ANESTHETIC MANAGEMENT IN ERAS PROTOCOLS FOR

TOTAL KNEE AND TOTAL HIP ARTHROPLASTY: AN INTEGRATIVE REVIEW

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Abstract

Aims and objectives: The aim of this integrative review is 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).

Methods: Articles published between 2006 and December 2016 were critically appraised for validity, reliability, and rigor of study.

Results: The administration of non-steroidal anti-inflammatory drugs (NSAIDs), acetaminophen, gabapentinoids, and steroids result in shorter hospital length of stay (LOS) and decreased postoperative pain and opioid consumption. A spinal anesthetic block provides benefits over general anesthesia, such as decreased 30-day mortality rates, hospital LOS, blood loss, and complications in the hospital. The use of peripheral nerve blocks result in lower pain scores, decreased opioid consumption, fewer complications, and shorter hospital LOS.

Conclusion: Perioperative anesthetic management in ERAS protocols for TKA and THA patients should include the administration of acetaminophen, NSAIDs, gabapentinoids, and steroids. 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 knee arthroplasty, total hip arthroplasty

Anesthetic Management in ERAS Protocols for

Total Knee and Total Hip Arthroplasty

Demand for total knee arthroplasty (TKA) and total hip arthroplasty (THA) has increased with society living longer and desiring an active lifestyle. Osteoarthritis affects 15% of the population and is the leading cause of pain and disability in the elderly (Christelis et al., 2015). According to the Agency for Healthcare Research and Quality (2013), there were 732,570 knee arthroplasty and 493,685 hip replacement procedures performed in the United States in 2013. Between the years 2000 and 2010, the number of total hip replacements grew by 92% among those ages 75 and older, and increased by 205% in those aged 45 to 54 (Wolford, Palso, & Bercovitz, 2015). Considering increasing risk factors such as increased age, obesity, and the prevalence of osteoarthritis, the demand for TKA and THA is likely to increase (Christelis et al., 2015).

The purpose of this integrative review was to review current evidence and provide practice recommendations on anesthetic management strategies that support early mobility and improved pain management postoperatively for the patient undergoing elective total knee or hip arthroplasty. Specifically, the questions that guided the review were:

1. What anesthetic management strategies have an impact on postoperative recovery in the elective TKA/THA patient?

2. What are the effects of regional anesthetic peripheral nerve blocks on postoperative recovery in the elective TKA/THA patient?

3. How do different anesthetic modalities affect patients' length of stay (LOS) in the hospital after elective TKA/THA?

Methods

The identification of best current evidence included searches of the following online electronic databases: MEDLINE/PubMed, The Cochrane Library, Academic Search Premier, Google Scholar, and Cumulative Index to Nursing & Allied Health Literature (CINAHL). The following search terms were utilized 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 of Enhanced Recovery, and the Centers for Disease Control and Prevention (CDC) were searched, as well.

The international literature search was limited to English-language articles published between 2006 and 2016. The relevant literature was critically appraised for validity, reliability, and rigor of study. A matrix was utilized for data extraction and categorizing reference, sample, methods, findings, and strengths and limitations.

Results

Enhanced Recovery After Surgery Protocols

Enhanced Recovery After Surgery (ERAS) protocols are increasingly being used to reduce postoperative pain, encourage early ambulation, and reduce LOS in the orthopedic surgical population. Varied definitions exist for ERAS protocols. Christelis et al. (2015, p. 363) defines ERAS programs as "a care package of evidence-based interventions used in a multimodal, integrated clinical care pathway to achieve improved functional outcomes and rapid recovery." An alternative definition, by Winther et al. (2015, p.78), includes "an evidence-based multimodality treatment that reduces convalescence time and improves clinical results, including reduction in morbidity and mortality." For the purpose of this paper, an ERAS protocol is

defined as evidence-based perioperative multimodal management strategies designed to improve clinical outcomes and enable rapid recovery. The key elements of an ERAS protocol for TKA and THA patients emphasize optimal anesthesia and analgesia strategies, fluid restriction, and early postoperative mobilization (Winther et al., 2015).

The concept for an ERAS protocol originated with Danish surgeon Henrik Kehlet in 1997. The original intent was to standardize multimodal interventions to accelerate postoperative recovery in colorectal patients in an effort to decrease hospital LOS and improve patient satisfaction and clinical outcomes. Over the years, these protocols have been tailored for various surgeries and implemented throughout the world in an effort to improve patient outcomes after surgery (White, Houghton-Clemmey, & Marval, 2013).

Orthopedic ERAS protocol goals are to optimize each step of a patient's surgical pathway and allow patients to be active participants in their postoperative recovery. The philosophy behind this protocol is that the establishment of adequate preoperative patient education and an optimized anesthetic and analgesic plan will allow patients to mobilize earlier in the recovery process. This, in turn, will allow for a reduced length of hospital stay with fewer complications (White et al., 2013).

Anesthetic implications within ERAS protocol goals begin preoperatively with a thorough assessment, plan for postoperative pain relief, and patient education. Administration of preemptive analgesics and peripheral nerve blocks are implemented at this time to allow for earlier postoperative mobilization. Intraoperative anesthetic techniques such as a short-acting spinal with light sedation are considered to enable a more rapid recovery. Additional considerations include prophylactic antiemetics and consistent, effective analgesia to support early mobilization.

ERAS protocols are widespread for the colorectal surgical procedures for which they were first developed. However, they remain to be universally adopted for orthopedic surgery. Some suggest that the large volume of TKA and THA procedures and sizeable orthopedic departments create a barrier to the implementation of ERAS protocols throughout multidisciplinary departments (White et al., 2013). While there are 12 published guidelines from the ERAS Society currently available, none are related to orthopedic procedures.

Anesthetic Management and Postoperative Recovery

To facilitate ERAS protocol goals, analgesic strategies should be opioid-sparing and include alternative agents such as acetaminophen and non-steroidal anti-inflammatory drugs (NSAIDs). This strategy will help to facilitate physical therapy and decrease opioid-related side effects (Aasvang, Luna, & Kehlet, 2015). The addition of gabapentinoids and steroids to ERAS protocols have also been found useful. Gabapentinoids decrease postoperative pain and may be a useful adjunct to reduce opioid requirements and their side effects such as nausea, vomiting, prolonged sedation, respiratory depression, hemodynamic instability, ileus, and depression (Christelis et al., 2015; Sarridou et al., 2015). While concern has been raised over steroids increasing surgical site infections, this claim has been refuted with current evidence showing improved outcomes with no higher incidence of infection (Malviya et al., 2011). The perioperative administration of NSAIDs, acetaminophen, gabapentinoids, and steroids are encouraged in all TKA and THA patients, without a contraindication.

Gabapentanoids. Gabapentanoids gabapentin and pregabalin are membrane-stabilizing medications that exhibit antinociceptive effects. Perioperative administration of gabapentin or pregabalin have been found to be effective analgesic adjuvants while also demonstrating sedative qualities and opioid-sparing effects (Imani & Rahimzadel, 2012). Gabapentin is a structural

analog of gamma-aminobutyric acid (Clarke et al., 2010). The primary binding site of gabapentin is thought to be the alpha-2-delta subunit of voltage-dependent calcium channels (Imani & Rahimzadel, 2012). Studies also show a link to central inhibitory GABAergic pathways in the central nervous system (Clarke et al., 2009). Pregabalin is a more potent analog of gabapentin with better bioavailability and decreased side effects (Jain, Jolly, Bholla, Adatia, & Sood, 2012). Perioperative administration of these drugs prove to be effective analgesic adjuvants while also demonstrating sedative qualities and opioid-sparing effects that are useful in ERAS protocols (Imani & Rahimzadel, 2012).

Three studies found perioperative gabapentinoids to provide decreased pain, decreased opioid consumption, and improved mobility postoperatively (Clarke et al, 2009; Clarke et al., 2014; Jain et al., 2012). YaDeau et al. (2015) assessed patients on postoperative day 14 of continued daily pregabalin administration and found no benefit in terms of pain scores, opioid consumption, or mobility. Clarke et al. (2014) found no improvement in pain or physical function beyond postoperative day four of continued gabapentin treatment. These findings provide support for the inclusion of gabapentinoids in ERAS protocols for administration preoperatively through postoperative day four.

Clarke et al. (2009) found patients who received postoperative gabapentin consumed less PCA morphine at 24, 36, and 48 hours postoperative compared to those who received a placebo. These patients also reported significantly less pruritis. Patients who received gabapentin postoperative demonstrated significantly better active knee flexion on postoperative days two and three, with a trend toward better direction on postoperative day four. No significant difference in reports of sedation, nausea, vomiting, or dizziness were found. Limitations of this study include a small sample size of 36 participants. While the study was not double-blinded,

neither the patient nor physiotherapist knew whether the patient was receiving a placebo or gabapentin and at what dosage. The results of this study provide evidence for the use of gabapentin to be continued through postoperative day four to reduce opioid consumption and encourage rehabilitation.

Non-Steroidal Anti-Inflammatory Drugs. Non-steroidal anti-inflammatory drugs (NSAIDs) in either oral or parenteral form are used in the perioperative period to decrease inflammation and improve postoperative analgesia with opioid-sparing effects. When incorporated into a multimodal therapy protocol, four studies reviewed report decreased pain, less opioid consumption, and improved mobility in the postoperative period (Huang et al., 2008; Ittichaikulthol et al., 2010; Jianda et al., 2016; Sarridou et al., 2015).

Celecoxib, a selective cyclooxygenase (COX) 2-inhibitor, inhibits prostaglandin synthesis in the periphery and spinal cord resulting in a decreased postoperative hyperalgesic state. Huang et al. (2008) found patients who received celecoxib 400 mg one hour prior to TKA and celecoxib 200 mg every 12 hours for five days postoperatively reported decreased pain scores at rest at 48 and 72 hours. Those who received celecoxib had increased active range of motion, especially in the first 72 hours postoperative. Finally, opioid consumption was approximately 40% lower in patients who received celecoxib.

Further support for celecoxib was established by Jianda et al. (2016), who also studied the effects of the drug when administered perioperative to patients undergoing TKA. Celecoxib 400 mg was administered within one hour of surgery and 200 mg twice daily beginning 12 hours postoperative and continued throughout their hospital stay. Patients who received celecoxib required less opioids in the first 48 hours and reported less pain with both rest and ambulation for the first postoperative week. These findings support the use of celecoxib administered

preoperatively and continued until discharge.

Parecoxib is a parenteral COX-2 inhibitor and may be given intravenously or intramuscularly. Sarridou et al. (2015) studied postoperative outcomes in TKA patients who received intravenous parecoxib in addition to spinal anesthesia and continuous femoral nerve block. Patients who received parecoxib were found to have decreased opioid consumption and statistically significant lower pain scores at postoperative hours 4, 12, and 24 when compared to a group receiving a placebo.

Ittichaikulthol et al. (2010) compared the outcomes of patients who received either celecoxib, parecoxib, or a placebo one hour before surgery. The celecoxib group received 400 mg orally and the parecoxib group received 40 mg intravenously. Both celecoxib and parecoxib groups had significantly decreased morphine requirements compared to the placebo group at hours 1, 6, 12, and 24 postoperative. The celecoxib group required more morphine than the parecoxib group at hours 1, 6, 12, and 24 hours postoperative. The parecoxib group reported lower pain scores than the celecoxib and placebo groups at hours 1, 6, and 12 postoperative. While the placebo group had a higher sedation score compared to both treatment groups, there was no increase in nausea, vomiting, or pruritus. These findings indicate intravenous parecoxib to be superior in improving pain and decreasing opioid consumption the day of surgery compared to oral celecoxib or placebo.

The literature reviewed is in support of NSAIDs as a tool to decrease inflammation, pain, and narcotic needs in the TKA and THA patient. When selecting which NSAID to administer, providers should also consider the advantages of COX-2 selective inhibitors and intravenous parecoxib over traditional oral NSAIDs. These drugs avoid gastric-related side effects while also helping to avoid opioid-related side effects. Intravenous parecoxib results in a greater reduction

in pain and opioid consumption than oral celecoxib and should be utilized if available.

      Acetaminophen. Acetaminophen is an analgesic and antipyretic agent utilized as an opioid-sparing adjunct. Acetaminophen, available in intravenous, oral, and rectal forms, primarily inhibits central prostaglandins while affecting peripheral COX enzymes to a lesser extent. While the mechanism of action is not fully understood, studies have shown the inhibition of vanillin-1 receptors, activation of the descending modulatory serotonergic pathway, and an increase in levels of endogenous cannabinoids (Johnson et al., 2013; Mallet et al., 2010; Pickering et al., 2006).

      Pain, narcotic consumption, and LOS were reduced in all studies reviewed in which the ERAS protocol included administration of acetaminophen (Auyong et al., 2015; Christelis et al., 2015; White et al., 2013; Winther et al., 2014; Van Egmond, Verburg, & Mathijssen, 2015). All literature reviewed support the inclusion of acetaminophen in ERAS protocols for TKA and THA patients. However, further studies are necessary to determine the most effective route and timing of administration.

      Steroids. An increase in inflammation sensitizes nociceptors which causes increased pain and immune, endothelial, and organ dysfunction. Steroids decrease inflammation and reduce the perioperative neuroendocrine stress response. Reducing preoperative local inflammation may decrease the risk for acute and late persistent postoperative pain. When administered prior to TKA, intravenous methylprednisolone 125 mg showed significant postoperative pain reduction for two days, as well as less fatigue and nausea. Similar but less prominent findings were seen with THA patients (Aasvang, Luna, & Kehlet, 2015).

      Steroids injected directly into a surgical wound, such as with local infiltration anesthesia (LIA), reduce the production of prostaglandins and increase vasodilation, resulting in decreased

postoperative pain (Tran & Schwarzkopf, 2015). There is also strong evidence to support

dexamethasone 4 mg administered intravenously at the time of incision to reduce postoperative

nausea and vomiting (De Oliveira, Castro-Alves, Ahmad, Kendall, & McCarthy, 2013). Lower

incidences of postoperative nausea and vomiting are associated with increased ambulation (Scott

et al., 2012). Some ERAS protocols include higher doses of dexamethasone at 16-20 mg, which

provides antiemetic effects and decreases the inflammatory response of surgery (Winther et al.,

2014). Concern has been raised over the immunosuppressive properties of steroids in higher

doses. Malviya et al. (2011) found no significant difference in return-to-operating room

incidences for wound problems between patients who received dexamethasone 4 mg

intravenously at induction or dexamethasone 10 mg orally the night before surgery with 4 mg

intravenously at induction.

The literature findings support the inclusion of steroids in an ERAS protocol to decrease

inflammation and pain, as well as the incidence of postoperative nausea and vomiting. While

most ERAS protocols reviewed included intravenous dexamethasone 4-10 mg, the anesthetist

should consider administering the appropriate drug, dose, and route to effectively decrease local

and systemic inflammation in the patient undergoing TKA or THA.

Intraoperative Anesthesia Management

Intraoperative anesthetic management options for TKA and THA include general

anesthesia or neuraxial anesthetic block with sedation. Three researchers studied the effects of

general and neuraxial anesthesia for TKA and THA and found improved outcomes with spinal

anesthesia (Basques et al., 2015; Memtsoudis et al., 2014; Sansonnens, Taffe, & Burnand, 2016).

Benefits of neuraxial anesthesia included decreased 30-day mortality rates, decreased hospital

LOS, decreased blood loss, and decreased complications in the hospital (Memtsoudis et al.,

2014).   Regional anesthesia offers a lower risk of deep vein thrombosis, pulmonary embolus, myocardial infarction, pneumonia, and delirium (Starks, Wainwright, Lewis, Lloyd, & Middleton, 2014). The implications of these findings for ERAS protocol development are important. By utilizing a standardized ERAS protocol that includes a spinal anesthetic with regional block and sedation as needed, hospital LOS and risks of general anesthesia are reduced.

After reviewing numerous ERAS protocols, a clear trend toward the use of spinal anesthesia for intraoperative management has emerged. Spinal anesthesia offers the benefit of potentially avoiding airway manipulation, decreased blood loss and need for transfusion, decreased metabolic stress response, and more. In order to provide adequate non-opioid analgesia in the immediate postoperative period, spinal anesthesia should be especially considered in all THA patients or any TKA patient who is not a candidate for or refuses a peripheral nerve block.

Postoperative Pain Management and Recovery

To facilitate ERAS protocols for THA and TKA, postoperative pain management must be included. Peripheral nerve blocks play a key role in postoperative pain control. Peripheral nerve blocks may be administered preoperatively or postoperatively to provide postoperative pain relief following TKA. Patients who receive a peripheral nerve block as part of their multimodal analgesic plan have lower pain scores, decreased opioid requirements, fewer complications such as urinary retention or ileus, and a shorter hospital LOS (Hebl et al., 2008). The anesthesia provider should consider the merits of single-shot or continuous-catheter femoral nerve blocks (FNB), sciatic nerve blocks (SNB), adductor canal blocks (ACB), and LIA and their implications for ERAS protocols. The literature does not provide strong evidence to suggest the use of one of

these methods explicitly over the others, but it does strongly support the use of performing at least one of these postoperative pain management strategies.

Adductor canal block. The adductor canal is the potential space formed by the sartorius muscle, medial femoral muscle, and adductor muscles (Zhang, Hu, Tao, Liu, & Wang, 2014). Adductor canal blocks provide local anesthetic to the saphenous nerve, the largest cutaneous sensory branch of the femoral nerve. The saphenous nerve supplies 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 (Grevstad, Mathiesen, Lind, & Dahl, 2014).

Improved postoperative mobility and decreased narcotic consumption has been found with ACB following TKA (Auyong et al, 2015; Grevstad et al., 2014; Mudumbai et al, 2014; Perlas et al., 2013). Patients who receive ACB are more likely to have shorter hospital LOS and to be discharged home rather than a rehabilitation facility (Auyong et al., 2015; Perlas et al., 2013). Alternatively, three studies found no statistically significant difference in postoperative analgesia between FNB or LIA compared with ACB (Dong, Dong, & He, 2014; Mudumbai et al., 2014; Zhang et al., 2014). Because numerous studies demonstrate its ability to improve postoperative mobility while providing safe and adequate analgesia, ACB should be included in ERAS protocols if appropriate to decrease narcotic use, improve the rehabilitation process, and shorten hospital LOS.

Femoral nerve block. Femoral nerve blocks are commonly used peripheral nerve blocks for postoperative analgesia management with TKA procedures. A disadvantage of a FNB is the motor loss of the quadriceps muscles, which the anesthetist avoids in a successful ACB. Three

studies reviewed have found strong evidence FNB provides improved analgesia and decreased

opioid consumption (Chan et al., 2014; Ozen et al., 2006; Sahin et al., 2014).

Sahin, Korkmaz, Sahin, and Atalan (2014) studied outcomes of patients who received

FNB with local anesthesia compared to those who received a saline placebo via the same FNB

method. Those who received a FNB anesthetic had significantly lower pain and morphine

requirements. These findings are supported by Chan, Fransen, Parker, Assam, and Chua (2014),

who found patients who received FNB had lower pain scores, decreased opioid consumption,

decreased nausea and vomiting, increased range of motion, and higher patient satisfaction

compared to patients who received intravenous morphine patient-controlled analgesia (PCA)

with no peripheral nerve block.

Ozen, Inan, Tumer, Uyar, and Baltaci (2006) studied the merits of a single-shot 3-in-1

FNB. This variation on the FNB aims to block three nerves with one injection: the femoral nerve,

lateral cutaneous nerve of the thigh, and the obturator nerve. Local anesthetic is injected at the

femoral nerve and manipulated to spread proximally to block the other two nerves. Patients who

received a 3-in-1 FNB of 40 cc of ropivacaine 0.375% had better pain relief, less morphine

consumption, and fewer side effects (nausea, vomiting, and hypotension) than those who

received no block.

In contrast, two studies found results conflicting with those of the prior discussed studies

(Beaupre et al., 2012; Ng et al., 2012). Beaupre, Johnston, Dieleman, and Tsui (2012) found

mobility, pain, opioid consumption, and hospital LOS were all similar between patients who

received morphine PCA and those who received the PCA and FNB. Ng, Chiu, Yan, and Ng

(2012) also compared outcomes between patients who received a continuous FNB and those who

received intravenous morphine PCA. The study found non-significant differences in pain, overall

satisfaction, and hospital LOS. However, patients in the PCA-only group experienced significantly more opioid-related side effects including nausea, vomiting, dizziness, and pruritis. The sum of these findings support the use of FNB in ERAS protocols to improve postoperative pain and mobility, as well as decrease opioid consumption and incidence of nausea, vomiting, hypotension, dizziness, and pruritis.

Femoral nerve blocks may be performed as a single-shot injection of local anesthesia or with continuous infusion via catheter. Chan et al. (2014) found that within the first 24 hours postoperative, patients with continuous femoral nerve blocks (CFNB) reported less pain and opioid consumption compared to those who received single-shot femoral nerve blocks (SSFNB). One disadvantage of a CFNB is illustrated in a meta-analysis by Johnson, Kopp, Hebl, Erwin, and Mantilla (2013) which found that patients who receive a CFNB may be at increased risk for falls compared to SSFNB. However, the attributable risk for falls due to continuous blockade fell within the expected probability of postoperative falls for patients undergoing orthopedic surgery. While Johnson et al. (2013) reported a 2% fall rate in TKA patients who received FNB, Memtsoudis et al. (2014) reported the fall risk after TKA to be 1.6%, regardless of peripheral nerve blockade.

Sciatic nerve block. Nociception of the knee joint involves both femoral and sciatic nerves (Nakagawa et al., 2016). A FNB alone will not provide pain relief in the posterior portion of the knee. A SNB provides more thorough analgesia coverage when administered to patients receiving FNB for TKA postoperative pain (Spangehl et al., 2014).

Wegener et al. (2011) studied outcomes in patients who received one of three types of postoperative pain management strategies: PCA via FNB alone, PCA via FNB with continuous SNB, or PCA via FNB with single-shot SNB. No difference was found amongst the three groups

in knee function, local anesthetic consumption, nausea, vomiting, or LOS. However, patients who were supplemented with a continuous SNB consumed significantly less opioids and reported significantly less pain until postoperative day two. These findings suggest superior pain control and decreased narcotic needs when a FNB is supplemented with a continuous SNB.

In contrast, two studies did not find strong evidence to support the use of SNB as a supplement to FNB in patients undergoing TKA (Nagafuchi et al., 2015; Paul, 2010). Paul et al. (2010) found patients who received a SSFNB to have similar opioid consumption and pain scores as those who received SSFNB with SNB supplementation. Nagafuchi et al. (2015) performed a randomized control trial including 34 patients undergoing TKA. The 17 patients who received SNB with FNB reported lower pain scores during the 3-12 hour postoperative period compared to 17 patients who received LIA with FNB. However, 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 and the LIA mixture utilized. The LIA mixture of ropivacaine and epinephrine did not include ketorolac or corticosteroids, which have been proven to provide effective analgesia. 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 postoperative TKA and THA patients.

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 within the posterior capsule retinacular layer and subcutaneous tissues. The anesthetic mixture often contains a combination of local anesthetic, ketorolac, and steroids. LIA is typically performed by the surgeon at the conclusion of the procedure. While peripheral nerve blocks

provide effective pain management, their disadvantages include slower recovery of lower extremity function, time required to perform, complications, and cost (Spangehl et al., 2015). Benefits of LIA include its ease to perform, lower cost, and avoidance of potential complications associated with peripheral nerve blocks (Affas et al., 2011).

Eight studies were reviewed that compared LIA to placebo or FNB and demonstrated conflicting results. Three of the studies found patients who received LIA to have decreased supplemental analgesic requirements postoperative (Essving et al., 2009; Nakagawa et al., 2016; Niemelainen et al., 2014). Four of the eight articles reviewed found similar outcomes in patients who received LIA and those who received FNB with or without SNB (Affas et al., 2011; Nagafuchi et al., 2015; Spangehl et al., 2014; Uesugi et al., 2014). One randomized control trial found patients who received LIA required more narcotic and had decreased mobility postoperative than those who received a continuous FNB (Carli et al., 2010). Of note, one article found patients who received a CFNB with single-shot SNB only consumed less narcotic compared to LIA on postoperative day zero, with no significant difference thereafter (Spangehl et al., 2014).

Nakagawa et al. (2016) provided the only study to support the use of LIA over FNB. The 66 subjects included in this study received either LIA or FNB depending on whether their surgery was performed on an even- or odd-numbered day. Patients who received LIA were 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 into the posterior articular capsule of the knee joint, patellar retinaculum, subcutaneous tissue, and pes anserinus just prior to cement fixation of the implant. In the second group, ropivacaine 150 mg was administered as a single-shot FNB upon the completion of the procedure using echo

guidance and an electric stimulator. While pain scores between the two groups remained similar through postoperative day five, the amount of rescue analgesics consumed was significantly lower in the LIA group. Similar results were found between the two groups in terms of postoperative mobility and time to discharge. One limitation of this study is its small sample size. Further research, including randomized-control trials with large samples, is needed in order to recommend the use of LIA over FNB as a means to decrease rescue analgesic requirements.

There is evidence to support the use of LIA over a saline placebo but not necessarily in place of a FNB with SNB (Essving et al., 2009; Niemelainen et al., 2014). Further research is needed to determine the optimal role for LIA in ERAS protocols for TKA and THA patients.

Intravenous narcotics and patient-controlled analgesia. Opioids are useful in treating acute postoperative pain associated with rehabilitation (Rosero & Joshi, 2014). The anesthesia provider has the ability to decrease pain associated with rehabilitation and reduce the need for narcotics through the use of preemptive analgesics, peripheral nerve blocks, and local infiltration anesthesia in the perioperative phase of treatment. In addition to helping avoid undesirable side effects, the avoidance of PCA results in earlier mobilization and shorter LOS (Scott et al., 2012). Because ERAS protocol goals are to enable early postoperative mobilization and decrease hospital LOS, all opioid-sparing anesthetic management strategies should be considered in an ERAS protocol.

Discussion

This integrative literature review indicates a trend toward the 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 the use of ERAS protocols in this population may improve postoperative pain, enable earlier rehabilitation, and decrease hospital LOS. Despite this, many

variations on the protocol exist. In order to standardize a specific ERAS protocol for THA and TKA additional research is needed.

Gaps in Knowledge

While literature supports the use of adjunctive medications to provide analgesia and decrease opioid consumption, the literature is inconclusive on optimal drug, dosage, and number of days to administer postoperatively. In addition, further research is needed to determine the most effective route of administration and the number of days acetaminophen should be continued postoperatively. Additional research is also warranted to validate the use of intravenous parecoxib over oral COX-2 inhibitors or other NSAIDs. Research is also necessary to determine the optimal type and dosage of intravenous steroids that provides the most benefit and the least side effects.

The studies reviewed support the use of ACB, FNB, and LIA as opposed to narcotics alone for postoperative pain control. However, further research is necessary to determine whether ACB, FNB, LIA or a combination of methods provide superior analgesia, improved postoperative mobility, and shorter hospital LOS.

Implications and Recommendations for Practice

Numerous anesthetic management strategies impact postoperative recovery for the TKA and THA patient. Uncontrolled pain is a limiting factor for early postoperative mobilization (Winther et al., 2015). Adjunct medications that improve pain and mobility while decreasing opioid-related side effects include gabapentinoids, NSAIDs, acetaminophen, and steroids. The use of peripheral nerve blocks and LIA have been further implicated in decreasing pain and narcotic consumption while improving early mobilization. Recommendations for practice to addressanesthetic management strategies and their impact on postoperative recovery include:

- Preoperative administration of NSAIDs, acetaminophen, and gabapentinoids continued postoperative for a minimum of four days

- Placement of peripheral nerve blocks, such as ACB or FNB supplemented with SNB or LIA, for the TKA patient.

- Decreased opioid use to avoid undesirable opioid-related side effects

Studies have found peripheral nerve blocks play an important role in improving postoperative recovery in the patient undergoing TKA and THA. According to Hebl et al., (2008), patients who received a peripheral nerve block reported lower pain scores, decreased analgesia requirements, and experienced fewer complications. Peripheral nerve blocks provide pain relief during rehabilitation and also help to avoid troublesome side effects of opioids that hinder mobility, such as 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:

- Administering a low-volume ACB to avoid local anesthetic traveling cephalad and blocking the quadriceps muscles, or

- Administering a FNB supplemented with either SNB or LIA

- Utilizing a continuous infusion of local anesthetic via catheter for longer-lasting postoperative pain control

The literature shows many factors affect patients' hospital LOS. Uncontrolled pain, dizziness, and general weakness are main causes resulting in increased LOS (Winther et al., 2015). The anesthetic strategies discussed in this review help to control pain and dizziness, often

associated with opioid use. Utilization of ERAS protocols for TKA and THA patients has

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 particular importance in this higher risk

patient population in order to reduce patient's LOS. Recommendations for practice to address

anesthetic modalities and their impact on hospital LOS include:

- Perioperative administration of acetaminophen and other opioid-sparing analgesics

- Utilization of spinal anesthesia with light sedation as the intraoperative anesthetic

- Administration of peripheral nerve blocks

- Avoidance of postoperative PCA use

Conclusion

The purpose of this integrative literature review was to review and synthesize current

evidence to provide practice recommendations for anesthetic management in ERAS protocols for

TKA and THA procedures. Specifically, the review focused on anesthetic management strategies

that support early mobility and improved postoperative pain management for the patient

undergoing elective TKA or THA.

Limitations of this review include the strength of available research on certain anesthetic

and analgesic strategies. Ideally, all literature reviewed would have a large number of

participants undergoing randomized control trials to provide strong evidence. Another limitation

stems from the wide variability between articles in utilizing different dosages and times of

administration for the same drug. To provide stronger evidence, these studies should be

replicated with equal drug dosage and times of administration to prove reproducibility and credibility of findings.

Based on this integrative review it appears that improvements in pain, narcotic consumption, mobility, and hospital LOS are to be expected in patients undergoing TKA and THA procedures. However, conclusive evidence is necessary in order to develop a universally adopted ERAS protocol that clearly impacts postoperative patient outcomes. Therefore, the author recommends further research on anesthesia and analgesia modalities within ERAS protocols for TKA and THA patients.

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