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Comfortably numb (at Home): Perioperative applications of peripheral nerve blocks

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Peripheral nerve blocks are well described, but not universally accepted or utilized. In a national survey of 409 anesthesiologists evaluating the use of peripheral nerve blocks, Hadzic et al. (Hadzic, 1998) reported that while nearly all respondents perform regional techniques, less that half performed more than five peripheral nerve blocks per month. Importantly, lower extremity blocks other than ankle blocks were seldom used. This is unfortunate, since lower extremity blocks have many advantages over neuraxial techniques, and represent alternatives for both intraoperative anesthesia and postoperative analgesia. Anesthesiologists in Europe have already shifted their practice towards peripheral blocks. A prospective study of 103,730 regional anesthetics performed in France over a five-month period included 21,278 peripheral blocks.

Lower extremity blocks may be accomplished when neuraxial blockade is contraindicated. Spinal and epidural anesthesia are often avoided in the anticoagulated or febrile patient because of the catastrophic consequences of bleeding or infection in the central nervous system. Although it is difficult to quantitate the incidence of hemorrhagic or infectious complications of peripheral nerve blocks, the lack of case reports suggests the risk of serious morbidity is minimal.

Although not commonly used in the outpatient setting, ambulatory surgical patients are ideally suited for peripheral blocks. Advantages include reduced recovery room admissions, decreased nausea/emesis and urinary retention, and improved postoperative analgesia. These benefits may translate into shortened hospital stays, fewer unplanned admissions, and reduced hospital costs and patient charges. It is likely that a major impetus toward peripheral blocks will be economic. However, timely and efficient (as well as successful) performance is paramount if these techniques are to supplant neuraxial and general anesthesia as the anesthetic/analgesic of choice.

Despite these many advantages, peripheral nerve blocks have not been widely used in the United States. Peripheral blocks are more technically demanding than neuraxial techniques, often requiring multiple injections, increased onset time, and larger volumes of local anesthetic. Advances in needle and catheter technology, refinement of devices to localize neural structures, as well as the introduction of longer-lasting encapsulated local anesthetics will improve the acceptance and popularity of peripheral techniques.

This lecture will describe upper and lower extremity peripheral nerve blocks focusing on innovations of existing techniques, descriptions of new approaches, and pearls for improved success. Importantly, applications of peripheral nerve blocks, which contribute to, improved patient outcomes will be highlighted.

UPPER EXTREMITY TECHNIQUES

Upper extremity regional anesthesia consists mainly of brachial plexus techniques. Numerous studies have documented the improved analgesia, reduced hospital stays and fewer unplanned hospital admissions with these approaches. Indeed, axillary blocks, compared to lower extremity blocks, are often performed in the ambulatory setting (Schroeder, 1996). New applications of upper extremity peripheral techniques involve placement of continuous catheters to facilitate rehabilitation and avoid hospital admission (Ilfeld, 2004). More patients are being discharged with disposable pumps set to deliver a local anesthetic infusion or bolus for approximately 24-48 hours (Ilfeld, 2005). Ongoing studies will soon reveal the optimal use of these devices. In addition to innovations in block technology, several new approaches to the brachial plexus have been described- the midhumeral (Bouaziz, 1997) and intersternocleidomastoid (Pham Dang, 1997) techniques. The clinician is urged to read the descriptions of these blocks by the original authors and apply them to their individual practice as appropriate.

LOWER EXTREMITY TECHNIQUES

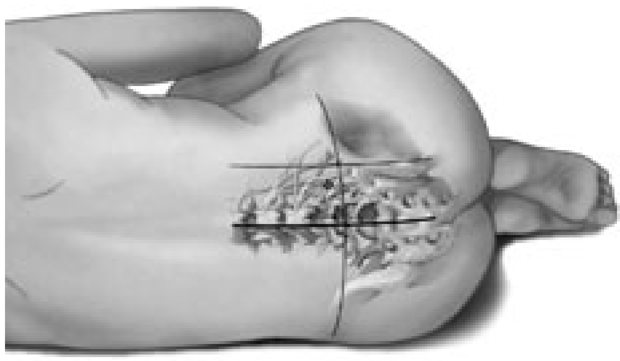
Lower extremity peripheral techniques, which allow complete unilateral blockade, have traditionally been under utilized (Enneking, 2005). In part, this is due to the widespread acceptance and safety of spinal and epidural anesthesia. Furthermore, unlike the brachial plexus, the nerves supplying the lower extremity are not anatomically clustered where they can be easily blocked with a relatively superficial injection of local anesthetic. Because of the anatomic considerations, lower extremity blocks are technically more difficult and require more training and practice before expertise is acquired. Many of these blocks were classically performed using paresthesia, loss of resistance or field block techniques that resulted in variable success.

Advances in needles, catheters and nerve stimulator technology have facilitated the localization of neural structures and improved success rates. These blocks are safe and their unilateral nature makes them ideal for the patient undergoing total hip or knee arthroplasty as the contralateral limb is immediately available to assist with early ambulation. Although single injection techniques have been utilized, the duration of effect after a single injection is not sufficient to result in major improvements in analgesia or outcome (Allen, 1998; Stevens, 2000; Capdevile, 2005). Recent applications of peripheral nerve block techniques have allowed prolonged postoperative analgesia (with an indwelling catheter) to assist rehabilitation and facilitate hospital dismissal (Capdevila, 1999; Singelyn, 1998; Singelyn, 1999; Chelly, 2001; Kaloul, 2004; Ganapathy, 1999; Capdevila, 2002; Ben-David, 2004; Pham-Dang, 2005).

The lumbar plexus may be blocked by three distinct approaches. Block of the full lumbar plexus (femoral, lateral femoral cutaneous, obturator) is accomplished with the psoas block (Chayen, 1976; Enneking, 2005; Capdevila, 2005; Awad, 2005). In comparison, the fascia iliac and femoral approaches will reliably block the femoral but not the lateral femoral, cutaneous and obturator nerves (Capdevila, 2005; Awad, 2005; Morau, 2003). Complete unilateral lower extremity blockade is achieved by combining a lumbar plexus technique with a proximal sciatic block (Enneking, 2005). Selection of regional analgesic technique is dependent on the surgical site. For example, the psoas compartment approach to the lumbar plexus is preferable for surgery to the hip because it is the most proximal lumbar plexus technique. Conversely, for surgery to the knee, the more distal femoral and fascia iliac approaches are sufficient.

Psoas compartment block

A horizontal line is drawn parallel to the posterior superior iliac spine (PSIS) while a vertical line is drawn at the L4-5 level. The distance from midline to the PSIS horizontal is divided into thirds and the junction of the lateral third and medial two-thirds is identified. Needle insertion is 1 cm cephalad to this point. A 10-cm (4 inch) stimulating needle is advanced until the transverse process of L4 is contacted. The needle is redirected caudad and advanced behind the transverse process. Approximately 2 cm deep to the transverse process, the lumbar plexus is identified (through elicitation of a quadriceps motor response) and 25 ml of local anesthetic is



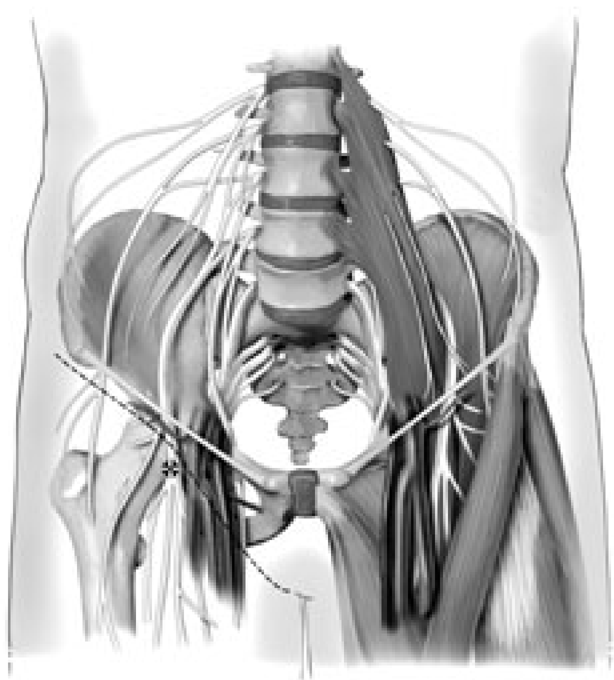
KNEE ARTHROSCOPY AND ANTERIOR CRUCIATE LIGAMENT REPAIR

Outpatient knee surgery may be performed under a variety of regional anesthetic techniques. Traditionally, neuraxial anesthesia was utilized. However, prolonged lower extremity weakness and/or urinary retention delayed hospital discharge. Furthermore, concerns over transient neurologic symptoms propelled a search for an alternative to intrathecal lidocaine. Unfortunately, the reliable sensory and motor block (of limited duration) associated with lidocaine has not been duplicated. Lower extremity peripheral blocks provide adequate analgesia intraoperatively, with the added benefit of postoperative analgesia.

Diagnostic knee arthroscopy is a relatively minor procedure that may be performed under local anesthesia with sedation. The performance of a single dose or continuous lower extremity block is probably not warranted in the majority of patients. Several studies have failed to demonstrate a clinically significant difference in patient outcome with respect to anesthetic technique. De Andres et al. (De Andres, 1993) compared intraarticular bupivacaine, continuous lumbar plexus block for 24 hours, and intraarticular morphine for patients undergoing knee arthroscopy. VAS scores were reduced in the 3-in-1 block group 16 and 24 hours postoperatively. However, patients in all groups required little supplemental analgesia. Similar results were reported by Schwarz et al. (Schwarz, 1999). The authors noted that the addition of a femoral 3-in-1 block to intraarticular ropivacaine did not reduce analgesic requirements following arthroscopic knee surgery. Few data exist on the use of lower extremity blocks for patients undergoing anterior cruciate ligament repair. However, preliminary studies suggest that a lumbar plexus block (combined with a spinal or sciatic block) dramatically reduces postoperative opioids requirements as well as opioid related side-effects (Matheny, 1993). Thus for outpatient procedures, the complexity/duration of the surgical procedure will determine the usefulness of peripheral blocks compared to neuraxial or general anesthesia (Jankowski, 2003; Horlocker, 2003).

Femoral block

The dotted line corresponds to the inguinal crease. Needle insertion site is 1-2 cm lateral to the femoral arterial pulsation at this level. A 5-cm (2 inch) needle is advanced until a quadriceps response is noted, 25 ml of local anesthetic is incrementally injected.



HIP FRACTURE

Femoral neck fracture occurs in elderly patients who often have multiple medical co-morbidities. Complications include thromboembolic events, confusion, and pulmonary infections. In addition, quadriceps spasm contributes to perioperative pain and the need for opioid analgesia. Several studies have evaluated the use of continuous lumbar plexus block (psoas approach) in the pre-, intra-, and postoperative management of hip fracture.

An early study performed in 1978 included 21 patients with femora neck fracture. Continuous psoas catheters were placed, using a loss of resistance technique, upon arrival to the ward. The catheters were used intraoperatively, combined with a general anesthetic, and removed 48 hours postoperatively. During this time, the catheters were intermittently bolused with 15-20 ml of 0.5% bupivacaine. Eighty percent of patients had adequate analgesia and did not require supplementation (Brands, 1978). Similar results were reported in a more recent study by Chudinov et al. (Chudinov, 1999). Forty patients undergoing stabilization of femur fracture were randomized to receive a continuous psoas block (implemented 16-48 h preoperatively and continued 72 h postoperatively) or meperidine. The lumbar plexus block was inadequate for surgical anesthesia in 85% of patients. VAS scores were lower and patient satisfaction was higher in the psoas group. These studies suggest that continuous psoas block is an effective perioperative analgesic technique, but supplementation is required during surgical repair. In addition, possible improvement in patient outcomes has not been formally investigated.

TOTAL HIP ARTHROPLASTY

The usefulness of peripheral nerve blocks for total hip arthroplasty (THA) has not been clearly established. Innervation to the joint involves both the lumbar and sacral plexi. Therefore, while a lumbar plexus block may reduce pain postoperatively, it would not be sufficient to provide surgical anesthesia. A study in the orthopedic literature (Twyman, 1990) demonstrated reduced intraoperative blood loss (310 ± 81 ml *vs* 617 ± 230 ml) in THA patients that received a single-shot psoas block (0.42 ml/kg of 0.375% bupivacaine). No other outcomes were monitored.

Stevens et al. (Stevens, 2000) prospectively studied 60 patients undergoing THA who were randomized to receive general anesthesia with or without a psoas block. Blocks were performed using a nerve stimulator and 0.4 ml/kg of 0.5% bupivacaine with epinephrine was injected. The need for intraoperative supplemental fentanyl occurred three times more often in the control group. Pain scores and morphine consumption remained less in the psoas group for six hours postoperatively. Perioperative blood loss was also modestly decreased in the psoas group. There was epidural spread in 3 of 28 patients, but no other side effects were noted. A single study suggests that continuous psoas technique would further facilitate the rehabilitation of patients undergoing THA (Capdevila, 2002).

TOTAL KNEE ARTHROPLASTY

Patients undergoing total knee arthroplasty (TKA) experience significant postoperative pain. Failure to provide adequate analgesia impedes aggressive physical therapy and rehabilitation, which is critical to maintaining joint range of motion and potentially delays hospital dismissal.

Although numerous methods of providing postoperative analgesia after total knee arthroplasty have been reported, the optimal technique based on efficacy, number/type of side effects, surgical outcome, and resource utilization is unknown. Several European studies have suggested that aggressive postoperative analgesic techniques maintained for 48-72 hours result in a shorter rehabilitation period and increased joint mobility. Singelyn et al (Singelyn, 1998) assessed the influence of three analgesic techniques (patient-controlled analgesia, continuous femoral 3-in-1 block, and epidural analgesia) on postoperative knee rehabilitation after TKA. Patients receiving regional analgesic techniques reported significantly lower pain scores, better knee flexion (until 6 weeks after surgery), faster ambulation, and shorter hospital stay compared to patients receiving intravenous morphine. However, these benefits did not affect outcome at 3 months.

Knee flexion and duration of stay during rehabilitation after total knee arthroplasty

Knee mobility in degrees median (25^{th}-75^{th} percentile)	Patient-controlled analgesia (PCA) N = 19	Continuous Femoral block (CFB) N = 20	Continuous epidural analgesia (CEA) N = 17
Day 5	60 (50-70)*	80 (65-85)	85 (75-100)
Day 7	80 (65-90)*	90 (70-95)	90 (78-100)
1-month	90 (85-100)	95 (95-100)	105 (100-120)
3-month	125 (100-125)	125 (105-125)	130 (115-130)
Days of rehabilitation, Median (range)	50 (30-80)*	40 (31-60)	37 (30-45)

*p < 0.05 *vs* CFB and CEA. Adapted from Capdevila et al. Anesthesiology 1999;91:8-15.

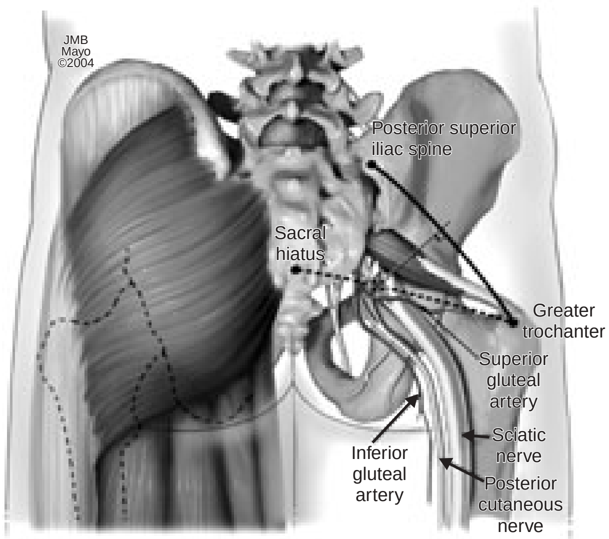
Capdevila et al (Capdevila, 1999) also evaluated the effect of postoperative analgesia on surgical outcome and rehabilitation following TKA. Patients were randomized to receive one of three postoperative analgesia techniques for 72 hours: continuous epidural infusion, continuous femoral block, or intravenous patient-controlled morphine. Pain was assessed at rest and during continuous passive motion using a visual analog scale. To evaluate functional outcome, the maximal amplitudes were measured again on postoperative day 5, at hospital discharge (day 7), and at 1- and 3-month follow-up examinations. When the patients left the surgical ward, they were admitted to a rehabilitation center, where their length of stay depended on prospectively determined discharge criteria. The continuous epidural infusion and continuous femoral block groups showed significantly lower visual analog scale scores at rest and during continuous passive motion compared with the patient-controlled morphine group. The early postoperative knee mobilization levels in both continuous epidural infusion and continuous femoral block groups were significantly closer to the target levels prescribed by the surgeon than in the patient-controlled morphine group. The durations of stay in the rehabilitation center were significantly shorter in the regional analgesic groups compared to the patient-controlled morphine group. Side effects were encountered more frequently in the continuous epidural infusion group.

These landmark studies demonstrate the long-term effects of an aggressive postoperative analgesic technique following orthopedic surgery- continuous femoral and epidural analgesia hastened rehabilitation and improved joint mobility (Todd, 1999). Additional studies are required to assess these outcomes in a managed care environment with shorter hospital stays of approximately five days, and discharge to home, rather than a rehabilitation center for an extended period as is the standard in Europe. For example, the median duration of hospital stay (including rehabilitation unit) in the study by Singelyn et al. was 19 days, while the patients in the investigation by Capdevila et al. were hospitalized for as long as 80 days postoperatively. An additional relevant result of these investigations is the finding that continuous femoral block provides a quality of analgesia and surgical outcomes similar to that of continuous epidural analgesia, but is associated with fewer side effects. This suggests that continuous peripheral techniques may be the optimal analgesic method following total knee arthroplasty.

More recent investigations suggest that supplemental sciatic (Ben-David, 2004; Pham-Dang, 2005) or obturator (Macalou, 2004) is required to obtain adequate analgesia following total knee (but not hip) arthroplasty. The sciatic nerve may also be blocked at several sites in the hip and thigh. However, the more proximal approaches are necessary to achieve blockade of the posterior femoral cutaneous nerve, which is important in decreasing the posterior knee pain that knee replacement patients often experience in the early postoperative period.

Classic (posterior) approach to sciatic nerve block

Needle insertion is 5 cm along the perpendicular that bisects a line connecting the greater trochanter and posterior superior iliac spine. A 10-cm (4 inch) stimulating needle is advanced until either a tibial or peroneal motor response is elicited; then 20-30 ml of local anesthetic is incrementally injected.



Current innovations emphasize continuous peripheral nerve blocks combined with multiple scheduled analgesics (OxyContin®, acetaminophen), and *prn* (oxycodone) analgesics; no intravenous opioids are administered. Using strict criteria, 90% of patients undergoing minimally invasive primary hip or knee replacement achieved readiness for hospital discharge within 48 hours (Hebl, 2005). These studies support the movement towards continuous peripheral technique as the optimal analgesic method following total knee and hip arthroplasty. Additional information is needed to determine the effectiveness of these techniques in conventional primary and revision joint arthroplasty.

Surgery to the ankle and foot

Innervation of the foot is provided by the femoral nerve (via the saphenous nerve) and by the sciatic nerve (via the posterior tibial, sural, deep and superficial peroneal nerves). Therefore, central neuraxial blockade and peripheral nerve blocks at the upper leg, knee or ankle are appropriate regional anesthetic techniques for foot surgery.

The selection of the regional technique is based upon the surgical site, use of a calf or thigh tourniquet, degree of weight-bearing/ambulation, and the need for postoperative analgesia. For example, inflation of a thigh tourniquet for longer than 15 to 20 minutes necessitates a general or neuraxial anesthetic, regardless of surgical site. The distal surgical site and the ability to block the pain pathways at multiple sites gives regional anesthesia an advantage over general anesthesia for surgery to the ankle and foot. The main disadvantage of peripheral blocks is the technical expertise (and theoretically, the associated complications) required for consistent success rate; neuraxial techniques are a suitable alternative.Common surgical procedures are discussed in the following table:

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Anesthetic techniques for common foot and ankle operations

	Surgical procedure	Regional technique	Comments
Forefoot*	Hallux valgus	Metatarsal, ankle, popliteal blockade	Sural nerve block not necessary for surgery
	Amputations	Ankle, popliteal blockade	Popliteal blockade is the technique of choice in the presence of infection or swelling
Midfoot*	Transmetatarsal amputations	Popliteal, ankle blockade	
Hindfoot*	Ankle arthroscopy	Spinal, epidural or general anesthesia	Operation typically requires good muscle relaxation for manipulation; thigh tourniquet
	Achilles tendon repair	Spinal, epidural, or popliteal blockade	Spinal or epidural anesthesia whenever thigh tourniquet is required
	Triple arthrodesis	Spinal or epidural	Neuraxial technique preferred for bone graft harvesting; popliteal blockade for postoperative analgesia

*Femoral or saphenous block required if the incision extends to the medial aspect of the foot or ankle
From Hadzic A, Vloka JD. Techniques in Regional Anesthesia and Pain Management; 1999;3:113.

NEUROLOGIC COMPLICATIONS

Perioperative nerve injuries have long been recognized as a complication of regional anesthesia. Fortunately, severe or disabling neurologic complications rarely occur. Risk factors contributing to neurologic deficit after regional anesthesia include neural ischemia, traumatic injury to the nerves during needle or catheter placement, infection, and choice of local anesthetic solution. Neurologic complications may also occur coincidental to a regional anesthetic, but are actually related to surgery, patient positioning, tourniquet ischemia, or a combination of factors. Recognition of patient, anesthetic, and surgical risk factors for perioperative nerve injury will allow modification in practice to improve neurologic outcome.Orthopedic surgical procedures are well suited to regional anesthetic techniques. However, while the benefits of regional anesthesia in this patient population are well established, orthopedic surgical procedures often involve peripheral nerves with preexisting deficits, such as ulnar nerve transposition and carpal tunnel release. In addition, the operative site may be adjacent to neural structures, as with total shoulder arthroplasty or fractures of the proximal humerus (Lynch, 1996). For example, 4% of patients undergoing total shoulder arthroplasty have a documented postoperative neurologic deficit, including 3% of patients with injury to the brachial plexus. The level of injury is at the level of the nerve trunks- the level at which an interscalene block is performed, making it impossible to determine the etiology of the nerve injury (surgical versus anesthetic). Most of these nerve injuries represent a neuropraxia; 90% will resolve in three to four months. However, the significant incidence of neurologic deficits demonstrates the importance of clinical examination prior to regional anesthetic techniques in these patients. These patients are also at risk for tourniquet or surgery-related nerve injury. Sciatic nerve palsy is one of the most distressing complications associated with total hip arthroplasty. Likewise, peroneal nerve palsy is a rare complication of total knee arthroplasty, with an estimated incidence of 0.3% to 10%. Orthopedic surgeons may wish to avoid sciatic nerve blocks in patients undergoing TKA in order to assess peroneal nerve function postoperatively.

In summary, peripheral nerve blocks are valuable regional anesthetic techniques. Additional outcome studies are required to define their role in among ambulatory and inpatient procedures. It is also imperative that prior to attempting the new approaches and continuous catheters, anesthesiologists thoroughly review neural anatomy and practice with meticulous regional anesthetic technique to improve success rate and avoid neurologic complications.

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