Regional Anesthesia for Total Joint Arthroplasty

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Patients undergoing total joint arthroplasty (TJA) experience high levels of pain after surgery that often interferes with their functional recovery and sleep patterns in the postoperative period. In one study, patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA) reported mean worst pain severities of 7.6 and 8.1 on a 10-point scale, respectively.

Numerous techniques have been developed for anesthesia and analgesia in an effort to optimize perioperative pain control, patient satisfaction, and functional recovery. Because clinician preference strongly influences patient selection and decision making, anesthesiologists and orthopedic surgeons must understand the current literature and level of evidence for each technique. This article provides an updated review of the evidence for regional anesthesia for TJA surgery with an emphasis on the risks and benefits of each technique for intraoperative anesthesia and postoperative analgesia.

TJA is performed with either a primary regional or general anesthetic technique. Many methods exist for continued perioperative pain control (Table 1). In some cases, various modalities will be combined in an effort to optimize pain management. Each method for pain control is associated with specific benefits, risks, side effects, economic implications, patient satisfaction levels, and labor requirements for the health care team.

General Versus Regional Anesthesia for Total Joint Arthroplasty

Several advantages have been suggested for the use of neuraxial anesthesia for TJA surgery. These include modification of the hypercoagulable surgical state, improvements in regional blood flow, improvement in pain control, and reduction in the surgical neuroendocrine stress response (Table 2). From the surgeon’s perspective, spinal anesthesia also provides ideal operating conditions—profound muscle relaxation—moderate hypotension, which reduces blood loss, and the potential for faster room turnover.
Recent systematic reviews have examined the influence of the anesthetic choice for TJA surgery on outcomes. Reviews that included dates from 1966 onward suggest that neuraxial anesthesia improves specific end-organ outcomes and postoperative pain control. In a meta-analysis specifically examining neuraxial regional anesthesia for TJA, regional anesthesia was associated with significant reductions in operating time, need for transfusions, nausea and vomiting, and incidence of thromboembolic disease including deep vein thrombosis (DVT) and pulmonary embolism (PE). It is important to note that many of the studies in this review that favored regional anesthesia over general anesthesia in the reduction of vascular events were earlier trials that examined individuals who were not receiving anticoagulation prophylaxis. A review of general and regional anesthesia for THA that contained research from 1966 to August 2005, suggested that neuraxial block decreased the incidence of radiographically diagnosed DVT and PE, and decreased operative time by 7.1 minutes and intraoperative blood loss by 275 mL.

Contemporary reviews that examined only papers from 1990 onward have provided evidence for improvement in pain control but do not always demonstrate improvements in cardiovascular outcomes and mortality. One systematic review of studies published since 1990 found insufficient evidence from randomized controlled trials to conclude that anesthetic technique affected mortality, cardiovascular morbidity, or incidence of DVT and PE in patients undergoing THA. In addition, regional anesthesia did not reduce hospital length of stay or facilitate rehabilitation. In 2009, a systematic review that examined contemporary literature on randomized controlled trials of TKA published since 1990 found insufficient evidence to conclude that anesthesia technique influenced mortality, cardiovascular morbidity, or incidence of DVT and PE when using thromboprophylaxis.

Anesthetic choice also has been shown to affect other important outcomes, in addition to pain control, including rates of surgical site infection (SSI) and medical costs. In a retrospective review of more than 3,000 knee or hip arthroplasty surgeries, Chang and colleagues demonstrated a significant reduction in 30-day SSI rates—1.2% for epidural or spinal anesthesia versus 2.8% for general anesthesia. The odds of an SSI occurring in a patient receiving general anesthesia were 2.2 times greater than when neuraxial anesthesia was used. Proposed mechanisms for possible reduction in SSIs infections with neuraxial anesthesia include modulation of the inflammatory response, vasodilation and improvement in tissue oxygenation, and improvements in postoperative analgesia.

Spinal anesthesia has been shown to be more cost-effective for TJA. Gonano and colleagues randomized 40 patients to receive either spinal anesthesia or general anesthesia and examined the costs of drugs and supplies for both the chosen anesthetic and associated recovery. They found that spinal anesthesia was associated with lower fixed and variable costs, resulting in a 48% savings (excluding expenditures for personnel) compared with general anesthesia.

### Regional Techniques for Postoperative Analgesia for Total Joint Arthroplasty

Several analgesic techniques exist for postoperative pain management for TJA surgery. Each regional anesthetic technique has specific advantages and disadvantages. Selection of the appropriate technique is best guided through an understanding of the associated risk–benefit profile of each technique and the pain management needs for the specific clinical situation.

### Intrathecal Opioids

One analgesic approach that requires only minor modifications in the anesthetic plan is the addition of intrathecal opioids to the spinal injection of local anesthetic. Typically, intrathecal morphine will be added in a dose range from 0.2 to 0.3 mg. For THA and TKA,

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Table 1. Methods of Postoperative Pain Control for Total Joint Arthroplasty

<table>
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<tr>
<th>Pain Control Method</th>
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<tbody>
<tr>
<td>Intravenous opioids (IV-PCA)</td>
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<tr>
<td>Oral opioids</td>
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<tr>
<td>Nonopiod analgesics</td>
</tr>
<tr>
<td>Neuraxial anesthesia and analgesia</td>
</tr>
<tr>
<td>• Spinal-intrathecal opioids</td>
</tr>
<tr>
<td>• Epidural-continuous infusion</td>
</tr>
<tr>
<td>• Epidural-single-injection EREM</td>
</tr>
<tr>
<td>Single and continuous peripheral nerve blocks</td>
</tr>
<tr>
<td>• Femoral nerve block</td>
</tr>
<tr>
<td>• Sciatic nerve block</td>
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<tr>
<td>• Lumbar plexus block</td>
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</table>

EREM, extended-release epidural morphine; PCA, patient-controlled analgesia

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PAIN MEDICINE NEWS SPECIAL EDITION • DECEMBER 2012 17
Table 2. Physiologic Sequelae of the Neuroendocrine Stress Response

<table>
<thead>
<tr>
<th>Physiologic Sequelae</th>
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<tbody>
<tr>
<td>Hyperactivity of the autonomic nervous system</td>
</tr>
<tr>
<td>Increased cardiovascular stress</td>
</tr>
<tr>
<td>Dysfunction in respiratory mechanics</td>
</tr>
<tr>
<td>Decreased muscle protein synthesis</td>
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<tr>
<td>Elevated metabolic rate with an associated protein catabolic state</td>
</tr>
<tr>
<td>Increased formation of blood clots</td>
</tr>
<tr>
<td>Slower return of bowel function</td>
</tr>
<tr>
<td>Impaired immune function</td>
</tr>
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</table>

Intrathecal morphine has been shown to improve patient satisfaction compared with IV patient-controlled analgesia (IV-PCA) with opioids. However, intrathecal morphine only reduced the supplemental postoperative PCA morphine requirements for the patients undergoing THA.10

When intrathecal opioids are administered, additional forms of pain control are needed to control “breakthrough pain” and for pain that outlasts the duration of the therapy. Respiratory monitoring also is required when intrathecal opioids are administered.

**Epidural Analgesia**

Epidural analgesia with a single injection of extended-release epidural morphine (EREM) or continuous epidural infusions with local anesthetics can be effective methods of pain control in patients undergoing joint surgery. When specifically examining the use of epidurals for TJA compared with IV-PCA, epidural analgesia has been shown in high-quality studies to improve pain relief and recovery time.11,12 A Cochrane Collaboration review demonstrated that epidural analgesia for pain relief following TJA in comparison to systemic analgesia was beneficial, but its effects may be limited only to the early postoperative period, 4 to 6 hours.13

Use of EREM has been studied in patients undergoing TKA and THA. Compared with IV-PCA, the patients treated with EREM for TKA required significantly less postoperative opioids and had reduced mean pain intensity recall scores.14 For THA surgery, EREM demonstrated improved pain control at rest to 48 hours postdose and improvement in pain control ratings15; 25% of THA patients who received EREM did not require supplemental analgesia.

Regional Techniques for Postoperative Analgesia for Total Hip Arthroplasty

THA is associated with a high level of postoperative pain, although perhaps less than TKA. Many techniques for administering regional anesthesia have been explored for THA to improve pain control.6 These include neuraxial analgesia, peripheral nerve blocks (PNBs), and EREM. Singelyn and colleagues compared IV-PCA with morphine, continuous epidural analgesia, and continuous femoral nerve sheath block for postoperative analgesia in THA.17 The authors found no difference in quality of pain relief, postoperative hip rehabilitation, and duration of hospital stay for any of these approaches. The continuous femoral block was associated with a lower incidence of side effects, including nausea and vomiting, urinary retention, and arterial hypotension. Single and continuous lumbar plexus blocks also have been employed for postoperative analgesia. A lumbar plexus block is performed with the goal of anesthetizing additional nerve branches (lateral femoral cutaneous, femoral, and obturator nerves) that innervate the surgical area. A continuous lumbar plexus block was found to be superior to IV-PCA for pain management, with a reduction in morphine consumption, improvement in pain control, and patient satisfaction.18

Although the lumbar plexus nerve block provides effective analgesia, recently published guidelines from the American Society of Regional Anesthesia and Pain Medicine for patients receiving antithrombotic therapy circumscribe its use.19 The new guidelines state that the same precautions should be applied to deep peripheral nerve catheters as neuraxial techniques. Alternatives to the lumbar plexus block have been investigated, including a continuous femoral nerve block (CFNB). In one study, Ilfeld and colleagues compared a continuous posterior lumbar plexus nerve block with a CFNB.20 The femoral nerve-stimulating catheter was advanced up to 15 cm beyond the tip with the goal of obtaining coverage of the obturator and lateral femoral cutaneous nerves. Pain control was equivalent for these 2 methods. The CFNB was associated with shorter ambulation distances the morning after surgery, suggesting greater impairment in the quadriceps femoris muscle.

Regional Anesthesia for Total Knee Arthroplasty

**Peripheral Nerve Blocks**

PNBs, including single-injection and continuous PNB catheters (CPNBC), have received substantial attention as alternatives to neuraxial analgesia and systemic opioids for TKA. Some of the emphasis on PNBs arises from concerns about concurrent anticoagulation and neuraxial anesthesia. The employment of
low-molecular-weight heparin for DVT prophylaxis has limited the use of epidurals for postoperative analgesia. Although CPNBCs have been advocated as a means of prolonging the duration of action of single-injection nerve blocks, debate still continues on their advantages and disadvantages compared with single-injection blocks.

**Femoral and Sciatic Nerve Blocks**

The most commonly used PNBs for TKA are femoral and sciatic (Figure). In 2010, Paul et al performed a meta-analysis of randomized controlled trials that compared a femoral block with or without a sciatic nerve block with PCA or epidural analgesia. Compared with PCA alone, a femoral block reduced morphine consumption at 24 and 48 hours, pain scores with activity (but not at rest) at 24 and 48 hours, and the incidence of nausea. No further improvements were found with the addition of a CFNB. Although the femoral nerve does not innervate the posterior portion of the knee, in this meta-analysis a single-injection sciatic nerve block did not offer a pain control advantage.

In a recent trial comparing a single-injection femoral block to CFNB for TKA, pain-intensity ratings were improved during the first and second days after surgery. Opioid consumption and pain-intensity ratings during physical therapy also were significantly lower with a CFNB.

Although a femoral block does improve postoperative pain control for TKA, 60% to 80% of patients still will complain of clinically significant pain. In an attempt to improve pain control, single and continuous sciatic nerve blocks can be administered. Evidence is mixed for the analgesic benefits of adding a single-injection or continuous catheter sciatic nerve block to a femoral nerve block technique. In addition, no consensus has been reached on whether a sciatic nerve block should be performed for all TKA cases in which a femoral nerve block also is performed. Neither a single-injection nor a continuous catheter sciatic nerve block is without theoretical risks and possible disadvantages, including the prevention of the early detection of compartment syndrome or neurologic injury resulting from surgery and the further impairment of motor function, thus impeding physical therapy during its duration of action. Some of the hesitation to perform sciatic nerve blocks is related to the risk profile of the procedure and the surgical vulnerability of the nerve. Sciatic nerve injury after TKA, not related to regional anesthetic technique, is a known complication.

Two randomized controlled trials and a recent systematic review have attempted to address whether blocking the sciatic nerve is advantageous for postoperative pain control and other related clinical outcomes following TKA. In one trial, patients undergoing TKA were randomized to 1 of 3 groups: a femoral nerve catheter, a femoral catheter combined with a single injection, or a femoral catheter plus a continuous sciatic nerve block. The addition of a single-injection sciatic nerve block to the CFNB reduced postoperative pain on the day of surgery. The continuous sciatic nerve block reduced moderate pain during mobilization on the first 2 postoperative days. A sciatic nerve block did not influence time-to-discharge readiness. In a second study, Pham Dang and colleagues demonstrated improvements in pain control with a continuous sciatic nerve block during the first 36 postoperative hours.

A recent systematic review, examining 4 intermediate-quality randomized and 3 observational studies, established that there is inadequate evidence to define the role of adding a sciatic nerve block, and could not demonstrate a benefit in analgesia beyond 24 hours. Unlike a CFNB, continuous sciatic nerve blocks have not been shown to improve functional outcomes or decrease time until discharge readiness.

![Figure. An ultrasound-guided right-sided femoral nerve block. The red arrows delineate the placed needle. The triangle-shaped femoral nerve is lateral to the femoral artery (FA).](image-url)
With the current level of evidence for a sciatic nerve block, one method to determine its implementation could be to observe the patient during early recovery to see if he or she is experiencing significant pain from the posterior aspect of the knee that is not relieved by the femoral nerve block. If so, the analgesia could be augmented with a single-injection sciatic nerve block.

Complications

Other factors that must be incorporated into decision making for the anesthetic and analgesic technique for TJA include complications and adverse events. All the regional anesthetic techniques described above have the following risks, including but not limited to bleeding, nerve damage, vascular injury, block failure, and infection. Neuraxial techniques and deep peripheral nerve catheters have been associated with devastating bleeding complications. When opioids are incorporated into neuraxial anesthesia, respiratory depression may occur. Other opioid-related side effects also may result, including sedation, pruritus, urinary retention, and postoperative nausea and vomiting. The risks and complications specifically associated with CPNBs are shown in Table 3.

Although bacterial colonization may be common with certain catheters, the overall risk for infection is low. In one study, the incidence of bacterial colonization for femoral catheters was reported to be as high as 57% when catheters were removed at 48 hours. Although 3 cases of transitory bacteremia likely related to the femoral catheters were reported, no patients developed an abscess or cellulitis. Abscesses, cellulitis, and transient bacteremia have been reported with CPNBs. The presence of diabetes mellitus may increase the risk for infection. Appropriate steps to reduce the risk for infection include limiting the duration of catheter use and following strict aseptic guidelines. Another potential hazard of CPNBs that has received significant recent attention is the association between lower-extremity blocks and patient falls. Continuous PNBs are associated with muscle weakness that may lead to falls or that can delay rehabilitation. Lower-extremity nerve blocks have been shown to impair the maintenance of limb stiffness, alter proprioception, and decrease lateral stability. Postoperative protocols should be in place to safely and appropriately manage quadriceps weakness associated with femoral nerve blocks in the postoperative period. In addition, the selected postoperative pain management technique should be tailored to allow for early rehabilitation following TJA. Early intensive rehabilitation following TKA (ie, starting rehabilitation within 24 hours) has been shown to improve muscle strength, range of motion, and pain by the time of discharge from the hospital.

Conclusion

TJA is associated with significant levels of postoperative pain. An appropriately selected anesthetic and analgesic plan will positively influence pain levels and function after the procedure. To obtain optimal results with regional anesthetic and analgesic techniques, these therapies should comprise one facet of a multimodal perioperative treatment plan that includes nonopioid analgesics and a structured rehabilitation program. A massive increase in the number of patients undergoing TJA surgery in the United States is expected to occur over the next 2 decades; by 2030, it is estimated that nearly 3.5 million primary TKA surgeries alone will be performed in this country. Research must continue to define and refine the selection of perioperative pain treatment based on efficacy, safety, and patient satisfaction. The economic implications and labor requirements of each technique also should be further explored.

**Table 3. Complications/Adverse Events Associated With CPNBs and Time Frame of Occurrence**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Insertion</th>
<th>Infusion</th>
<th>Removal</th>
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</thead>
<tbody>
<tr>
<td>Neurologic injury</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Vascular injury</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Local anesthetic toxicity</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Migration/dislodgment</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Catheter knotting</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Catheter retention</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Secondary block failure</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle weakness&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

<sup>a</sup> X denotes most likely time frame of occurrence or presentation.

<sup>b</sup> Muscle weakness may put patients at risk for falls or delay physical therapy after knee or hip arthroplasty.

CPNBs, continuous peripheral nerve block catheter
References


