Anesthetic Management in Early Recovery After Surgery Protocols for Total Knee and Total Hip Arthroplasty

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The aim of this integrative review was to provide current, evidence-based anesthetic and analgesic recommendations for inclusion in an Enhanced Recovery After Surgery (ERAS) protocol for patients undergoing total knee arthroplasty (TKA) or total hip arthroplasty (THA). Articles published between 2006 and December 2016 were critically appraised for validity, reliability, and rigor of study.

The administration of nonsteroidal anti-inflammatory drugs (NSAIDs), acetaminophen, gabapentinoids, and corticosteroids resulted in shorter hospital length of stay (LOS) and decreased postoperative pain and opioid consumption. A spinal anesthetic block provided benefits over general anesthesia, including decreased 30-day mortality rates, hospital LOS, blood loss, and complications. The use of peripheral nerve blocks for postoperative pain management resulted in lower pain scores, decreased opioid consumption, fewer complications, and shorter hospital LOS. Perioperative anesthetic management in ERAS protocols for patients undergoing TKA and THA should include the administration of acetaminophen, NSAIDs, gabapentinoids, and corticosteroids. Preferred intraoperative anesthetic management in ERAS protocols should consist of spinal anesthesia with light sedation. Postoperative pain should be managed with peripheral nerve blocks such as adductor canal block or femoral nerve block supplemented with sciatic nerve block or local infiltrated anesthesia.

Keywords: Anesthetic management, Enhanced Recovery After Surgery protocol, total hip arthroplasty, total knee arthroplasty.

Demand for total knee arthroplasty (TKA) and total hip arthroplasty (THA) is on the rise as life expectancy increases and lifestyles become more active. According to the Agency for Healthcare Research and Quality, there were 732,570 TKAs and 493,685 THAs performed in the United States in 2013. Between 2000 and 2010, THAs grew by 92% among those aged 75 years and older and increased by 205% in those aged 45 to 54. Given risk factors such as increased age, obesity, and the prevalence of osteoarthritis, demand for TKA and THA is likely to increase.

The purpose of this integrative review was to examine current evidence and provide practice recommendations for anesthetic management that support early mobility and improved pain management postoperatively for the patient undergoing TKA or THA. Specifically, the questions that guided the review for patients undergoing elective TKA or THA were as follows:
1. What anesthetic management strategies affect postoperative recovery?
2. What are the effects of regional anesthetic peripheral nerve blocks on postoperative recovery?
3. How do anesthetic modalities affect patients’ hospital length of stay (LOS)?

Methods
Identification of best current evidence included searches of the following electronic databases: MEDLINE/PubMed, The Cochrane Library, Academic Search Premier, Google Scholar, and Cumulative Index to Nursing & Allied Health Literature. The following search terms were used alone and in combination: anesthesia, anesthetic management, Enhanced Recovery After Surgery, fast track, rapid recovery, protocol, guidelines, orthopedic, total hip arthroplasty, total knee arthroplasty, total hip replacement, and total knee replacement. The ERAS Society, the American Society for Enhanced Recovery, and the Centers for Disease Control and Prevention were also searched. The international literature search was limited to English-language articles published between 2006 and 2016. A matrix was used for data extraction and categorizing references, sample, methods, findings, and strengths and limitations.

Results
- Enhanced Recovery After Surgery Protocols (ERAS). Increasingly, ERAS protocols are being used to reduce postoperative pain, encourage early ambulation, and reduce LOS in the orthopedic surgical population. Varied definitions exist for ERAS protocols. ERAS programs

Anesthetic Management and Postoperative Recovery.

Nonsteroidal Anti-Inflammatory Drugs. Either oral or parenteral NSAIDs are used perioperatively to decrease inflammation and reduce postoperative analgesia. When NSAIDs are incorporated into a multimodal therapy protocol, studies report significantly less pain, less opioid consumption, and improved postoperative mobility.7,8,10,18

Celecoxib, a selective cyclooxygenase 2 (COX-2) inhibitor, inhibits prostaglandin synthesis in the periphery and the spinal cord, resulting in a decreased postoperative hyperalgesic state. Patients who received 400 mg of celecoxib 1 hour before TKA and 200 mg of celecoxib every 12 hours for 5 days postoperatively reported significantly decreased pain scores at rest at 48 hours (P = .03) and 72 hours (P = .02).7 Those who received celecoxib had significantly increased active range of motion, especially in the first 72 hours (POD 1, P = .01; POD 2, P = .004; POD 3, P = .004). Finally, opioid consumption was approximately 40% lower in patients who received celecoxib (P = .03).

Parecoxib is a parenteral COX-2 inhibitor (intravenous [IV] and intramuscular [IM] routes). Intravenous parecoxib has been found to be beneficial for patients undergoing TKA when administered as an adjunct to spinal anesthesia and continuous femoral nerve block (FNb). Patents who received parecoxib were found to have decreased opioid consumption and significantly lower pain scores at postoperative hours 4 (P = .044), 12 (P = .001), and 24 (P = .012) compared with a placebo. Patients who received parecoxib consumed less morphine at each time, with borderline statistical significance (P = .054).10

Patient outcomes following the use of celecoxib,
parecoxib, and placebo have also been compared when the agents were administered 1 hour before surgery.\textsuperscript{18} Both celecoxib and parecoxib groups had significantly decreased morphine requirements compared with a placebo group ($P < .001$). Furthermore, the celecoxib group required significantly more morphine compared with the parecoxib group ($P < .001$). The parecoxib group reported significantly lower pain scores than the celecoxib and placebo groups at hours 1, 6, and 12 postoperatively. Although the placebo group had a higher sedation score compared with both treatment groups ($P = .008$), there was no increase in nausea and vomiting ($P = .36$) or pruritus ($P = .12$). Findings indicate IV parecoxib to be superior in reducing pain and decreasing opioid consumption on the day of surgery compared with oral celecoxib.

Findings provide support for use of NSAIDs to decrease inflammation, pain, and narcotic use after TKA and THA. When selecting an NSAID, providers should consider the advantages of COX-2 selective inhibitors and IV parecoxib over traditional oral NSAIDs. Gastric-related side effects are avoided, and opioid-related side effects are reduced, with no increase in bleeding or other adverse effects.\textsuperscript{8,10,18} Intravenous parecoxib results in a greater reduction in pain and opioid consumption than does oral celecoxib and should be used if available.

- **Acetaminophen.** Acetaminophen is an opioid-sparing analgesic and antipyretic agent. Acetaminophen (IV, oral, rectal routes) primarily inhibits central prostaglandins while affecting peripheral COX enzymes to a lesser extent. Although the mechanism of action is not fully understood, effects are thought to be due to inhibition of vanillin-1 receptors, activation of the descending modulatory serotonergic pathway, and increased levels of endogenous cannabinoids.\textsuperscript{19-21}

Pain, narcotic consumption, and LOS were reduced in all studies reviewed in which the ERAS protocol included administration of acetaminophen.\textsuperscript{3-5,22} All literature reviewed supports the inclusion of acetaminophen in ERAS protocols for TKA and THA. However, further studies are necessary to determine the most effective route and timing of administration.

- **Corticosteroids.** Inflammation sensitizes nociceptors causing pain and immune, endothelial, and organ dysfunction. Steroids decrease inflammation and reduce the perioperative neuroendocrine stress response. When administered before TKA, IV methylprednisolone, 125 mg, reduced pain ($P < .04$), narcotic consumption ($P = .02$), fatigue ($P = .02$), nausea ($P < .05$), and C-reactive protein levels ($P < .001$) postoperatively.\textsuperscript{23} Similar, but less prominent, findings were seen for THA. Patients who received IV methylprednisolone, 125 mg, before THA exhibited decreased pain ($P < .01$) and reduced C-reactive protein concentrations ($P < .001$) postoperatively when administered with paracetamol, celecoxib, and gabapentin.\textsuperscript{24}

Steroids injected directly into a surgical wound, such as with local infiltration anesthesia (LIA), reduce the production of prostaglandins and decrease postoperative pain.\textsuperscript{25} There is also strong evidence to support dexamethasone at a dosage of 4 mg administered IV at the incision to reduce postoperative nausea and vomiting.\textsuperscript{26} Lower incidences of postoperative nausea and vomiting are associated with increased accumulation ($P = .002$).\textsuperscript{27} Some ERAS protocols include higher doses of dexamethasone (16-20 mg).\textsuperscript{4} Concern has been raised over the immunosuppressive properties of steroids in higher doses. However, no significant difference has been found in wound infections between patients who received dexamethasone, 4 mg IV, only at induction or dexamethasone, 10 mg orally, the night before surgery with 4 mg IV at induction.\textsuperscript{11} Although most ERAS protocols reviewed included 4 to 10 mg of IV dexamethasone, the anesthetist should consider administering the appropriate drug, dose, and route to effectively decrease local and systemic inflammation.

- **Intraoperative Anesthesia Management.** Intraoperative anesthetic management options for TKA and THA include general anesthesia or neuraxial anesthetic block with sedation. Improved outcomes have been found with spinal compared with general anesthesia for TKA and THA.\textsuperscript{28,29} Benefits of neuraxial anesthesia include decreased operating room time, 30-day mortality rates, hospital LOS, blood loss, and hospital complications.\textsuperscript{28,29} Regional anesthesia offers a lower risk of deep vein thrombosis, pulmonary embolus, myocardial infarction, pneumonia, and delirium.\textsuperscript{30} The implications of these findings for ERAS protocol development are important. Spinal anesthesia should be especially considered in all patients undergoing THA or TKA who are not candidates for or who refuse a peripheral nerve block.

- **Postoperative Pain Management and Recovery.** To facilitate ERAS protocols for TKA and THA, postoperative pain management should be included. Peripheral nerve blocks play a key role in providing postoperative pain relief following TKA and may be administered preoperatively or postoperatively. Patients who receive a peripheral nerve block as part of their multimodal analgesic plan have lower pain scores, decreased opioid requirements, fewer complications, and shorter hospital LOS.\textsuperscript{31} The anesthesia provider should consider the merits of single-shot or continuous-catheter FNB, sciatic nerve block (SNB), adductor canal block (ACB), and LIA and their implications for ERAS protocols. The literature does not provide strong evidence for the use of one method over the other, but it does strongly support the use of at least one of these strategies.\textsuperscript{32-34}

- **Adductor Canal Block.** The adductor canal is the potential space formed by the sartorius, medial femoral, and adductor muscles.\textsuperscript{35} Adductor canal blocks anesthetize the saphenous nerve, the largest cutaneous sensory branch of the femoral nerve. The saphenous nerve sup-
plies sensation to the medial and anterolateral skin below the patella and anterior-inferior joint capsule. The goal of an ACB is to provide postoperative pain relief without hindering mobility.36

Improved postoperative mobility and decreased narcotic consumption has been found with patients who receive ACB following TKA.22,36-38 Subjects receiving a continuous ACB demonstrate significantly greater quadriceps muscle strength at 4 hours \((P < .04)\) and 48 hours \((P = .001)\) postoperatively.35 Ambulation distances are greater with a continuous ACB compared with FNB on POD 1 (37 vs 6 m, \(P < .001)\) and POD 2 (60 vs 21 m, \(P < .008)\).35 Patients who receive ACB are more likely to have shorter hospital LOS and to be discharged home rather than to a rehabilitation facility.22,38 No difference has been found in postoperative analgesia between FNB or LIA compared with ACB \((P > .05)\).35,37,39 If appropriate, ACBs should be included in ERAS protocols.

- **Femoral Nerve Block.** Following TKA, FNBs are commonly used for postoperative analgesia management. There is strong evidence that FNB improves analgesia and reduces opioid consumption.32-34 Femoral nerve blocks significantly lower pain and morphine requirements \((P < .001)\).34 These findings are supported by Chan et al,32 who found that patients receiving FNBs had lower pain scores, decreased opioid consumption (mean difference [MD] = −14.74 mg, 95% CI = −18.68 to −10.81 mg), less nausea and vomiting (relative risk = 0.47), increased range of motion (MD = 6.48 degrees, 95% CI = 4.27 to 8.69 degrees), and higher patient satisfaction (SMD = 1.06, 95% CI = 0.74 to 1.38) compared with patients who received IV morphine via PCA with no peripheral nerve block.

The single-shot, 3-in-1 FNB is a variation of the FNB that aims to block the femoral nerve, lateral cutaneous nerve of the thigh, and obturator nerve with 1 injection. Local anesthetic is injected at the femoral nerve and is manipulated to spread proximally to block the other 2 nerves. Patients who received a 3-in-1 FNB of 40 mL of 0.375% ropivacaine had better pain relief \((P < .05)\), less morphine consumption \((P < .001)\), and fewer side effects (nausea, vomiting, and hypotension) than those who received no block.33 In contrast, other research findings conflict with the prior discussed studies. Mobility, pain, opioid consumption, and hospital LOS have been found to be similar between patients who received morphine PCA and those who received PCA and FNB.40,41 However, the PCA-only group experienced more opioid-related side effects, including nausea, vomiting, dizziness, and pruritus \((P < .05)\).31

Femoral nerve blocks may be performed as a single-shot injection of local anesthesia or with continuous infusion via catheter. Patients who receive a continuous FNB reported less pain and opioid consumption in the first 24 hours compared with those who received single-shot FNB.32 One disadvantage of a continuous FNB is that patients who receive this block may be at an increased risk of falls compared with a single-shot FNB. However, the attributable risk of falls due to continuous blockade fell within the expected probability of postoperative falls for patients undergoing orthopedic surgery.39 Fall rates differ between studies for patients undergoing TKA who received an FNB from 2%19 to 1.6%29 regardless of peripheral nerve blockade.

- **Sciatic Nerve Block.** Nociception of the knee joint involves both femoral and sciatic nerves.42 An FNB alone will not provide adequate pain relief in the posterior portion of the knee. An SNB provides more thorough analgesia coverage when administered in combination with FNB for TKA postoperative pain.43 Three postoperative pain management strategies have been compared: PCA via FNB, PCA via FNB with continuous SNB, and PCA via FNB with single-shot SNB.44 No difference was found between groups in knee function, local anesthetic used, nausea, vomiting, or LOS. However, patients supplemented with continuous SNB consumed significantly less opioids and reported significantly less pain until POD 2 \((P < .01)\).

A study by Nagafuchi et al45 did not support the use of SNB as a supplement to FNB in patients undergoing TKA. Patients who received SNB with FNB reported lower pain scores 3 to 12 hours postoperatively compared with patients who received LIA with FNB. Despite this finding, there were no differences in analgesic consumption, time to first analgesic administration, nausea, vomiting, patient satisfaction, or hospital LOS. Limitations to this study include its small sample size \((n = 34)\) and the LIA mixture used. The LIA mixture of ropivacaine and epinephrine did not include ketorolac or corticosteroids, which have been proven to provide effective analgesia.25,46 This study does not provide evidence to suggest supplementing FNB with LIA over SNB, or vice versa. Additional evidence is necessary to warrant the risks that come with performing an additional peripheral nerve block to supplement FNB in patients after TKA and THA.

- **Local Infiltration Anesthesia.** Local infiltration anesthesia may be used as an alternative or supplement to peripheral nerve blocks. In periarticular infiltration, an anesthetic mixture is injected into the posterior capsule retinacular layer and subcutaneous tissues. The anesthetic mixture often contains a combination of local anesthetic, ketorolac, and steroids. Typically, LIA is performed by the surgeon at the conclusion of the procedure. Although peripheral nerve blocks provide effective pain management, their disadvantages include slower recovery of lower extremity function, time required to perform, complications, and cost.43 Benefits of LIA include its ease to perform, lower cost, and avoidance of potential complications associated with peripheral nerve blocks.47 Several studies compared LIA with placebo or FNB and demonstrated conflicting results. Studies found patients
who received LIA to have decreased supplemental analgesic requirements postoperatively. Four studies found similar outcomes in patients who received LIA and those who received FNB with or without SNB. A randomized controlled trial found patients who received LIA required significantly more narcotic ($P = .02$) and had significantly decreased mobility postoperatively ($P < .05$) compared with those who received a continuous FNB. Of note, one article found patients who received a continuous FNB with only single-shot SNB consumed less narcotic compared with LIA on POD 0 ($P < .001$), with no significant difference thereafter.

Only one study supported the use of LIA over FNB. In this study, the LIA group was administered a mixture of morphine (5 mg), ropivacaine (150 mg), epinephrine (0.3 mg), and betamethasone (4 mg) diluted in 50 mL of saline. The LIA mixture was administered just before cement fixation of the implant. In the second group, ropivacaine 150 mg was administered as a single-shot FNB on procedure completion. Although pain scores between groups remained similar through POD 5, the amount of rescue analgesics consumed was significantly lower in the LIA group ($P = .048$). Similar results were found between groups in postoperative mobility and time to discharge. Further research, including large randomized controlled trials, is needed to recommend LIA over FNB to decrease rescue analgesic needs.

There is evidence to support the use of LIA over a saline placebo but not necessarily in place of an FNB with an SNB. Further research is needed to determine the optimal role for LIA in ERAS protocols for total arthroplasty of the knee and hip.

**Discussion**

This integrative review indicates a trend toward use of ERAS protocols for TKA and THA procedures, although a specific protocol has yet to be universally adopted. There is strong evidence to suggest that ERAS protocols in this population reduce postoperative pain, enable earlier rehabilitation, and decrease hospital LOS and mortality. Outcomes are affected by preoperative and perioperative anesthetic management strategies. Therefore, when ERAS protocols are developed, the impact of anesthesia on recovery must be considered. Specific anesthetic recommendations for practice that serve as starting points for integration into ERAS protocols have been developed using the guiding questions for this review and are discussed here.

- **What Anesthetic Management Strategies Affect Postoperative Recovery?** Uncontrolled pain is a limiting factor for early postoperative mobilization. Gabapentinoids, NSAIDs, acetaminophen, and steroids all play an important role in ERAS protocols for THA and TKA. Peripheral nerve blocks and LIA have been shown to decrease pain and narcotic consumption while improving early mobilization. Therefore, ERAS protocols should incorporate anesthetic management strategies that limit pain and enhance recovery. Recommendations for practice to address anesthetic management strategies and their impact on postoperative recovery are summarized in the Table and include the following:

  - Preoperative administration of NSAIDs, acetaminophen, and gabapentinoids continued postoperatively for a minimum of 4 days
  - Placement of peripheral nerve blocks, such as ACB or FNB supplemented with SNB or LIA, for the patient undergoing TKA
  - Decreased opioid use to avoid undesirable opioid-related side effects
  - **What Are the Effects of Regional Anesthetic Peripheral Nerve Blocks on Postoperative Recovery in Elective Total Arthroplasty?** Studies have found peripheral nerve blocks play an important role in improving postoperative recovery in the patient undergoing TKA or THA. Peripheral nerve blocks provide pain relief during rehabilitation and also help avoid troublesome side effects of opioids that hinder mobility (sedation, dizziness, nausea, and vomiting). Not only do the improved analgesia effects support postoperative mobility, peripheral nerve blocks also have a positive impact on cognitive function and sleep, an important component in the healing process. Recommendations for practice to address the effects of regional anesthetic peripheral nerve blocks and their impact on postoperative recovery include the following:

  - Administering a low-volume ACB to avoid local anesthetic traveling cephalad and blocking the quadriceps muscles, or
  - Administering an FNB supplemented with either SNB or LIA
  - Using a continuous infusion of local anesthetic via catheter for longer-lasting postoperative pain control
  - **How Do Anesthetic Modalities Affect Patients’ Hospital Length of Stay After Elective Total Knee and Hip Arthroplasty?** The literature provides evidence for factors that affect hospital LOS. Pain, dizziness, and general weakness are main causes for an increased LOS. The anesthetic strategies discussed in this review help to control pain and dizziness, often associated with opioid use. ERAS protocols used for TKA and THA have resulted in a significant decrease in average hospital LOS. Patient factors associated with increased LOS include increased age, female sex, unmarried patients, and increasing ASA classification. The use of ERAS protocols may be of importance in high-risk patient populations to reduce LOS. Recommendations for practice to address anesthetic modalities and their impact on hospital LOS include:

  - Perioperative administration of acetaminophen and other opioid-sparing analgesics
• Use of spinal anesthesia with light sedation as the intraoperative anesthetic
• Administration of peripheral nerve blocks
• Avoidance of postoperative PCA use

**Limitations.** Limitations of this review include the low strength of research on some anesthetic and analgesic strategies. Systematic reviews and larger, randomized control trials are needed. There is also a wide variability regarding drug dosages and administration intervals. Although prior research supports the use of adjunctive medications to provide analgesia and to decrease opioid consumption, the optimal drug, dosage, and number of days of administration are inconclusive. Further research is needed to (1) determine the most effective route of administration and number of days that acetaminophen should be continued postoperatively, (2) validate the use of IV parecoxib over oral COX-2 inhibitors or other NSAIDs, and (3) determine the optimal type and dosage of IV steroids that provides the most benefit and fewest side effects. Finally, the studies reviewed support use of ACB, FNB, and LIA, as opposed to narcotics alone, for postoperative pain control. Further research is needed to determine whether ACB, FNB, LIA, or a combination of methods provides superior analgesia, improved postoperative mobility, and shorter hospital LOS.

**Conclusion**
This integrative review indicates that improvements in pain, narcotic consumption, mobility, and hospital LOS are influenced by preoperative and perioperative anesthetic management strategies for patients undergoing TKA or THA procedures. Preoperative peripheral nerve blocks and adjunctive medications clearly have an impact on postoperative outcomes following TKA and THA. Perioperative spinal anesthetic management clearly has a positive impact on postoperative outcomes as well. This

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**Table. Enhanced Recovery After Surgery (ERAS) Protocol Recommendations**

<table>
<thead>
<tr>
<th>Medication and dosage</th>
<th>Benefit</th>
</tr>
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<tbody>
<tr>
<td><strong>Acetaminophen</strong> (choose 1)</td>
<td>Reduces pain, opioid consumption, and length of stay&lt;sup&gt;2,5,22&lt;/sup&gt;</td>
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<tr>
<td>• 1 g IV at wound closure and every 6 h for 5 days</td>
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<tr>
<td>• 1-1.5 g orally preoperatively and every 6 h to POD 7</td>
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<tr>
<td><strong>COX-2 Inhibitors</strong> (choose 1)</td>
<td>• Reduces pain and opioid needs&lt;sup&gt;16-18&lt;/sup&gt;</td>
</tr>
<tr>
<td>• Parecoxib, 40 mg IV, at induction and every 12 h&lt;sup&gt;10,18&lt;/sup&gt;</td>
<td>• Improves mobility&lt;sup&gt;7-9,18&lt;/sup&gt;</td>
</tr>
<tr>
<td>• Celecoxib, 400 mg orally preoperatively, followed by 200 mg orally every 12 h to POD 7&lt;sup&gt;7,8,18&lt;/sup&gt;</td>
<td>• Reduces pain and opioid consumption&lt;sup&gt;18&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Gabapentin</strong></td>
<td>• Reduces pain and opioid consumption&lt;sup&gt;18&lt;/sup&gt;</td>
</tr>
<tr>
<td>600 mg orally preoperatively, followed by 200 mg 3 times daily through POD 4</td>
<td>• Improves mobility postoperatively&lt;sup&gt;1,2,14-16&lt;/sup&gt;</td>
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<tr>
<td><strong>Dexamethasone</strong></td>
<td>• Reduces pain and opioid use&lt;sup&gt;26&lt;/sup&gt;</td>
</tr>
<tr>
<td>8-10 mg orally night before surgery and 4-20 mg IV at induction&lt;sup&gt;4,11&lt;/sup&gt;</td>
<td>• Decreases PONV&lt;sup&gt;26&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>• Increases ambulation&lt;sup&gt;27&lt;/sup&gt;</td>
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<tr>
<td><strong>As-needed analgesic</strong></td>
<td>Earlier mobilization and shorter LOS&lt;sup&gt;27&lt;/sup&gt;</td>
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<tr>
<td>• Avoid PCA use</td>
<td></td>
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<tr>
<td>• Tramadol, 50 mg orally, with or without oxycodone, 5-10 mg orally&lt;sup&gt;4,11,22&lt;/sup&gt;</td>
<td></td>
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<tr>
<td><strong>Peripheral nerve block</strong></td>
<td>Reduces pain and analgesic requirements, shorter hospital LOS, decreased complications&lt;sup&gt;38-41&lt;/sup&gt;</td>
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<tr>
<td><strong>Intraoperative anesthetic management</strong></td>
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<tr>
<td><strong>Subarachnoid block</strong> (choose 1)</td>
<td>• Opiate-free L2-L5 SAB</td>
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<tr>
<td>• 2-3 mL of 0.25% bupivacaine</td>
<td>• Short- to intermediate-acting in duration to allow for early rehabilitation&lt;sup&gt;4,6,15,46&lt;/sup&gt;</td>
</tr>
<tr>
<td>• 2 mL of 0.5% bupivacaine</td>
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<tr>
<td>• Mepivacaine</td>
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<tr>
<td><strong>Light sedation</strong></td>
<td>• Decreases postoperative analgesia requirements&lt;sup&gt;25,42,46,48&lt;/sup&gt;</td>
</tr>
<tr>
<td>Propofol with or without ketamine&lt;sup&gt;4,9,11&lt;/sup&gt;</td>
<td>• Safe, inexpensive, and easy to perform&lt;sup&gt;11&lt;/sup&gt;</td>
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<tr>
<td><strong>Local infiltration anesthesia</strong></td>
<td></td>
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<tr>
<td>100 mL of 0.125% levobupivacaine with ketorolac and epinephrine</td>
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Abbreviations: COX-2, cyclooxygenase 2; IV, intravenous; LOS, length of stay; PCA, patient-controlled analgesia; POD, postoperative day; PONV, postoperative nausea and vomiting; SAB, subarachnoid block.
review provides the beginning direction for the incorporation of anesthesia management strategies into ERAS protocol development for THA and TKA procedures. Future research is needed to define specific medication regimens and the most beneficial combination of preoperative peripheral nerve blockade.

REFERENCES


39. Dong CC, Dong SL, He FC. Comparison of adductor canal block and...


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The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss off-label use within the article.

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