Analgesia for primary hip and knee arthroplasty: the role of regional anaesthesia

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Key points

Pain after total hip arthroplasty is variable but can be severe; pain after total knee arthroplasty is typically severe.

Regional anaesthesia is associated with lower perioperative morbidity and mortality and may also facilitate improved functional outcome.

Intrathecal morphine and/or lumbar plexus block are the most effective regional analgesic techniques following total hip arthroplasty.

Continuous peripheral nerve blocks provide effective analgesia following total knee arthroplasty with fewer side effects when compared with either continuous epidural or parenteral opioids.

Low concentration local anaesthetic solutions should be used to establish and maintain continuous peripheral nerve blocks in order to minimize motor block in the post-operative period.

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The development of total hip and knee arthroplasty are regarded as amongst the most significant advances in orthopaedic surgery of the last century. Primary hip and knee arthroplasty are major surgical procedures associated with significant potential perioperative morbidity. Anaesthesia can play a significant role in reducing perioperative morbidity.

Anaesthetic technique for arthroplasty

Anaesthesia for total hip and knee arthroplasty should provide stable intra-operative conditions and allow rapid patient recovery. Analgesic techniques should aim to provide optimal pain relief whilst minimizing side effects such as sedation, post-operative nausea and vomiting (PONV), hypotension, and motor block. There is now good evidence that well-conducted regional analgesia can achieve these aims, leading to improved functional recovery facilitated by more rapid and effective joint rehabilitation.[1, 2]

Regional anaesthetic techniques have been shown to offer several advantages over general anaesthesia for this type of surgery. Regional anaesthesia is associated with less intra- and post-operative blood loss due to reductions in mean arterial pressure and venodilatation. Venous thromboembolic complications are reduced by ~50% when central neuraxial block is compared with general anaesthesia in patients who have not received antithrombotic prophylaxis. Experimental evidence suggests that this results from attenuation of the pro-thrombotic effects of the stress response.

Analgesia in the immediate post-operative period is improved following central neuraxial block. The intrathecal addition of a hydrophilic opioid (e.g. morphine) can further extend the analgesic benefits.

Multi-modal analgesia

Combining different classes of analgesic drugs is important to facilitate rehabilitation after hip and knee arthroplasty. Analgesia is not an end point in itself but is necessary to allow patients to mobilize as rapidly and effectively as possible. This can be achieved using a multi-modal analgesic technique. Continuous peripheral nerve blocks and low dose intrathecal opioids are the cornerstone of this approach. Regular oral analgesics also have an important role. Routine prescribing of regular paracetamol and a long acting oral opioid (e.g. sustained release oxycodone) are particularly useful.

Epidural anaesthesia and analgesia

Epidural anaesthesia remains a useful anaesthetic technique for lower limb arthroplasty in certain circumstances and combines some of the advantages associated with spinal anaesthesia, with the ability to prolong surgical anaesthesia. However, a 2003 Cochrane systematic review found that the *analgesic* benefits of continuous epidural analgesia compared with patient-controlled analgesia (PCA) with intravenous morphine were limited to the early (first 4–6 h) post-operative period.[3] Lumbar epidural analgesia is also commonly associated with unwanted side effects such as hypotension and urinary retention. Bilateral sensory and motor block are also undesirable side effects and can delay mobilization.

Spinal anaesthesia and intrathecal opioids

Spinal anaesthesia is quick, reliable, and simple to perform; the advantages of regional *anaesthesia* have already been mentioned. The recovery profile and analgesia in the immediate

doi:10.1093/bjaceaccp/mkn007
Continuing Education in Anaesthesia, Critical Care & Pain | Volume 8 Number 2 2008

post-operative period, combined with the ability to co-administer long acting intrathecal opioids make spinal anaesthesia, in several ways, the optimal anaesthetic technique.

Low dose intrathecal opioids have been shown to provide prolonged analgesia after hip and to a lesser extent knee arthroplasty.[4, 5] The analgesic effect is regulated via μ-receptors in the white matter and dorsal horn of the spinal cord. The analgesic spread of intrathecal opioid is produced by spread of drug within the cerebrospinal fluid (CSF), while their action is offset by systemic absorption in the spinal cord and spread to the adjacent epidural space. The more lipophilic agents (e.g. fentanyl) have a more rapid onset and shorter duration of action than hydrophilic agents such as morphine. Morphine has the longest duration of analgesic action because its low lipid solubility slows redistribution from the dorsal horn.

Dose finding studies suggest that the optimal dose for morphine in total hip arthroplasty is 100 μg,[4] providing effective analgesia for up to 21 h. This dose appears to be at the upper end of the dose–response curve with lower doses lacking equivalent analgesic efficacy and higher doses increasing the incidence of side effects. Intrathecal diamorphine, still popular in the UK, has not been as extensively investigated in arthroplasty patients. Its high lipid solubility means that the duration of action is typically only ~10 h.

The evidence supporting the use of intrathecal morphine following total knee arthroplasty is not as compelling. The optimum dose has yet to be conclusively identified. Larger doses of 200–500 μg (in keeping with the greater severity of pain associated with total knee arthroplasty) have been shown to reduce post-operative analgesic requirements[5] but with an increase in the incidence of side effects. Single shot femoral nerve block alone has been shown to produce comparable analgesia to 250 μg intrathecal morphine following knee arthroplasty, but with fewer reported side effects and increased patient satisfaction.[6]

PONV can be a problem and is seen in up to 35% of patients who are given intrathecal opioids and do not receive prophylactic antiemetics. This is similar to the rate seen following intravenous or intramuscular opioid administration. The incidence of PONV can be significantly reduced if antiemetic prophylaxis is used. The reported incidence of pruritus and urinary retention is approximately 30%. Pruritus is probably mediated via opioid receptors (as opioid antagonists appear to be more effective in relieving symptoms than antihistamines), while urinary retention is a result of sacral parasympathetic inhibition and spinal cord analgesia. We recommend routine urinary catheterization after surgery, which allows hourly urine volumes to be monitored in the first 24 h.

Rostral spread within the CSF may produce respiratory depression, although this complication is extremely rare with the 100–200 μg doses that are used in current clinical practice. The timing of this complication is as early as 20–30 min after administration of lipophilic agents but as late as 24 h following intrathecal administration of morphine. It is crucial that appropriate monitoring for signs of respiratory depression be continued for at least 24 h post-operatively. The best early indicator of respiratory depression is increasing sedation; therefore, ward staff must be trained to monitor patients appropriately. A protocol should be in place for the management of delayed respiratory depression should this very rare complication arise.

Peripheral nerve blocks

The use of either single shot or continuous peripheral nerve blocks is becoming increasingly popular for post-operative analgesia following lower limb arthroplasty. Current evidence supports earlier and improved rehabilitation when peripheral nerve blocks are used to provide post-operative analgesia.[1,2,7] They can provide excellent analgesia with minimal motor block. This facilitates early and more effective joint mobilization and physiotherapy, while limiting reflex muscle spasm. In addition, they avoid the systemic side effects associated with continuous epidural analgesia (hypotension, urinary retention) and PCA morphine (sedation, PONV).

A thorough knowledge of the appropriate anatomy as well as the principles and practice of regional anaesthesia is essential in order to use these techniques safely and appropriately. This is outwith the scope of this article; however, a simple description of the innervation of the lower limb is pertinent.

Innervation of the hip and knee

The hip joint is innervated by three nerves (Fig. 1): (i) femoral nerve via nerve to rectus femoris (L2,3,4); (ii) sciatic nerve via nerve to quadratus femoris (L4,5,S1,2,3); and (iii) obturator nerve directly from its anterior division (L2,3,4). Cutaneous innervation of the lateral aspect of the thigh is predominantly supplied by the lateral cutaneous nerve of thigh, with variable innervation proximally from the sub-costal nerve (T12).

Innervation of the knee joint is derived from (i) femoral nerve via the branch to vastus medialis (anterior aspect of the joint capsule); (ii) sciatic nerve via genicular branches of both tibial and common peroneal components (posterior aspect of the joint capsule and all of the intra-articular structures); and (iii) obturator nerve by a branch from its posterior division that accompanies the femoral artery through adductor magnus into the popliteal fossa. Cutaneous innervation of the anterior aspect of the knee is supplied by the femoral nerve. The obturator nerve supplies the skin on the medial aspect of the knee in less than 40% of people.

Continuous peripheral nerve blocks

Continuous peripheral nerve blocks provide prolonged sensory nerve block and analgesia when compared with single shot blocks. This has been demonstrated for femoral, lumbar plexus, and sciatic nerve blocks.[8] In order to minimize motor block in the post-operative period, low concentration local anaesthetic solutions should be used (i.e. ≤0.1% levobupivacaine), although the optimal concentration to maximize analgesia and minimize motor block is

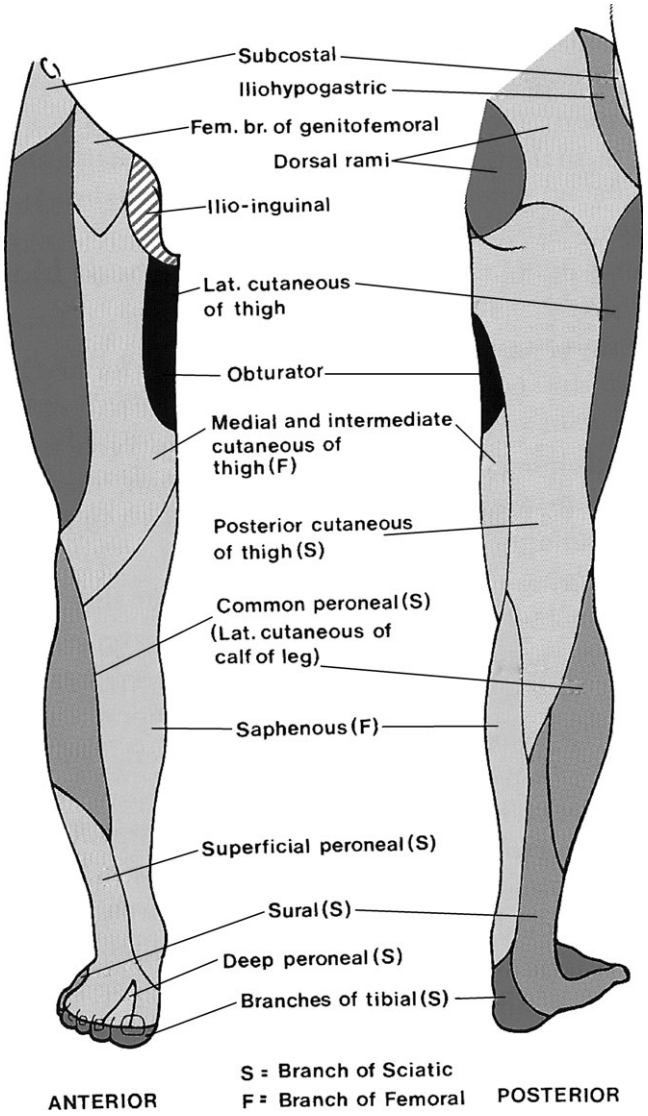

Fig. 1 Innervation of the lower limb (used with permission).

not yet known. The typical rate of local anaesthetic infusion is between 5 and 10 ml h^{-1} (per block).

The insertion of continuous peripheral nerve catheters requires a greater level of expertise and can be both time consuming and technically challenging. Good local anaesthetic skin infiltration and an appropriate level of sedation are important to minimize patient discomfort and anxiety when performing these procedures in awake patients. We strongly recommend that peripheral nerve blocks are not carried out in patients under general anaesthesia to minimize the risk of accidental intra-neural or intravenous injection.

The quality of equipment now available on the market for continuous peripheral nerve block is excellent and has largely been responsible for the increased use of these techniques. Most kits are supplied with an 18–19.5G insulated needle that can be used in conjunction with a peripheral nerve stimulator. Stimulating catheters are also available that allow confirmation of final catheter position in proximity to the appropriate nerve. Catheters are typically 20G polyamide with a radio-opaque strip and a single end hole or multiple side-hole openings.

Continuous nerve blocks should be performed under strict aseptic conditions with careful attention to adequate skin disinfection. A bolus of local anaesthetic can be given once correct needle placement has been established, either before or following subsequent catheter insertion. Catheters must be well secured to the skin, away from the surgical and tourniquet sites. Catheter patency and aspiration to exclude intravascular placement should always be confirmed following insertion and application of dressings.

Post-operatively, infusion of dilute local anaesthetic solution can be commenced in the post-anaesthetic care unit and these are typically continued for 48–72 h. Single use elastomeric pumps have become a popular alternative to electronic infusion devices. They are simple, relatively cheap and portable, allowing the patient to move about freely and even go home with a working continuous peripheral nerve block.[7]

Motor block may still be a problem with continuous nerve blocks, even when using dilute local anaesthetic solutions, and care should be taken when mobilizing patients to ensure both motor function and proprioception are adequate. Nursing and physiotherapy staff requires training to ensure that they can fully assess and safely mobilize these patients. Serious complications relating to continuous peripheral nerve block are rare. Infection, haematoma, systemic toxicity, catheter knotting, and shearing have all been described. Minor adverse events are more common (e.g. catheter kinking, obstruction, dislodging).[9]

Total hip arthroplasty: peripheral nerve blocks

A range of techniques and options exist for peripheral nerve blocks to provide anaesthesia and post-operative analgesia for total hip arthroplasty.

Lumbar plexus block (posterior approach)

Lumbar plexus block is a logical choice for analgesia after hip arthroplasty because it is the most reliable method of blocking the lateral cutaneous nerve of thigh, femoral and obturator nerves (Fig. 2). It can be performed as a single shot or continuous technique. The sacral plexus is not reliably blocked by this approach. A local anaesthetic bolus of 15–20 ml will reliably block the lumbar plexus. Recent anatomical studies have demonstrated that the appropriate point of needle insertion for lumbar plexus block lies more medial and caudad to that originally described by Winnie.[10]

Single shot lumbar plexus block has been shown to provide good analgesia for a relatively short period of time after total hip arthroplasty, typically 6–12 h. Low dose intrathecal morphine appears to offer better and longer acting analgesia after total hip arthroplasty when compared with single shot lumbar plexus block.

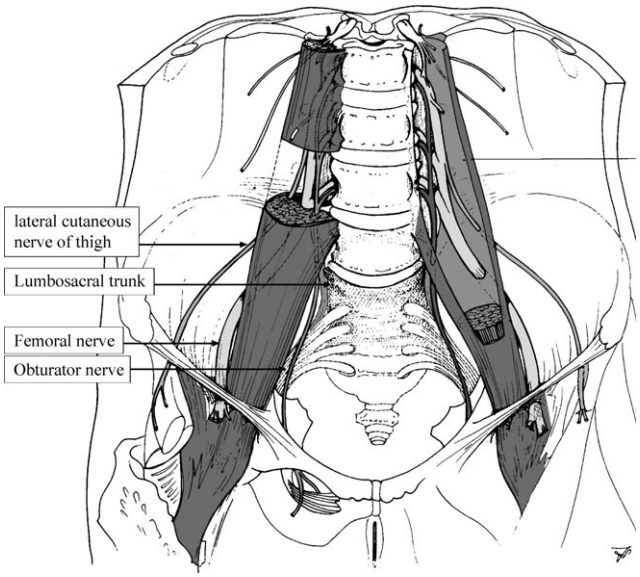

Fig. 2 The lunbar plexus (adapted from Farny[16])

Continuous lumbar plexus block can greatly prolong the duration of effective analgesia. The infusion rate of low concentration local anaesthetic is usually set at 10 ml h^{-1} and we prefer a high-rate, low-concentration technique. Preliminary published data[10] and expert opinion support the efficacy of this technique following total hip arthroplasty. However, to date, there are no published clinical trials comparing continuous lumbar plexus block with other analgesic techniques after total hip arthroplasty.

Lumbar plexus block has been associated with some potentially serious side effects such as total spinal anaesthesia, psoas haematoma or abscess, epidural spread, and renal trauma. It is a deep block and should be avoided in patients with abnormal clotting or platelet dysfunction; it is not a block for the novice.

Femoral nerve block

A single shot, low volume femoral nerve block is not useful after hip arthroplasty as this approach is too distal to provide clinically useful anaesthesia or analgesia of the hip. Complete lumbar plexus block has been shown to occur in only 35% of patients after larger volume '3-in-1 block'. The obturator and lateral cutaneous nerve of thigh are inconsistently blocked with this technique so the name '3 in 1' should be abandoned. The use of a single shot femoral technique appears to offer little advantage over more conventional PCA morphine for total hip arthroplasty.

In contrast, continuous femoral nerve block has been shown to provide equivalent analgesia following total hip arthroplasty when compared with PCA morphine and epidural analgesia.[11] Its advantages are the low incidence of side effects and lack of technical problems when compared with PCA morphine or continuous epidural analgesia. However, the catheter may impinge on the surgical field.

Fascia iliaca block

Indications for a fascia iliaca block are similar to those for femoral nerve block. It relies on proximal spread of local anaesthetic beneath the fascia iliaca providing an anterior approach to the branches of the lumbar plexus. The advantages of this block are its relative simplicity, making it quick and safe to perform without the need for a nerve stimulator. However, the extent of lumbar plexus block is variable with the femoral nerve being blocked more consistently than the obturator and lateral cutaneous nerve of thigh. The reliance on the anaesthetist's ability to distinguish fascial planes when performing this technique raises doubts over the reliability of this block, although some evidence suggests that ultrasound guidance may greatly facilitate correct needle placement.

Sciatic nerve block

Complete anaesthesia of the hip joint requires sciatic nerve blockade. As the sacral nerves are not usually blocked by lumbar plexus block, adding a sciatic nerve block may be beneficial. A proximal approach using either the classical approach described by Labat or a parasacral approach is recommended. Despite the fact that there is no published evidence supporting sciatic block for post-operative analgesia following total hip arthroplasty, a completely pain free hip is impossible without it. Without sciatic nerve block, buttock pain can be problematic.

Total knee arthroplasty: peripheral nerve blocks

In recent years, the number of primary knee replacements performed in the UK has increased dramatically in line with trends from other developed countries. Data from the National Joint Registry 2006 report show that the number of primary knee replacements performed annually in England and Wales is now greater than primary hip operations.

Pain following total knee arthroplasty is typically severe and opioid consumption is significantly greater than that following a total hip arthroplasty, probably because of the more extensive osteotomy and the quadriceps splitting which is part of the surgical technique. Poorly controlled pain in the acute post-operative setting can result in delayed rehabilitation as well as cardiorespiratory complications. Numerous analgesic options exist, but continuous peripheral nerve blocks provide the most effective and long-lasting analgesia with fewer side effects when compared with PCA morphine or continuous epidural analgesia.

The best combination of peripheral nerve blocks and choice of local anaesthetic solution for continuous infusion following total knee arthroplasty is currently unknown. The knee is innervated by the femoral, sciatic and obturator nerves (Fig. 1) so each must be considered when planning regional anaesthesia for post-operative analgesia.

The impact of intrathecal opioids in this setting is not as clear as in total hip arthroplasty. Intrathecal morphine at doses with an

acceptable side effect profile is unlikely to provide adequate analgesia following total knee arthroplasty.

Femoral nerve block

Femoral nerve block has a high success rate and carries a low risk of complications. However, proximal spread of local anaesthetic to the other branches of the lumbar plexus is unreliable. Single shot femoral nerve block using a long acting amide local anaesthetic will provide analgesia to the anterior aspect of the knee for up to 24 h, although the incidence of profound motor block of the quadriceps muscles will be unacceptably high if large volumes of concentrated local anaesthetic agents are used, for example, >20 ml of $>0.375\%$ levobupivacaine.

Continuous femoral nerve block is technically simple to perform with a low incidence of side effects. The infusion is continued for 48–72 h before catheter removal and patients are allowed to mobilize during this time provided they have adequate motor power and proprioception. Several recent studies have confirmed that the analgesic efficacy of this technique is equivalent to both continuous epidural analgesia and continuous lumbar plexus block following total knee arthroplasty; however, continuous femoral nerve block was associated with fewer side effects than the other techniques.[12]

Sciatic nerve block

Pain behind the knee is a problem for a significant proportion of patients who only receive femoral nerve block because all of the intra-articular structures are innervated by the tibial nerve. The benefit of adding a sciatic nerve block to a femoral nerve block has become the subject of debate in regional anaesthesia circles. The advantage of improved analgesia in some patients may be offset by the extra time taken to perform the procedure, the potential for greater motor block and concerns regarding early detection of surgically induced sciatic nerve injury post-operatively.

Single shot sciatic nerve block combined with femoral nerve block will provide analgesia for up to 24 h. When performing the block using a nerve stimulator, success rates are highest if inversion (tibial and peroneal nerve) or plantar flexion (tibial nerve) of the foot are elicited.

The combination of continuous femoral and sciatic nerve blocks has been shown to provide superior analgesia with less PONV when compared to other analgesic techniques.[12] The potential disadvantages of adding a continuous sciatic block to continuous femoral nerve block are increased time required to perform two continuous blocks and the potential problems mobilizing patients post-operatively because of more extensive motor block. The practical alternative is to use continuous femoral nerve block combined with single shot sciatic nerve block.

Lumbar plexus block

It has been suggested that lumbar plexus block may be better than femoral nerve block because it blocks the femoral, obturator, and lateral femoral cutaneous nerves more reliably. However, there is little evidence from clinical trials to support this hypothesis.[12] Continuous lumbar plexus block is a logical and effective technique that has been shown to improve analgesia and facilitate earlier mobilization following total knee arthroplasty compared with single shot lumbar plexus block.[8] Again, the combination of a sciatic nerve block should be considered.

Obturator nerve block

The addition of a separate obturator block to a femoral or lumbar plexus block is contentious. Femoral nerve block has been shown to spare the obturator nerve in as many as 50% of patients, contrasting with lumbar plexus block when the obturator nerve is missed in $<10\%$. It is interesting to note that a comparative study of continuous lumbar plexus and continuous femoral nerve block found no difference in analgesia.[12] On the other hand, there is some evidence that adding a single shot obturator block to single shot sciatic and femoral nerve blocks may improve analgesia.[13]

Step-down analgesia

Careful consideration should be given to concomitant and step-down analgesia in this group of patients following surgery. Regular oral acetaminophen should be given to all patients undergoing primary hip and knee arthroplasty, unless contraindicated.[14] The routine use of NSAIDs can be considered, although the risks of bleeding events, renal dysfunction and gastrointestinal ulceration in this group of patients in the perioperative period must firstly be considered. The inhibitory effect of NSAIDs on new bone formation may also be an issue in certain kinds of cementless prostheses. We recommend avoiding NSAIDs for at least 48 h after surgery because of these potential problems.

For the treatment of moderate to severe pain, sustained release oxycodone (Oxycontin® Napp Pharmaceuticals), has been shown to provide effective analgesia, shorten hospital stay and reduce the frequency of analgesic administration after hip and knee arthroplasty.[15] The biphasic pattern of absorption of this drug following oral administration results in an initial rapid absorption of approximately 40% of the dose, with rapid onset of analgesia (of about 1 h) which is then followed by sustained release of drug and stable plasma levels over a 12-h period, therefore twice daily dosing is all that is required. Most TKR and THR patients are able to take oral fluids and diet in the first few hours after surgery (especially if they have had a regional anaesthetic technique); so parenteral opioids are neither necessary nor desirable.

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Please see multiple choice questions 12–16