component. In the second RCT, adjunctive neurostimulation was compared to neurostimulation combined with echoguidance.⁵⁵ In 61 patients undergoing foot and ankle surgery, Domingo-Triado *et al.*⁵⁵ found that, with the combination of the two modalities, fewer attempts were required (1 vs 2; $P = 0.001$) and a denser sensory block was achieved ($P = 0.01$). However performance, onset and offset times were not significantly different between the two groups.

One RCT ($n = 60$), using 25 mL of mepivacaine 1.5%, compared single and double-injection techniques for the posterior popliteal approach and found similar success rates (77–87% of patients) as well as onset times for sensory block (21.9–22.1 min). Despite a quicker performance time with the single-injection technique (4.6 ± 2.8 vs 5.9 ± 3.1 min; $P = 0.03$), total anesthesia-related times were similar. However, patients receiving a single injection reported fewer paresthesiae (17 vs 40% of patients; $P = 0.04$).⁵⁶ Although observational studies have suggested that the optimal evoked motor response for posterior popliteal sciatic blockade is inversion, this finding requires further validation with RCTs.⁵⁷

Two RCTs have compared single and double-injection techniques for the lateral popliteal approach with conflicting results.^{58,59} In one RCT ($n = 50$), using

20 mL of an equal mix of lidocaine 2% and bupivacaine 0.5% and seeking foot inversion as the preferred response for the single-injection group, Paqueron *et al.*⁵⁸ observed a lower success rate (54 *vs* 88%; $P = 0.007$) with the latter. Onset times for sensory and motor block were similar. In contrast, Arcioni *et al.*⁵⁹ randomized 96 patients undergoing foot surgery to a lateral popliteal sciatic block using a single-injection technique seeking tibial nerve stimulation, a single injection seeking peroneal nerve stimulation (dorsiflexion or eversion) or a double-injection technique. The total volume administered was 30 mL of ropivacaine 0.75%. These authors reported that, compared to a double-injection technique, the single-injection method with tibial nerve electrolocation resulted in a similar performance time (400–487 sec) and success rate (94%). However the onset time for sensory blockade was shorter with the single-injection technique (14 ± 7 *vs* 21 ± 14 min; $P < 0.05$). Patients receiving a single injection with peroneal nerve electrolocation displayed a lower success rate than the other two groups (75%).⁵⁹ In another RCT ($n = 30$), Taboada Muniz *et al.*⁶⁰ also concluded that, compared to plantar flexion, dorsiflexion resulted in a lower success rate (33 *vs* 93%; $P < 0.05$). In addition, onset times for sensory and motor block were slower as well (24.3 ± 5.1 *vs* 16.6 ± 5.1 min and 28.1 ± 5.0 *vs* 20.1 ± 5.1 min; both $P < 0.05$).

TIBIAL NERVE BLOCK

In a study of 135 patients, Doty *et al.*⁶¹ compared three methods to anesthetize the posterior tibial nerve: blind infiltration around the medial malleolus, neurostimulation-guided injection around the medial malleolus or neurostimulation-guided injection 7 cm above the latter, in the subfascial plane between the flexor hallucis longus and flexor digitorum longus tendons. Compared to fan infiltration, electrolocation consistently resulted in a quicker onset and a higher success rate (93–100 *vs* 75.5%; $P = 0.02$). Posterior tibial nerve block with electrolocation at the distal site produced a quicker onset than at the proximal site (8 *vs* 15 min; $P = 0.05$).

PERONEAL, POSTERIOR FEMORAL CUTANEOUS AND ANKLE NERVE BLOCK

The optimal approaches and techniques for these blocks have not been investigated with RCTs.

INTERPRETATION

The posterior transgluteal approach is the most widely used approach for sciatic nerve blockade.³⁷ Review of the literature suggests that it may also be

one of the most reliable methods. The transgluteal approach is superior in efficacy (success rate) and efficiency (onset) to its posterior and lateral popliteal counterparts. In children, it provides a higher rate of success on the first attempt than the lateral and anterior approaches. Furthermore it may even be comparable to a more proximal method like the parasacral approach. However, by allowing quicker sciatic nerve electrolocation, the recently introduced posterior subgluteal approach offers an advantage over the traditional transgluteal method. For the placement of sciatic perineural catheters, fewer attempts are required with the subgluteal than the posterior popliteal approach. RCTs comparing other approaches for continuous sciatic catheters are lacking.

The sciatic nerve is composed of two distinct but contiguous neural structures: the tibial and peroneal nerves. To increase the efficacy of sciatic block, many authors have advocated separately electrolocating and anesthetizing the two nerves. In the literature, three RCTs (pertaining to the transgluteal and lateral popliteal approaches) have demonstrated an improved success rate using a double-injection technique.^{36,49,58} In contrast, three other RCTs (pertaining to the subgluteal, posterior and lateral popliteal approaches) failed to detect any such difference.^{52,56,59} Although a review of the optimal LA dose required for sciatic nerve blockade exceeds the scope of this paper, it is interesting to note that the studies that found an improved success rate with two injections used a total dose of 20 mL of LA. In contrast, those that did not employed a larger volume (25–30 mL).

Of the two bundles, the tibial nerve is larger in size: thus it would appear logical that LA deposition in its vicinity (in the context of a single-injection technique) would lead to a more successful block than injection around the peroneal nerve. Although non-randomized studies pertaining to the subgluteal and posterior popliteal approaches have suggested that inversion or plantar flexion should be preferentially sought during neurostimulation,^{53,57} only three RCTs (pertaining to the transgluteal and lateral popliteal approaches) have validated this finding.^{50,59,60}

Ultrasonography, in combination with neurostimulation, has been successfully used as an adjunct in one RCT pertaining to the lateral midfemoral approach.⁵⁵ Further RCTs are required to determine its role in other approaches. Finally, the best method for anesthesia of the posterior tibial nerve is a neurostimulation-guided injection around the medial malleolus.

LIMITATIONS

For practical reasons, a decision was taken to limit

TABLE Areas pertaining to lower extremity nerve blocks warranting further investigation with randomized controlled trials

Posterior approach for lumbar plexus block	<ul style="list-style-type: none"> • Reliability of Dekrey's and Capdevila's landmarks for pediatric patients • Comparison between loss of resistance and neurostimulation for localization of the lumbar plexus • Comparison between Winnie's, Chayen's, Dekrey's and Capdevila's landmarks for catheter placement • Optimal position for needle and catheter tips: between the quadratus lumborum and psoas vs inside the psoas muscle • Perineural sheath expansion for the placement of lumbar plexic catheters
3-in-1 block	<ul style="list-style-type: none"> • Comparison between 3-in-1 and isolated femoral nerve blocks
Femoral nerve block	<ul style="list-style-type: none"> • Comparison between elicitation of paresthesiae and neurostimulation as techniques for nerve localization • Comparison between single and multiple-injection techniques for local anesthetic volumes superior to 12 mL • Optimal surface landmarks for femoral nerve electrolocation • Optimal evoked motor response: sartorial vs quadriceps contraction
Sacral plexus block	<ul style="list-style-type: none"> • Comparison between the sacral plexus block and the posterior subgluteal approach to the sciatic nerve • Perineural sheath expansion for the placement of sacral plexic catheters
Sciatic nerve block	<ul style="list-style-type: none"> • Comparison between the subgluteal and non-transgluteal approaches (anterior, lateral midfemoral and lateral popliteal) • Comparison between approaches (other than posterior, lateral and anterior) for pediatric patients • Comparison between approaches (other than subgluteal and posterior popliteal) for the placement of sciatic catheters • Comparison between a single-injection technique using 25–30 mL LA and a double-injection technique using 20 mL LA • Optimal evoked motor response for methods other than the transgluteal and lateral popliteal approaches • Perineural sheath expansion for the placement of sciatic catheters

LA = local anesthetic agents.

this review to RCTs published in the English language. Although such a restriction may constitute a methodological limitation, we believe that its impact on overall conclusions is minimal: expansion of our search criteria (using the same databases and time periods) to languages other than English only yielded an additional five RCTs.^{62–66} Furthermore, no attempt was made to produce a meta-analysis. In our view, given the wide array of approaches and techniques

commonly used for lower extremity anesthesia, patient enrolment would have been insufficient for many approaches and techniques to support a systematic pooling of data. The heterogeneous definitions of endpoints like block success would also make this task very difficult. Finally, all RCTs published in English were kept for the analysis: no studies were excluded based on factors such as sample size justification, statistical power, blinding, definition of interven-

tion allocation or primary and secondary outcomes. This may represent a limitation to our review as it may serve to overemphasize evidence derived from “weaker” RCTs.

Conclusions

Compared to the 3-in-1 block, the posterior approach to the lumbar plexus is more reliable when anesthesia of the obturator nerve is required. In adults, no differences have been found between the different landmarks described for the posterior approach. In children, Chayen’s technique is associated with an increased incidence of epidural spread. The fascia iliaca compartment block may also represent a better alternative than the 3-in-1 block because of improved efficacy (better anesthesia of the lateral femoral cutaneous and obturator nerves) and efficiency (quicker performance time, lower cost).

For blockade of the sciatic nerve, the classic transgluteal approach constitutes a reliable method. However, because of the short time required for sciatic nerve electrolocation and placement of perineural catheters, the subgluteal approach should also be considered. Compared to electrolocation of the peroneal nerve, electrostimulation of the tibial nerve may offer a higher success rate especially with the transgluteal and lateral popliteal approaches. Furthermore, when performing sciatic and femoral nerve blocks with low LA volumes (20 and 12 mL respectively), a multiple-injection technique should be preferentially used.

For blockade of the lateral femoral cutaneous nerve, sensory neurostimulation is more reliable than fan infiltration. Compared to the traditional method, a new inguinal approach for obturator nerve block has been shown to decrease the performance time, patient discomfort and side effects. The transsartorial and paravenous approaches represent the best options for blockade of the saphenous nerve. The best method for anesthesia of the posterior tibial nerve is a neurostimulation-guided injection around the medial malleolus.

A critical survey of the available RCTs can provide an effective tool to establish the most effective approaches and techniques for lower limb anesthesia. Despite current best evidence, many issues regarding lower extremity nerve blocks remain unresolved and require further elucidation through well designed and meticulously conducted RCTs (Table). Furthermore, although promising, the role of adjunctive ultrasonography needs to be better and systematically defined.

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