Patients undergoing total hip and knee arthroplasty experience substantial and sustained postoperative pain. Failure to provide adequate analgesia impedes early physical therapy and rapid rehabilitation, which are important for maintaining joint range of motion and facilitating hospital dismissal. Traditionally, postoperative analgesia after total joint replacement was provided by either intravenous patient-controlled analgesia (PCA) or epidural analgesia. However, each technique has distinct advantages and disadvantages. For example, opioids do not consistently provide adequate pain relief and often cause sedation, constipation, nausea or vomiting, and pruritus. Epidural infusions containing local anesthetics [with or without an opioid] provide superior analgesia but are associated with hypotension, urinary retention, motor block that limits ambulation, and spinal hematoma secondary to anticoagulation. Recently, single-dose and continuous peripheral nerve techniques that block the lumbar plexus (fascia iliaca, femoral, psoas compartment blocks), with or without sciatic nerve blockade, have been used successfully in patients who have undergone total joint replacement. Several studies have demonstrated that unilateral peripheral block provided a quality of analgesia and surgical outcomes similar to those of continuous epidural analgesia, but with fewer side effects because of their opioid-sparing properties. Peripheral nerve block techniques may be the optimal analgesic method following total joint arthroplasty.
To the spinal cord and brain. Thus, sensitization of noxious afferent information in order to block the transmission of appropriate dorsal horns interventions, therefore, must produce a dense blockade of subsequent pain. It is designed to limit sensitization of the nervous system in response to these stimuli, with the goal of reducing subsequent pain. Preemptive analgesia is effective only when the treatment used is adequate. The interventions, therefore, must produce a dense blockade of appropriate duration in order to block the transmission of noxious afferent information from the peripheral nervous system to the spinal cord and brain. Thus, preemptive implies not only before incision but also of sufficient magnitude and time. Although the evidence from animal studies is convincing, it remains unclear whether preemptive analgesic regimens in humans are more effective in decreasing postoperative pain than conventional methods. A recent meta-analysis of 66 studies analyzed pain intensity scores, supplemental analgesic consumption, and time to first analgesic consumption in a total of 3,261 patients. Epidural analgesia decreased analgesic consumption, increased the time to first rescue analgesic request, and decreased postoperative pain scores. Wound infiltration with local anesthetic and preoperative administration of nonsteroidal anti-inflammatory drug (NSAID) decreased analgesic consumption and increased the time to first analgesia. Importantly, the least preemptive efficacy was demonstrated with systemic opioid administration.

**Preemptive Analgesia**

Preemptive analgesia is defined as an analgesic intervention initiated prior to the onset of noxious stimuli. It is designed to limit sensitization of the nervous system in response to these stimuli, with the goal of reducing subsequent pain. Preemptive analgesia is effective only when the treatment used is adequate. The interventions, therefore, must produce a dense blockade of appropriate duration in order to block the transmission of noxious afferent information from the peripheral nervous system to the spinal cord and brain. Thus, preemptive implies not only before incision but also of sufficient magnitude and time. Although the evidence from animal studies is convincing, it remains unclear whether preemptive analgesic regimens in humans are more effective in decreasing postoperative pain than conventional methods. A recent meta-analysis of 66 studies analyzed pain intensity scores, supplemental analgesic consumption, and time to first analgesic consumption in a total of 3,261 patients. Epidural analgesia decreased analgesic consumption, increased the time to first rescue analgesic request, and decreased postoperative pain scores. Wound infiltration with local anesthetic and preoperative administration of nonsteroidal anti-inflammatory drug (NSAID) decreased analgesic consumption and increased the time to first analgesia. Importantly, the least preemptive efficacy was demonstrated with systemic opioid administration.

**Conventional Analgesic Methods**

**Parenteral Opioid Analgesics**

When adequate analgesia is achieved with systemic opioids, significant side effects are common, including sedation, nausea, and pruritus. Nonetheless, opioid analgesics remain widely used for postoperative pain relief. Systemic opioids may be administered by intravenous, intramuscular, and oral routes. Current analgesic regimens typically use intravenous PCA for 24 to 48 hours postoperatively, with subsequent conversion to oral agents. The PCA device may be programmed for several variables, including bolus dose, lockout interval, and background infusion (Table 1).

The optimal bolus dose is determined by the relative potency of the opioid; insufficient dosing results in inadequate analgesia, whereas excessive dosing increases the potential for side effects, including respiratory depression. Likewise, the lockout interval is based on the onset of analgesic effects; too short a lockout interval allows the patient to self-administer additional medication before achieving the full analgesic effect (and may result in accumulation or overdose of the opioid). A prolonged lockout interval will not allow adequate analgesia. The optimal bolus dose and lockout interval are not known, but ranges have been determined. Varying the settings within these ranges appears to have little effect on analgesia or side effects. Although most PCA devices allow the addition of a background infusion, routine use in adult opioid-naïve patients is not recommended. There may be a role for a background opioid infusion in opioid-tolerant patients, however.

Because of the variation in patient pain tolerance, PCA dosing regimens may require adjustment to maximize the benefits and minimize the incidence of side effects. Despite the ease of administration and titratability, parenteral opioids do not provide adequate analgesia for total joint replacement patients, particularly during movement with ambulation. This is evident from pain scores in the moderate to severe range in the first 2 days postoperatively. The adverse effects of opioid administration can cause serious complications in patients undergoing major orthopaedic procedures. In a systematic review, Wheeler et al reported gastrointestinal side effects (eg, nausea, vomiting, ileus) in 37% of patients.
of patients, cognitive effects (eg, somnolence, dizziness) in 34%, pruritus in 15%, urinary retention in 16%, and respiratory depression in 2% of patients receiving PCA opioid analgesia.

**Neuraxial Analgesia**

A variety of single-dose and continuous infusion neuraxial (epidural or spinal) techniques may be performed to provide analgesia after primary total joint arthroplasty. Administration of a single dose of neuraxial opioid may be efficacious as the sole analgesic agent for moderate pain of limited duration, such as that associated with primary hip arthroplasty. However, the prolonged moderate to severe pain associated with revision arthroplasty typically necessitates either supplemental oral or intravenous analgesic agents or a continuous neuraxial infusion.

**Single-Dose Spinal and Epidural Opioids**

Neuraxial opioids provide superior analgesia compared with systemic opioids. The onset and duration of neuraxial opioids are determined by the lipophilicity of the drug. For example, lipophilic opioids, such as fentanyl, provide a rapid onset of analgesia, limited spread within the cerebrospinal fluid (and less respiratory depression), and rapid clearance and resolution. Conversely, hydrophilic opioids, including morphine and hydromorphone, have a longer duration of action but are associated with a greater frequency of side effects, such as pruritus, nausea, and vomiting, as well as delayed respiratory depression.

A new sustained-release formulation of epidural morphine (DepoDur, Endo Pharmaceuticals, Chadds Ford, PA) was released in 2004. Limited information exists regarding its efficacy after orthopaedic surgery. The analgesic effect is present for approximately 48 hours. Unfortunately, DepoDur is not to be administered in the presence of local anesthetics (ie, an epidural anesthetic may not be converted to provide epidural analgesia).

It is important to note that the typical side effects of opioids are much more common (and more prolonged) after neuraxial administration compared with all other routes. For example, in a large series, the frequency of pruritus, nausea and vomiting, and respiratory depression was 37%, 25%, and 3%, respectively, with an intrathecal morphine injection. Therefore, patients who exhibit sensitivity to an opioid when administered systemically should not receive that agent neuraxially.

**Epidural Analgesia**

Epidural analgesia may consist of a local anesthetic, an opioid, or a combined local anesthetic–opioid infusion. The combination of an opioid and local anesthetic creates a synergistic analgesic effect that allows lower concentrations of each component of the solution. For example, without an opioid adjuvant, the concentration of a local anesthetic solution may be sufficiently high to result in a dense sensory and motor block, such that the patient may be unable to ambulate or void. Likewise, a pure opioid epidural infusion may not provide adequate analgesia. As a result, most epidural solutions consist of dilute concentrations of both local anesthetic and opioid. This results in superior analgesia, minimal sensory and motor block (allowing ambulation and mobilization), and a decreased incidence of opioid-related side effects.

Although individual small series often have reported improved efficacy with epidural analgesia compared with other modalities, this efficacy was recently evaluated systematically in a Cochrane report. Fourteen studies, involving 585 patients, were included in the analysis. There was no difference in the frequency of nausea or vomiting or of respiratory depression with epidural analgesia compared with systemic analgesia.

Sedation was less frequent, and urinary retention, pruritus, and hypotension more frequent, with an epidural approach. Functionally, for early (4-6 h) postoperative pain at rest, epidural analgesia was superior to systemic analgesia. In addition, epidural analgesia was associated with lower pain scores for both early and late (18-24 h) pain during leg movement or ambulation. This was most remarkable in the studies that involved an epidural infusion (rather than a bolus) containing a local anesthetic (with or without an opioid). Although several studies included in the meta-analysis reported statistically significant increases in the amount of knee flexion achieved by patients receiving epidural analgesia compared with systemic analgesia, numbers were insufficient to draw conclusions about the effect of epidural analgesia on functional outcomes or length of hospital stay.

Despite the potential advantages, patients undergoing total joint replacement are often not considered candidates for epidural analgesia because of the need for thromboprophylaxis. Although guidelines for antithrombotic therapy continue to evolve, thromboprophylaxis with low-molecular-weight heparin (LMWH), warfarin, or fondaparinux is recommended for patients undergoing major lower extremity surgery. Unfortunately, antithrombotic therapy in the presence of an indwelling epidural catheter is associated with a markedly increased risk of neurologic compromise from expanding spinal hematoma. For example, the frequency of spinal hematoma may be as high as 1 in 3,000 in patients who receive once or twice daily dosing of LMWH while an epidural catheter is in situ. Current anesthetic management guidelines recommend removal of the epidural catheter before initiating thromboprophylaxis with fondaparinux or LMWH. Alternatively, thromboprophylaxis may
be delayed, placing the patient at risk for thromboembolism. Thus, although epidural analgesia provides excellent analgesia, the associated risk of spinal hematoma in (anticoagulated) patients with indwelling epidural catheters led to a search for alternative methods of providing postoperative analgesia after major orthopaedic surgery.

Multimodal Analgesia and Peripheral Nerve Blockade

Multimodal analgesia is a multidisciplinary approach to pain management; its goal is maximizing the positive aspects of the treatment while limiting the associated side effects. Because many of the negative side effects of analgesic therapy are opioid-related (and dose-dependent), limiting perioperative opioid use is a major principle of multimodal analgesia. The efficacy and side effects of analgesic therapy are major determinants of patient satisfaction. In a prospective survey of 10,811 patients, after adjusting for patient and surgical factors, moderate or severe postoperative pain and severe nausea and vomiting were associated with patient dissatisfaction. The use of peripheral or neuraxial regional anesthetic techniques, and a combination of opioid and nonopioid analgesic agents for breakthrough pain, results in superior pain control, attenuation of the stress response, and decreased opioid requirements.

Nonopioid Analgesics

The addition of nonopioid analgesics reduces opioid use, improves analgesia, and decreases opioid-related side effects (Table 2). The multimodal effect is maximized through selection of analgesics that have complementary sites of action. For example, acetaminophen acts predominantly centrally, whereas other NSAIDs exert their effects peripherally.

Table 2
Oral Nonopioid Analgesics

<table>
<thead>
<tr>
<th>Analgesic</th>
<th>Dose</th>
<th>Dosing Interval</th>
<th>Maximum Daily Dose</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaminophen</td>
<td>500-1,000 mg po</td>
<td>q 4-6 h</td>
<td>4,000 mg</td>
<td>As effective as aspirin; 1,000 mg more effective than 650 mg in some patients</td>
</tr>
<tr>
<td>Celecoxib</td>
<td>400 mg initially, then 200 mg po</td>
<td>q 12 h</td>
<td>800 mg</td>
<td>Celecoxib is the only cyclooxygenase (COX)-2 inhibitor available in North America</td>
</tr>
<tr>
<td>Aspirin</td>
<td>325-1,000 mg po</td>
<td>q 4-6 h</td>
<td>4,000 mg</td>
<td>Most potent anti-platelet effect</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>200-400 mg po</td>
<td>q 4-6 h</td>
<td>3,200 mg</td>
<td>200 mg equal to 650 mg of aspirin or acetaminophen</td>
</tr>
<tr>
<td>Naproxen</td>
<td>500 mg po</td>
<td>q 12 h</td>
<td>1,000 mg</td>
<td>250 mg equal to 650 mg of aspirin, but with longer duration</td>
</tr>
<tr>
<td>Ketorolac</td>
<td>15-30 mg po, IM/IV</td>
<td>q 4-6 h</td>
<td>60 mg (&gt;65 years of age); 120 mg (≤65 years)</td>
<td>Comparable to 10 mg morphine; reduce dose in patients &lt;50 kg or with renal impairment; total duration of administration is 5 days</td>
</tr>
<tr>
<td>Tramadol</td>
<td>50-100 mg po</td>
<td>q 6 h</td>
<td>400 mg; less in cases of renal or hepatic disease</td>
<td>Combination product of tramadol-acetaminophen is also available</td>
</tr>
</tbody>
</table>

IM = intramuscular, IV = intravenous, po = oral

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Acetaminophen

The mechanism of analgesic action of acetaminophen has not been fully determined. Acetaminophen may act predominantly by inhibiting prostaglandin synthesis in the central nervous system. Acetaminophen has very few adverse side effects and is an important addition to the multimodal postoperative pain regimen, although the total daily dose must be limited to <4,000 mg. To maximize the pharmacologic effects, the administration should be scheduled (ie, not provided on an as-needed basis). Also, many oral analgesics are an opioid-acetaminophen combination (Table 3). In these preparations, the total dose of opioid will be restricted to the acetaminophen ingested.

Nonsteroidal Anti-inflammatory Drugs

The NSAIDs have a mechanism of action through the cyclooxygenase (COX) enzymatic pathway and ulti-
mately block two individual prostaglandin pathways. The COX-1 pathway is involved in prostaglandin E₂–mediated gastric mucosal protection and thromboxane effects on coagulation. The inducible COX-2 pathway is mainly involved in the generation of prostaglandins included in the modulation of pain and fever, but it has no effect on platelet function or the coagulation system. In general, NSAIDs block both the COX-1 and COX-2 pathways. Advantages of the COX-2 inhibitors are the lack of platelet inhibition and a decreased incidence of gastrointestinal effects.

Traditionally, NSAIDs have been viewed as peripherally acting agents. However, there may be a central analgesic effect through inhibition of spinal COX.

The introduction of selective COX-2 inhibitors represented a breakthrough in perioperative pain management. Because they do not interfere with the coagulation system, COX-2 inhibitors may be continued until the time of surgery. They also may be administered in the immediate postoperative period. The perioperative administration of rofecoxib has been shown to have a notable opioid-sparing effect after major orthopaedic surgery with no significant increase in perioperative bleeding. However, despite their efficacy, two of three COX-2 inhibitors [rofecoxib [Vioxx; Merck, Whitehouse Station, NJ] and valdecoxib [Bextra; Searle, Skokie, IL]] were voluntarily removed from general use because of an increased relative risk for confirmed cardiovascular events, such as heart attack and stroke, after 18 months of treatment. Celecoxib [Celebrex; Searle] is currently the only COX-2 inhibitor available in the United States. In April 2005, the Food and Drug Administration [FDA] released a Public Health Advisory requesting that safety information be included regarding potential cardiovascular and gastrointestinal risks of selective and nonselective NSAIDs except aspirin.

Although numerous NSAIDs have been used in the perioperative management of pain, ketorolac is the only NSAID that can be given parenterally. An intravenous dose of ketorolac 10 to 30 mg was found to have an efficacy similar to that of 10 to 12 mg of intravenous morphine and to reduce opioid consumption by 36% in surgical patients. Because of the potential for serious side effects, ketorolac should be used for no more than 5 days in adults with moderate to severe acute pain.

The major side effects limiting use of NSAIDs for postoperative pain control (eg, renal failure, platelet dysfunction, gastric ulcers or bleeding) are related to the nonspe-
pecific inhibition of the COX-1 enzyme.28 Advantages of the COX-2 inhibitors are the lack of platelet inhibition and a decreased incidence of gastrointestinal effects. All NSAIDs have the potential to cause serious renal impairment. Inhibition of the COX enzyme may have only minor effects in the healthy kidney, but it can lead to serious side effects in elderly patients or those with a low-volume condition (e.g., blood loss, dehydration, cirrhosis, heart failure). Therefore, NSAIDs should be used cautiously in patients with underlying renal dysfunction, specifically in the setting of volume depletion resulting from blood loss.28 Similar to the COX-2 inhibitors, NSAIDs also interfere with the inhibitory COX-1 effect of aspirin on platelet activity and may counter the cardioprotective effects.26

The effect of NSAIDs on bone formation and healing is of concern in orthopaedic patients. Although data are conflicting, there is evidence from animal studies that COX-2 inhibitors may inhibit bone healing.29 Thus, the adverse effects of COX-2 inhibitors must be weighed against the benefits. Until definitive human trials are performed, caution is reasonable in the use of NSAIDs and COX-2 inhibitors, especially when bone healing is critical. To date, there is no evidence that COX-2 inhibitors have a clinically important effect on bone ingrowth to hip and knee implants after total joint replacement.

Tramadol

Tramadol is a centrally acting analgesic that is structurally related to morphine and codeine. Its analgesic effect is through binding to the opioid receptors as well as blocking the re-uptake of both norepinephrine and serotonin. Tramadol has gained popularity because of the low incidence of adverse effects, specifically respiratory depression, constipation, and potential for abuse. Tramadol has been shown to provide adequate analgesia, superior to placebo and comparable with that of various opioid and nonopioid analgesics for the treatment of acute pain. Thus, tramadol may be used as an alternative to opioids in a multimodal approach to postoperative pain, specifically in patients who are intolerant to opioid analgesics.

Ketamine

Ketamine is a noncompetitive N-methyl-d-aspartate (NMDA) receptor antagonist that may play a critical role in the intensity of perceived postoperative pain.30 In patients undergoing knee arthroplasty, a low-dose infusion of ketamine (3 µg/kg per minute intraoperatively and 1.5 µg/kg per minute for 48 hours postoperatively) reduced morphine requirements and decreased the time to achieve 90° of active flexion.31

Oral Opioids

Oral opioids (Table 3) are available in immediate-release and controlled-release formulations. Immediate-release oral opioids are effective in relieving moderate to severe pain, but they must be administered as often as every 4 hours. When these medications are prescribed as needed, there may be a delay in the administration and thus a subsequent increase in pain. Furthermore, interruption of the dosing schedule, particularly during the night, may lead to increased pain. The Acute Pain Management Guidelines developed by the Agency for Healthcare Policy and Research32 recommend a fixed-dose or an as-needed schedule for all patients requiring opioid medications for more than 48 hours postoperatively. The adverse effects of oral opioid administration are considerably less than those of intravenous administration and are mainly gastrointestinal in nature.15

A controlled-release formulation of oxycodone has been shown to provide therapeutic opioid concentrations and sustained pain relief over an extended period. Administration of controlled-release oxycodone for 72 hours postoperatively improves analgesia and is associated with less sedation, vomiting, or sleep disturbances than oxycodone given on either a fixed-dose or an as-needed basis.33 Therefore, a multimodal analgesic approach may include scheduled administration of controlled-release oxycodone combined with as-needed oxycodone for breakthrough pain to maximize the analgesia and to decrease the associated side effects.

Peripheral Regional Anesthetic Techniques

Lower extremity peripheral techniques, which allow complete unilateral blockade, have traditionally been underutilized.34 In part, this is because of 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 and thus easily blocked with a relatively localized injection of 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 stimulation 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 because the contralateral limb is immediately available to assist with early ambulation. Although single-injection techniques have been used, the duration of effect after a single injection is not sufficient to result in major improvements in analgesia or out-
Recent applications of peripheral nerve block techniques have allowed prolonged postoperative analgesia (with an indwelling catheter) to assist rehabilitation and facilitate hospital dismissal. The lumbar plexus may be blocked by three distinct approaches (Table 4). Block of the full lumbar plexus (ie, femoral, lateral femoral cutaneous, and obturator nerves) is accomplished with the psoas block. In comparison, the fascia iliaca and femoral approaches will reliably block the femoral but not the lateral femoral, cutaneous, and obturator nerves. Complete unilateral lower extremity blockade is achieved by combining a lumbar plexus technique with a proximal sciatic block.

Selection of a regional analgesic technique depends on the surgical site. For example, the psoas compartment approach to the lumbar plexus (Figure 1, A) 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 (Figure 1, B) and fascia iliaca (Figure 2) approaches are sufficient. Supplemental sciatic block or obturator block is required to obtain adequate analgesia after total knee (but not hip) arthroplasty (Figure 3). The sciatic nerve also may 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. This is quite important for decreasing the posterior knee pain that patients undergoing knee replacement often experience in the early postoperative period.

Peripheral block techniques are equally as effective as epidural analgesia (and both are superior to PCA morphine) in providing analgesia and facilitating rehabilitation after total joint replacement. For example, after total knee arthroplasty, patients receiving epidural analgesia or continuous femoral block reported lower pain scores, better knee flexion, faster ambulation, and shorter hospital stays than did patients who received intravenous PCA morphine. However, continuous femoral block was the preferred analgesic technique in each study because fewer technical problems and fewer side effects were noted compared with the epidural and PCA approaches. Similar effective results were reported for patients undergoing total hip arthroplasty who received a continuous psoas block rather than epidural analgesia or PCA.

Recent innovations emphasize the use of continuous peripheral nerve blocks combined with multiple scheduled analgesics.

### Table 4

<table>
<thead>
<tr>
<th>Peripheral Technique</th>
<th>Technique of Neural Localization</th>
<th>Area of Blockade</th>
<th>Duration of Blockade*</th>
<th>Perioperative Outcomes †</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar plexus</td>
<td>Femoral</td>
<td>Femoral, partial lateral femoral cutaneous and obturator</td>
<td>12-18 h</td>
<td>Improved analgesia and joint range of motion, decreased hospital stay compared with PCA; fewer technical problems, less urinary retention and hypotension than epidural analgesia (TKA)</td>
</tr>
<tr>
<td></td>
<td>Fascia iliaca</td>
<td>Femoral, partial lateral femoral cutaneous, obturator and sciatic (S1)</td>
<td>12-18 h</td>
<td>Improved analgesia and joint range of motion compared with PCA (TKA)</td>
</tr>
<tr>
<td></td>
<td>Psoas compartment</td>
<td>Complete lumbar plexus; occasional spread to sacral plexus or neuraxis</td>
<td>12-18 h</td>
<td>Reduced morphine consumption, pain at rest compared with PCÄ (TKA, THA); reduced blood loss (THA); analgesia equivalent to continuous femoral block (TKA)</td>
</tr>
<tr>
<td></td>
<td>Sciatic</td>
<td>Posterior thigh and leg (except saphenous area)</td>
<td>18-30 h</td>
<td>Supplemental sciatic required (TKA); proximal approaches allow block of posterior femoral cutaneous nerve (TKA)</td>
</tr>
</tbody>
</table>

PCA = patient-controlled analgesia, THA = total hip arthroplasty, TKA = total knee arthroplasty
* Duration of block performed with long-acting local anesthetic (eg, bupivacaine, ropivacaine); intermediate-acting agents (eg, lidocaine, mepivacaine) will resolve after 4 to 6 hours
† Outcomes most marked in patients who receive a continuous lumbar plexus catheter with infusion of 0.1% to 0.2% bupivacaine or ropivacaine at 6 to 12 mL/h for 48 to 72 hours
tin; Purdue Pharma, Norwalk, CT), acetaminophen, and as-needed analgesics (oxycodone); no intravenous opioids are administered. Using strict criteria, 90% of patients undergoing minimally invasive primary hip or knee replacement were ready for discharge from the hospital within 48 hours.40 These studies support the movement toward continuous peripheral technique as the optimal analgesic method after total knee and hip arthroplasty. Additional information is needed to determine the effectiveness of these techniques in conventional primary and revision joint arthroplasty.

Neurologic dysfunction and intravascular injection are the primary concerns associated with peripheral blockade. However, in a large series involving more than 50,000 peripheral blocks, there were six seizures, and 12 patients (0.02%) reported postoperative nerve injury. Most neurologic complications were tran-
sient. In addition, because of the proximity of the neuraxis with the psoas approach, epidural spread and intrathecal injection have been reported. Thus, attention to total intrathecal injection have been re-
psoas approach, epidural spread and proximity of the neuraxis with the dwelling neuraxial catheter. Unilat-
phylaxis in the presence of an in-
hematoma because of thrombopro-
ambulation, and the risk of spinal
reduction of urinary retention, motor block limiting
improvements, including joint range
of motion and decreased hospital
stay, depend on the method or methods used to provide postoperative analgesia in patients undergoing total knee and hip arthroplasty. Epidural infusions provide superior analgesia and functional outcomes similar to that of continuous epidural analgesia and superior to that of systemic intravenous opioid analgesia, but with fewer side effects. Continued collaboration between orthopaedic surgeons and anesthesiologists is necessary to further advance the perioperative management of this patient population.

### Summary

Sustained and substantial outcome improvements, including joint range of motion and decreased hospital stay, depend on the method or methods used to provide postoperative analgesia in patients undergoing total knee and hip arthroplasty. Epidural infusions provide superior analgesia compared with conventional systemic analgesics, but they are associated with hypotension, urinary retention, motor block limiting ambulation, and the risk of spinal hematoma because of thromboprophylaxis in the presence of an indwelling neuraxial catheter. Unilateral peripheral nerve blocks combined with oral analgesics administered on a schedule provide a quality of analgesia and functional outcomes similar to that of continuous epidural analgesia and superior to that of systemic intravenous opioid analgesia, but with fewer side effects. Continued collaboration between orthopaedic surgeons and anesthesiologists is necessary to further advance the perioperative management of this patient population.

### References

Citation numbers printed in **bold type** indicate references published within the past 5 years.


