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Author Note

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Abstract

Hip arthroplasty, a frequently performed orthopedic surgery, is gaining popularity. However, postoperative pain, opioid utilization, nausea, and vomiting are common side effects associated with this procedure. Perioperative analgesic management for hip arthroplasty varies among providers, leading to possible inadequate pain management. The goal of this scholarly project is to provide an optimal perioperative analgesic guideline to decrease postoperative pain, opioid consumption, nausea, and vomiting in adults undergoing elective hip arthroplasty utilizing evidence-based practice. The evidence suggests that a multimodal analgesic approach incorporating multiple drug classes and types of anesthesia is most effective in reducing adverse postoperative outcomes. Using the Johns Hopkins Evidence-Based Practice Model's process of practice, evaluation, and translation, project managers developed a plan to implement evidence-based practice guidelines over a year at an urban outpatient surgical center specializing in elective hip arthroplasties. The project's metrics included a visual numerical rating scale, total morphine milliequivalents utilization, and postoperative nausea and vomiting intensity scale. Chi-square and t-tests are used for outcome analysis with a p-value of less than 0.05 considered significant.

Keywords: evidence-based practice, morphine milliequivalents, pain score, post-anesthesia care unit, post-operative nausea and vomiting, total hip arthroplasty

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Introduction

Total Hip Arthroplasty (THA) is a surgical procedure that is being more utilized due to its effectiveness in treating hip pathologies and improving patients' quality of life. Due to advanced surgical techniques and cutting-edge technology, THA procedures have significantly increased in the United States (U.S.). Orthopedic surgeons in the U.S. perform over 450,000 THA procedures annually, projected to increase by 70% in the coming years (Foran & Fischer, 2020; Panzenbeck et al., 2021). Most patients undergoing hip arthroplasty are adults over 18 years, with peak incidence between ages 50 to 80 years (Foran & Fischer, 2020). During this invasive process, damaged or deteriorated hip parts are removed and replaced to enhance functional mobility (National Institutes of Health, 2020). Although hip arthroplasty has multiple benefits, it is often accompanied by intense postoperative pain, which impedes the patient's recovery process. Managing postoperative pain is crucial to ensure a smooth recovery and reduce the need for opioid usage. A known side effect of opioid consumption that further hinders the recovery process is postoperative nausea and vomiting (PONV).

Orthopedic surgeons and anesthesia providers should collaborate to create an efficient analgesic management plan for patients undergoing hip arthroplasty. The selection of the appropriate analgesic regimen should be based on evidence-based practice (EBP) research available in current literature rather than the personal preferences of the medical provider. With the increasing prevalence of THA surgery, it is crucial to establish an optimal guideline for managing postoperative pain and reducing opioid usage.

To determine the optimal analgesic method, comparison of the traditional analgesic approach (e.g., provider preference) with a multimodal anesthetic and analgesic guideline during the perioperative period is essential. After hip arthroplasty, patients experience severe pain during the first

24 hours, with the highest intensity during the first two hours postoperatively and gradually decreasing at hours four to eight (Panzenbeck et al., 2021). Therefore, an EBP project should include the immediate postoperative period, such as time in the post-anesthesia care unit (PACU), as the time frame for measuring postoperative outcomes. Since THA can cause severe pain, significant opioid consumption, and PONV, the project must consider these as intervention outcomes. The goal of this EBP project is to identify optimal perioperative analgesic guidelines for the adult undergoing elective THA, utilizing current evidence in the literature to assist in the reduction of postoperative pain, opioid consumption, and PONV.

Background

Pain

There are various sources of pain, especially during surgeries involving the hip. Pain can arise from either nociceptive or neuropathic pain receptors. Nociceptive pain is typically associated with inflammation or trauma to soft tissues, muscles, and joints, while neuropathic pain results from injury to the nerve (Slater & Davies, 2023). THA often causes severe postoperative pain due to innervation, soft tissue inflammation, surgical traction, and surrounding musculature manipulation (Cai et al., 2019; Kolaczko et al., 2019; Paul et al., 2021). According to an observational cohort study, nearly half of the patients (47%) who undergo THA experience moderate to severe postoperative pain (Wylde et al., 2011). Postoperative pain can negatively impact a patient's recovery by hindering ambulation, prolonging hospital stay, and even leading to cognitive decline (Wylde et al., 2011). Furthermore, if not appropriately managed, acute postoperative pain can increase the risk of chronic pain in patients who have undergone joint surgery (Wylde et al., 2011). In a study evaluating postoperative pain six months after hip arthroplasty, researchers found that patients who experienced chronic pain had decreased functionality and quality of life, as well as increased psychological distress (Erlenwein et al., 2017).

Implementing an EBP analgesic guideline during THA is vital to enhancing patient outcomes. Ideally, adequate pain control should begin before the surgery and continue throughout the recovery period. Effective pain management is a crucial aspect of THA due to its potentially long-lasting implications for patient health and well-being. To optimize patient outcomes, healthcare providers must adopt appropriate pain control measures that commence before the surgery and continue throughout the recovery process. By implementing these measures, patients can experience reduced discomfort, faster recovery times, and improved overall healing.

Opioid Consumption

THA surgery is often associated with high levels of opioid consumption after the surgery. In 2019, orthopedic surgeons ranked third among opioid prescribers (Newman, 2019). Although opioids are effective in managing moderate to severe postoperative pain, these medications come with a high risk of abuse that can lead to severe side effects such as respiratory depression, dizziness, constipation, nausea, vomiting, and decreased mobility, which can hinder the patient's recovery process (Coit & Shannon, 2019). THA patients are at risk of prolonged opioid exposure due to severe pain associated with surgery and the common practice of opioid prescribing by surgeons. Prolonged opioid exposure increases tolerance, hyperalgesia, and opioid-related side effects in THA patients. (Inacio et al., 2015). A study on opioid usage in THA patients found that 3-25% of patients continued opioid usage for up to five years post-surgery (Singh & Lewallen, 2010; Valdes et al., 2015). Misuse of opioids can also lead to being used for off-label indications for sleep and anxiety, extending beyond postoperative pain management. Given the current opioid crisis and efforts to decrease opioid utilization, it is essential to consider the benefits and risks of opioid use and explore alternative pain management options.

Postoperative Nausea and Vomiting

One significant adverse effect of opioid use is nausea and vomiting (Lim et al., 2016). Approximately 25 to 30% of all surgery patients experience PONV (Kovac, 2013). However, individuals

who undergo THA have a greater likelihood of experiencing PONV, with rates ranging from 20% to 83% (Wang et al., 2020). Depending on the severity, PONV can result in dehydration, decreased mobilization, aspiration pneumonia, stress on sutures, patient anxiety, prolonged hospital stay, and reduced patient satisfaction (Sansonnens et al., 2016; Lim et al., 2016). Thus, adverse effects from PONV may complicate the patient's recovery process. Given the adverse effects of opioids and the current opioid crisis, creating a comprehensive pain management plan is imperative to reduce opioid utilization among patients undergoing hip arthroplasty.

Significance to the Profession

Anesthesiologists and Certified Registered Nurse Anesthetists (CRNAs) are the primary pain management providers during the perioperative period. CRNAs, however, are increasingly becoming the anesthesia providers involved in direct patient care (American Association of Nurse Anesthesiology, 2023). A priority goal of an anesthesia provider is to provide adequate analgesia while mitigating potential adverse effects. Maintaining adequate analgesia with THA patients is challenging for anesthesia providers due to the severity of pain and the desire to decrease opioid use in practice. With the increase in adults undergoing THA procedures, CRNAs must have adequate knowledge to manage pain effectively.

In clinical practice, the anesthesia provider determines the perioperative regimen for pain management for patients undergoing hip arthroplasty. Historically, management techniques utilizing opioids as the primary analgesic agent have effectively controlled pain within this patient population. However, current EBP suggests that opioid adjuncts are an appropriate alternative for pain management, demonstrating a comparable or increased efficacy in pain reduction and lower risk for adverse side effects. Opioid adjuncts are additional analgesics that help reduce the utilization of opioids. Although The American Society of Anesthesiologists suggests a multimodal approach to managing pain, the anesthesia provider's expertise, opinion, and comfort with a particular method ultimately impact the

choice of pain relief for THA procedures (Anger et al., 2021; Paul et al., 2021). The issue with current practice is the variability among providers' preferred pain relief methods, and CRNAs may implement analgesic adjuncts based on personal preference that current EBP finds inferior to newer analgesic interventions. This practice exposes patients to unnecessary treatment side effects while increasing hospital resource utilization and treatment costs. Therefore, relying solely on personal preference can lead to ineffective pain management, inadequate pain relief, and patient addiction.

Patients who undergo THA depend on the anesthesia provider to effectively manage pain before, during, and after the surgery to ensure a seamless recovery process. CRNAs, as the primary anesthesia providers, must implement and advocate for an optimal analgesic regimen based on current EBP recommendations. Utilizing current EBP to formulate an optimal analgesic regimen instead of provider preference is crucial to ensure safe and effective treatment with THA procedures.

Problem Statement

An optimal anesthetic and analgesic plan should minimize opioid consumption while providing adequate pain relief. The American Society of Anesthesiologists recommends utilizing a multimodal approach when providing opioid-sparing analgesia (Paul et al., 2021). To ensure complete analgesic coverage in THA patients, a multimodal approach incorporating analgesic adjuncts with differing mechanisms of action is crucial to block the pain pathways elicited during the procedure. Studies identify opioid-sparing drugs (e.g., non-steroidal anti-inflammatory drugs, cyclooxygenase-2 inhibitors, acetaminophen, glucocorticoids, and gabapentinoids) and various anesthesia techniques (e.g., regional, neuraxial, and general) as an effective anesthetic and analgesic adjuncts in THA patients (Anger et al., 2021; Panzenbeck et al., 2021). Opioid-sparing enhanced recovery after surgery (ERAS) and postoperative pain management recommendations for THA patients have limitations; these recommendations focus on a single intervention, a specific perioperative period, or lack current EBP findings. The administration of analgesics for THA continues to be a matter of clinical judgment. While

there are suggested medications, the ultimate determination on which to use is at the provider's discretion. Healthcare providers' preferences for pain management vary greatly. Varying pain management regimens can result in unreliable or insufficient pain coverage, opioid utilization, and failure to incorporate EBP recommendations (Anger et al., 2021; Qi et al., 2020). Inadequate analgesia coverage postoperatively results in delayed patient recovery, limited mobility, adverse events, extended hospital stays, higher costs for the patient, and poor patient satisfaction (Anger et al., 2021; Kolaczko et al., 2020). An adequate analgesic regimen includes the entire perioperative period (e.g., preoperative, intraoperative, postoperative), multimodal drug approach, and is congruent with EBP. Therefore, an EBP project is needed to identify optimal opioid-sparing pain guidelines for arthroplasty patients during the perioperative period.

PICOT Question

To formulate an EBP project question, the author utilizes the person (P), intervention (I), comparison (C), outcome (O), and time (T) format, which is also known as the PICOT question. The following PICO(T) question is guiding the scholarly project: In adult patients undergoing hip arthroplasty (P), how would the development and implementation of perioperative anesthetic guidelines (I) versus traditional provider practice (C) affect postoperative pain scores, opioid consumption, and PONV (O) during the initial recovery period in PACU (T)?

Project Objectives

Inconsistency among anesthesia providers' preference for perioperative analgesic management of THA predisposes patients to inadequate analgesia and associated adverse effects such as increased postoperative pain, opioid consumption, and PONV. Developing an EBP project for the analgesic management of THA patients is essential to guide the care CRNAs provide. In order to develop optimal EBP guidelines, the process involves the following: searching, reviewing, and analyzing literature; the findings will then be translated into implementation guidelines and criteria to evaluate the EBP process

(Dang et al., 2022; Moran et al., 2020). The EBP project will analyze the effectiveness of implementing analgesic guidelines compared to traditional provider practice on postoperative outcomes, with the outcome of developing optimal perioperative analgesic guidelines for adult THA patients.

Forming objectives is necessary to facilitate the development of an EBP project. Objectives are precisely related to the problem and describe the project's overall goals (Moran et al., 2020). Therefore, objectives are needed to guide the development of analgesia recommendations for THA patients. The objectives of the EBP doctoral project are as follows:

- Review literature to formulate EBP perioperative analgesic guidelines for adult patients undergoing hip arthroplasty.
- Develop a comprehensive plan to facilitate the implementation of the hip arthroplasty perioperative analgesic guidelines.
- Develop a comprehensive plan to monitor and measure outcomes—pain score, opioid consumption, and PONV—during the immediate postoperative period.
- Develop a comprehensive plan to adjust the hip arthroplasty perioperative analgesic guidelines if the outcomes are less than desirable.

Along with employing a rigorous EBP approach, the project objectives will aid in developing an optimal analgesic guideline CRNAs may employ perioperatively for THA patients. Implementing analgesia guidelines will augment CRNA knowledge, thus enhancing the quality of care provided and improving patient outcomes.

Literature Search

Literature Review

Between October 2021 and June 2023, a comprehensive literature review was conducted on adult THA surgeries to investigate the effects of perioperative analgesics on PONV, pain scores, and opioid usage in THA patients. For the literature review, the following databases were searched: Google

Scholar, Otterbein University Courtright Memorial Library's OneSearch, PubMed, and PubMed Central. The following terms and phrases were used: "adult", "analgesia", "anesthesia", "hip arthroplasty", "intraoperative", "multimodal approach", "perioperative", "preoperative", "postoperative", "postoperative pain", "postoperative nausea and vomiting", and "postoperative opioid consumption". The primary literature search used a publication date filter from 2013 to 2023 and Boolean operators "AND" and "OR"; the initial search yielded 8,614 articles. Further addition of the filters: meta-analysis, randomized controlled study, systematic review, English language, and free full-text article access yielded 329 articles. As the project focuses on adult patients, the search was refined by adding the phrases "NOT elderly" and "NOT pediatric", resulting in 108 articles for review.

In order to determine the relevance of the article, specific inclusion criteria were used: adults 18 years and older who underwent THA surgery, received analgesic or anesthetic interventions during the perioperative period and had postoperative outcomes that evaluated pain score, opioid consumption, and PONV. Articles that lacked a perioperative analgesic intervention and did not measure at least one postoperative outcome (e.g., pain score, opioid consumption, or PONV) within the initial 24 to 48 hours following surgery were excluded. Furthermore, articles based on cadavers or animals and duplicates of existing articles were omitted. The literature review yielded 22 relevant articles, including eight meta-analyses and systematic reviews, six meta-analyses, four randomized controlled trials (RCT), one randomized controlled study, one retrospective cohort study, one retrospective chart review, and one observational study.

Strengths and Limitations

In the subsequent literature analysis, 12 articles were deemed high quality after utilizing the JHEBP Research Evidence Appraisal Tool, while seven were considered moderate quality. Utilizing moderate to high-quality articles and incorporating recent studies conducted within the past decade both contributed to the robustness of this scholarly DNP project. The articles included have several

limitations, such as the variability in study dosages, intervention timing, surgical approaches, anesthetic techniques, and sample size. Furthermore, the literature review included three articles that are of lower quality.

Literature Analysis

A review table was prepared to help analyze the literature obtained from the 22 articles found (See Appendix A). The level and quality of evidence were determined using the Johns Hopkins Evidence-Based Practice Hierarchy of Evidence tool (See Appendix B). Out of the 22 included articles, only 19 discussed statistical significance. Among these 19 articles, outcomes with a P value less than 0.05 were considered statistically significant in 18 articles. The remaining articles classified outcomes as statistically significant if the P value was less than 0.1 and the I2 statistic value was less than 50%. The sections below discuss the findings from the literature search and analysis of analgesic and anesthetic interventions on postoperative pain, opioid consumption, and PONV.

Primary Anesthesia

Pain and Opioid Consumption

Spinal anesthesia provides superior postoperative pain control and reduced opioid utilization compared to general anesthesia in THA patients (Kelly et al., 2021; Liang et al., 2017; Yap et al., 2022). A randomized controlled study found THA patients who underwent general anesthesia (e.g., midazolam, propofol, fentanyl, and vecuronium) experienced significantly higher postoperative pain scores compared to patients who received spinal-epidural anesthesia (e.g., 0.5% hyperbaric bupivacaine [spinal injection] and 0.25% bupivacaine with clonidine [epidural injection]). Similarly, Kelly et al. (2021) retrospective chart review found that THA patients who received spinal anesthesia (e.g., lumbar puncture with hyperbaric bupivacaine and intrathecal fentanyl at provider discretion) encountered significantly reduced postoperative pain and morphine equivalents in the PACU compared to patients who received general anesthesia (e.g., inhalational agents with intraoperative opioids). Yap et al. (2022)

retrospective cohort study found that general anesthesia significantly increased postoperative pain visual analog scale (VAS) scores and morphine equivalents compared to spinal anesthesia in patients undergoing joint arthroplasty.

Postoperative Nausea and Vomiting

Spinal anesthesia produces favorable PONV outcomes compared to general anesthesia (Sansonnens et al., 2016; Yap et al., 2022). In a study observing 3922 patients, Sansonnens et al. (2016) discovered that general anesthesia led to higher rates of PONV than spinal anesthesia in THA. In addition, Yap et al. (2022) retrospective cohort study found that joint arthroplasty patients who received general anesthesia experienced significantly higher PONV rates during PACU stay. It is important to note that both studies mentioned are classified as low quality; therefore, recommendations should be cautiously made based on their findings.

Regional Anesthesia

Pain and Opioid Consumption

Utilizing regional anesthesia techniques as analgesic adjuncts for THA patients produces significantly lower postoperative pain scores and opioid consumption (Fillingham et al., 2022; Huda & Ghafoor, 2022; Jimenez-Almonte et al., 2016; Ma et al., 2019). According to two meta-analyses, perioperative periarticular infiltration in THA significantly reduces postoperative pain scores and opioid consumption within the first 24 hours postoperatively compared to placebo (Jimenes-Almonte et al., 2016; Ma et al., 2019). Jimenez-Almonte et al. (2016) meta-analysis further compared infiltration technique to peripheral nerve blocks (e.g., fascia iliac, femoral, psoas compartment, 3 in 1, and continuous infusion) and found no significant differences among postoperative pain or opioid consumption; thus, providing evidence of the infiltration technique's equivalency to peripheral nerve blocks. Fillingham et al. (2022) meta-analyses evaluating the efficacy of peripheral nerve blocks (e.g., fascia iliac, lumbar plexus, quadratus lumborum) to placebo in THA patients found that peripheral nerve

blocks led to significantly lower postoperative pain scores and morphine consumption. While no significant differences in pain or opioid usage were found between the peripheral nerve blocks (fascia iliac block v. lumbar plexus block; fascia iliac block v. periarticular infiltration), the fascial iliac block incorporates fewer risks and skill level compared to the lumbar plexus and quadratus lumborum block (Fillingham et al., 2022). Huda & Ghafoor (2022) meta-analysis found that the periscapular nerve group (PENG) block provided significantly longer times to the first analgesia request and opioid consumption during the first 24 hours postoperatively compared to the placebo and the fascia iliac, femoral, and lumbar plexus blocks.

Postoperative Nausea and Vomiting

Regional anesthesia does not significantly reduce PONV during THA (Huda & Ghafoor, 2022; Ma et al., 2019). A meta-analysis evaluating the efficacy of the PENG block for THA did not significantly affect PONV rates compared to placebo or other peripheral nerve block techniques [e.g., fascia iliac, femoral, lumbar plexus] (Huda and Ghafoor, 2022). Another meta-analysis regarding periarticular infiltration in THA produced no effect on PONV compared to the control group (Ma et al., 2019).

Cyclooxygenase-2 Inhibitors

Pain and Opioid Consumption

Cyclooxygenase-2 inhibitors (COX2-I), a selective non-steroidal anti-inflammatory drug (NSAID), significantly reduce postoperative pain scores and morphine consumption when administered perioperatively to patients undergoing THA (Jiang et al., 2020; Kuang et al., 2016; Xia et al., 2019). Postoperative pain scores were substantially lower at rest and with ambulation among patients who received COX2-I perioperatively for THA compared to a placebo (Jiang et al., 2020). Kuang et al. (2016) meta-analysis produced similar results when comparing perioperative administration of celecoxib 200 to 400 milligrams (mg) to placebo in patients undergoing THA. A double-blinded study found that parecoxib 40 mg before incision and every 12 hours postoperatively significantly reduced pain scores

and morphine consumption compared to the control group (e.g., placebo or normal saline) in THA patients (Xia et al., 2019).

Postoperative Nausea and Vomiting

The effectiveness of perioperative COX2-I in reducing PONV shows variation across different studies. According to a meta-analysis conducted by Xia et al. in 2019, patients who received a placebo or normal saline (e.g., control group) during THA surgery had higher PONV than those who received COX2-I parecoxib; the difference was statistically significant. In contrast, Kuang et al. (2016) meta-analysis found no statistically significant difference in PONV between patients who received COX2-I celecoxib or a placebo. Therefore, the effect of COX2-I on PONV is indeterminate. Selective COX2-I exhibits fewer antiplatelet effects than non-selective NSAIDs (Xia et al., 2019). Therefore, selective COX2-I has the added benefit of reducing the risk of bleeding associated with surgery.

Acetaminophen

Pain and Opioid Consumption

While Guo et al. (2018) meta-analysis evaluating acetaminophen and paracetamol in THA patients found no significant difference in postoperative pain scores compared to the control group, Liang et al. (2022) meta-analysis found a statistically significant reduction in pain scores utilizing a VAS during the hours 0-72 postoperatively with parenteral administration of 1000 mg acetaminophen. Acetaminophen (e.g., 1000 mg to 2000 mg) significantly reduces opioid consumption when administered perioperatively for patients undergoing THA in two meta-analyses (Guo et al., 2018; Liang et al., 2022).

Postoperative Nausea and Vomiting

Of the studies evaluating acetaminophen alone, only one meta-analysis discussed acetaminophen's effect on PONV. Liang et al. (2022) meta-analysis found that perioperative administration of 1000 mg to 2000 mg of acetaminophen or paracetamol produced a statistically significant reduction in PONV compared to a placebo. Paracetamol and acetaminophen are

interchangeable names for the same medication, with no difference in chemical structure or recommended use (Gerriets et al., 2022). Acetaminophen is highly dependent on hepatic metabolization; thus, caution is needed in patients with severe hepatic impairment (Guo et al., 2018).

NSAID/Acetaminophen Combination

Pain and Opioid Consumption

Co-administration of NSAIDs and acetaminophen produces a favorable reduction in postoperative opioid consumption (Gupta et al., 2016; Thybo et al., 2019). Gupta et al. (2016) RCT among THA patients found that the co-administration of ibuprofen 800 mg at induction and acetaminophen 1000 mg at closure with similar dosages administered every six hours postoperatively resulted in lower postoperative morphine consumption and decreased postoperative day three pain scores compared to ibuprofen alone; findings were deemed statistically significant. Another RCT (Thybo et al., 2019) found paracetamol 1000 mg and ibuprofen 400 mg administered one hour prior to surgery and every six hours postoperatively significantly reduced morphine consumption during the first 24 hours postoperatively when compared to a half-strength combination, paracetamol, or ibuprofen alone. Furthermore, the full-strength paracetamol/ibuprofen combination also produced significantly lower pain VAS scores than the half-strength combination and paracetamol alone (Thybo et al., 2019).

Postoperative Nausea and Vomiting

One RCT found that co-administration of ibuprofen and acetaminophen compared to ibuprofen alone does not affect postoperative antiemetic consumption in THA patients (Gupta et al., 2016). In contrast, another RCT found co-administration of paracetamol 1000 mg with ibuprofen 400 mg one hour before surgery and every six hours postoperatively to significantly reduce postoperative nausea rates compared to half-strength paracetamol/ibuprofen combination, paracetamol, or ibuprofen alone (Thybo et al., 2019). The efficacy of combining an NSAID with acetaminophen or paracetamol on PONV is inconclusive due to conflicting data among studies. Of note, NSAIDs such as ibuprofen that non-

selectively inhibit COX1 and COX2 receptors have an increased risk of gastrointestinal irritation, ulcers, and bleeding in susceptible patient populations (Gupta et al., 2016)

Glucocorticoids

Pain and Opioid Consumption

Glucocorticoid administration significantly reduces postoperative pain and morphine consumption in THA patients (Fan et al., 2018; Lie et al., 2017; Li et al., 2022). Fan et al. (2018) meta-analysis and systematic review found that perioperative administration of 10-20 mg of dexamethasone in adjunct with general or spinal anesthesia for THA produces a statistical reduction in postoperative pain and opioid consumption within the first 24 hours postoperatively compared to a control group (e.g., ondansetron 4 mg or placebo). An RCT found that the administration of dexamethasone after induction as an adjunct to tranexamic acid significantly reduced postoperative pain (e.g., at rest and with ambulation) in THA patients undergoing an anterolateral approach with general anesthesia (Li et al., 2022).

Postoperative Nausea and Vomiting

The administration of glucocorticoids, such as dexamethasone, significantly reduces PONV in THA patients (Fan et al., 2018; Li et al., 2017; Li et al., 2022). Fan et al. (2018) meta-analysis and systematic review evaluating the efficacy of 10-20 mg dexamethasone perioperatively in THA found that the patients in the control group (e.g., ondansetron 4 mg or placebo) encountered significantly higher rates of PONV at postoperative hour 48. An RCT conducted by Li et al. (2022) found that dexamethasone significantly improves PONV and reduces antiemetic consumption when used in adjunct to tranexamic acid. In large doses, glucocorticoids can affect blood glucose levels and produce anti-inflammatory effects, which may prolong the healing process in severely immunocompromised patients (Li et al., 2017). Therefore, healthcare providers should carefully consider the risks and benefits for each patient before administering glucocorticoids.

Ketamine

Pain and Opioid Consumption

Ketamine significantly reduces postoperative pain scores and morphine consumption among THA patients (Wang et al., 2020; Xu et al., 2019). Two meta-analyses found that perioperative ketamine administration for THA reduces postoperative pain and morphine equivalents compared to a placebo (Wang et al., 2020; Xu et al., 2019). According to a meta-analysis conducted by Xu et al. (2019), the use of ketamine results in more significant pain relief and reduced opioid consumption during the first 24 hours when compared to intra-articular or epidural administration methods.

Postoperative Nausea and Vomiting

The present literature review incorporates two meta-analyses that examine the efficacy of perioperative ketamine administration in patients undergoing THA. Of the two, only one delves into PONV as an outcome measure. In 2020, Wang et al. conducted a comprehensive meta-analysis comparing the effects of ketamine versus placebo. The study found that administering ketamine during the perioperative period can significantly reduce the incidence of PONV in patients undergoing THA (Wang et al., 2020).

Ketamine, when used appropriately, is a relatively safe drug; however, in toxic doses, ketamine can cause neurological, cardiac, genitourinary, abdominal, and psychiatric symptoms such as delirium (Wang et al., 2020). While initial anesthesia ketamine doses range from 1 to 4.5 mg/kg intravenously, the recommended induction dose is 1 to 2 mg/kg (Rosenbaum et al., 2023). While the estimated lethal dose in 50% of the population (LD50) of ketamine is 11.3 mg/kg IV, ketamine's toxic effects are dose dependent (Vwaire et al., 2023; Wang et al., 2020). Hence, it is crucial to titrate the dosage carefully and avoid exceeding the recommended limit when prescribing ketamine. Additionally, it is essential to exercise caution while prescribing ketamine to patients with psychiatric disorders or neurological impairment.

Gabapentinoids

Pain and Opioid Consumption

Gabapentinoids, such as gabapentin or pregabalin, significantly reduce postoperative pain and narcotic consumption in patients undergoing THA (Han et al., 2016; Mao et al., 2016). However, the efficacy of the onset of gabapentinoids' beneficial effects varies among studies. One meta-analysis found that administration of gabapentin 600 to 800 mg preoperatively or postoperatively as an adjunct to spinal anesthesia significantly reduced narcotic consumption during the first 24 hours postoperatively and at-rest pain scores at hour 48; there were no effects on at-rest pain scores at 34 hours postoperatively, pain scores with movement (e.g., hours 0-48), or narcotic consumption at postoperative hour 48 (Han et al., 2016). Mao et al. (2016) meta-analysis found that compared to a placebo, the administration of gabapentin 600 to 1200 mg per day (mg/day) or pregabalin 150 to 300 mg/day one to two hours prior to surgery significantly reduces postoperative morphine consumption during postop hours 0-48 but did not report a significant reduction in pain scores.

Postoperative Nausea and Vomiting

The administration of a gabapentinoid perioperatively reduces postoperative nausea rates (Mao et al., 2016). Mao et al. (2016) meta-analysis, including seven RCTs, found that the utilization of a gabapentenoid (e.g., gabapentin 600-1200 mg/day or pregabalin 150-300 mg/day one to two hours prior to surgery) significantly reduces PONV incidence compared to a placebo in patients undergoing THA with either general or spinal anesthesia.

Summary

Perioperative administration of intravenous acetaminophen, dexamethasone, ketamine, a gabapentinoid, and spinal anesthesia improves PONV in THA patients. In addition, perioperative administration of COX2-I, acetaminophen, paracetamol/ibuprofen combination, dexamethasone, and ketamine produce favorable reductions in early postoperative pain scores and opioid usage. Further

analgesia adjuncts to reduce postoperative pain and opioid consumption during THA include the utilization of spinal anesthesia and an added regional anesthesia technique. Among regional anesthesia techniques, the PENG block produces a superior reduction in postoperative pain and opioid consumption. In cases where the PENG block is not utilized, the fascia iliac block and periarticular infiltration are two other regional techniques that provide favorable postoperative pain and opioid outcomes. Of note, administering nerve blocks or spinal anesthesia to high-risk bleeding patients requires careful consideration of potential risks, as these methods carry a risk of bleeding (Liang et al., 2017; Fillingham et al., 2022).

Evidence-Based Practice Model

Model Identification

To ensure THA patients receive the most favorable perioperative analgesic regimen, CRNAs should utilize analgesic guidelines derived from current EBP rather than rely on personal analgesic preferences. EBP involves analyzing current knowledge and research to recommend best practices with many frameworks available to help facilitate clinical practice (Johns Hopkins Medicine, 2023). The Johns Hopkins Evidence-Based Practice Model (JHEBPM) section of Process, Translation, and Evaluation (PET) was used to help formulate a plan to decrease postoperative pain, opioid consumption, and PONV in THA patients (See Appendix D & Appendix E).

The framework of the JHEBPM guides the development of the EBP project by evaluating EBP literature and implementing best practices. According to Johns Hopkins Medicine (2023), the JHEBM PET process model consists of three sections: practice question, evaluation, and translation. The JHEBPM models a twenty-step PET process to help guide the development of an EBP project. The first steps of the PET process reside with formulating a question relevant to a current problem in practice through the utilization of the person, intervention, comparison, and outcome (PICO) format (Dang et al., 2022). The second section of JHEBPM, evaluating evidence, focuses on the cultivation and analysis of current EBP

literature (Dang et al., 2022). The third section constitutes the translation phase of the PET process. Translation of literature analysis findings includes project implementation and recommendations such as making practice changes, maintaining current practice, or there is a need for further research (Dang et al., 2022). Reflecting on the project process and outcomes is essential for an EBP project. The JHEBPM framework presents reflection as a continuous aspect of the model (Johns Hopkins Medicine, 2023). Due to the simplicity, reliability, and alignment with EBP, the JHEBPM is the ideal framework for achieving the project objectives.

Design and Method

Practice Question

The first step of the JHEBPM involves assembling a diverse interprofessional team. Each project team member is assigned a responsibility for project review. The project's primary team leader was first point of contact for project review. The team's second leader focused on reviewing the anesthesia-related content for the project. The final project team leader focuses on project flow and grammar.

The project team identified an issue in practice that affects adult patients undergoing THA. This issue involves significant postoperative pain, opioid usage, and PONV. Also, providers lack consistency when managing analgesics. With the problem identified, the project team created an evidence-based practice question utilizing the PICOT format. To create a practical EBP question, the author defined the intended population, the standard analgesic management of provider preference, the comparison of analgesic management encompassing anesthetic guidelines, and the outcomes of interest.

The project team evaluated the clinical problem and recognized the need for an EBP project. The project's intended audience is anesthesia providers. The final PET step is identifying essential stakeholders for the project's success. The stakeholders include the anesthesia team, orthopedic surgeons, perioperative nurses, prescribing providers for the Post-Anesthesia Care Unit (PACU), and

pharmacists. Other essential stakeholders for the project's success include pharmacy, supply and distribution, quality improvement (QI), information technology (IT), and the education departments.

Evaluation

During the evaluation stage, a thorough examination of relevant literature is undertaken, culminating in creating a literature table. The project team utilized the JHEBPM hierarchy of evidence tool to assess the evidence level and literature quality (see Appendix A). After conducting a literature review, the project team compiled articles into an annotated bibliography, followed by a comprehensive analysis to identify common themes related to analgesic management for hip arthroplasty. After analyzing the literature, consistent findings, literature quality, and evidence strength are used to generate evidence-based recommendations.

Translation

The translation section of the PET process starts by identifying recommendations for clinical immersion specific to the setting. The optimal clinical immersion site for the project is an urban outpatient surgical center specializing in elective hip arthroplasties. Following a thorough assessment of the feasibility, fit, and acceptability of the EBP recommendations at the designated clinical immersion site, the project team deemed it appropriate to proceed with implementation (Johns Hopkins Medicine, 2023). To implement EBP guidelines effectively, the project team secured support from key stakeholders. The conclusive EBP guidelines are not only pragmatic but also entail minimal risk to the clinical site while strictly adhering to the clinical site's policies and procedures.

Considering clinical immersion, a plan of action is developed to put the EBP recommendation into practice. The plan designates a project leader at the clinical site, identifies change champions to advocate for the project, and outlines objectives and tasks with corresponding completion dates. The project evaluates the required resources and finances and secures them before implementing the action

plan. The next step is to identify qualitative and quantitative metrics to measure outcomes, such as postoperative pain, opioid consumption, and PONV.

Pain Metric. Pain is measured using both qualitative and quantitative metrics. A survey question is the qualitative pain metric, as pain is often subjective. A preoperative pain assessment is conducted to document a baseline pain score. Along with the baseline pain assessment, a realistic comfort pain level goal is documented using the visual numeric rating scale (NRS). Documentation is recorded in the electronic medical record (EMR). The NRS provides a quantitative measure of pain intensity on a scale from 0 to 10 (see Appendix F). The NRS is a validated method for standardizing pain measurement (Association of Perioperative Nurses, 2007; Hawker et al., 2011). According to Hawker et al. (2011), the NRS has a construct validity correlation with the VAS ranging from 0.86 to 0.95. Another study assessing the validity of differing pain scales found a strong correlation between pain intensity and the NRS in a study conducted on young and older surgical patients ($r=0.60-0.93$ for young patients and $r=0.72-0.91$ for older patients, $p<0.0001$) (Gagliese et al., 2005).

The perioperative nurses will evaluate the patient's pain utilizing both metrics preoperatively, postoperatively (e.g., initial arrival to PACU, at 15 minutes, and on PACU discharge), and before analgesic administration. In addition, pain evaluation will occur after analgesic administration at a time appropriate for the medication's onset of action (e.g., 30 minutes post oral analgesia; 10 minutes post intravenous analgesia). Patient responses are documented in the EMR. Pain rating and documentation are standard nursing practices with minimal disruption to workflow.

Opioid Metric. A way to determine the total dosage of opioids, considering the type and potency of the drug, is with the total milligram morphine equivalent (MME) as recommended by the Centers for Disease Control and Prevention (2019). This standardization of assessment allows project managers to use MME as a quantitative measure to assess postoperative opioid usage (see Appendix G). In collaboration with the QI department, project managers calculate the total MME during the PACU

period upon PACU discharge. The total MME allows for a comparison of opioid usage among hip arthroplasty patients during the postoperative period.

PONV Metric. To evaluate the intensity of PONV, healthcare professionals use the Postoperative Nausea and Vomiting Intensity Scale (see Appendix H). This scale consists of four questions that assess the degree of PONV, with each answer assigned a numerical value. A clinical score of over 50 indicates a clinically significant PONV, as confirmed by previous studies (Dalila et al., 2013; Wengritzky et al., 2010). Numerous studies have attested to the reliability and validity of the PONV intensity scale as a measurement tool (Allen et al., 2011; Dalila et al., 2013; Wengritzky et al., 2010). Nursing staff will assess PONV on initial arrival to PACU, at 15 minutes, and on PACU discharge. Total antiemetic administration is evaluated at PACU discharge.

Metric Evaluation. The IT department will modify EMR charting to include the PONV metric. With the QI department's help, project managers will perform a monthly audit analysis to evaluate the implementation impact on outcomes. After evaluating implementation outcomes, results are reported to project stakeholders. To improve the project, project managers will send a monthly email to project stakeholders requesting feedback related to the implementation process. The feedback received from the stakeholders for possible areas of project improvements (e.g., communication, workflow, evaluation process) is considered for future project modifications. Project managers will determine the next step based on project feedback and outcomes. Outcomes seen as beneficial should remain in place with the recommendation to become a clinical site policy. Unchanged outcomes require consideration of possible project modifications. Project managers should halt project implementation if the outcomes are adverse and reassess the project inquiry, procedure, and literature exploration. The final part of the translation section of the PET process involves disseminating findings to the public. Therefore, project managers will summarize the outcomes of the EBP project and publish findings for public access.

Comprehensive Guideline Implementation Plan

Clinical Practice Identification

The clinical immersion site is an urban outpatient surgical center specializing in elective hip replacements. The project incorporates 50 adult patients undergoing elective THA. While using the t-test for sample sizes smaller than 60 is advisable, the chi-square test is not recommended for sample sizes smaller than 50 (Namuth-Covert et al., 2024; Swinscow, 1997). Thus, the project team chose a sample size of 50 since the chi-square and t-test are utilized for outcome analysis.

The project team establish a meeting with the clinical site's administrative leaders to discuss the project. The project lead presents the clinical problem, the need for an EBP project, the literature review and analysis findings, and proposed guidelines to the administrative leaders of the organization. Organization leaders and project managers will discuss the project's feasibility, fit, and acceptance before moving to the next phase. Ensuring EBP recommendations align with the clinical practice site will improve care safety and the likelihood of stakeholder acceptance. Project managers proceed with the implementation process after receiving approval from the organization and Institutional Review Board.

Pre-Implementation Planning Logistics

The subsequent phase of the implementation process involves the creation of an action plan by the project associates that outlines the project's logistics. Before the implementation, the project managers identify a collaborative leader in collaboration within the site. The project collaborative leader, a member of the anesthesia team, is a critical resource for perioperative analgesia management, which is the primary focus of the EBP guidelines. Subsequently, the project team designates a change champion from each stakeholder department (e.g., manager or veteran associate), who will act as a resource and project advocate for that corresponding department. The selection of these designated members is crucial and depends on their experience, expertise, and willingness to participate in project

processes. During the final action planning stage, the project team adjusts workflows, the EMR, and resources to align with clinical objectives.

Resource Need

The team thoroughly evaluates the resources and funding, considering essential elements such as required medications, equipment, and supplementary educational needs. The project requires specific equipment for various types of anesthesia, including peripheral nerve blocks (e.g., ultrasound machine, needle, catheter, local anesthetic), neuraxial anesthesia (e.g., spinal kit, local anesthetic), and general anesthesia (e.g., anesthesia machine, airway equipment, volatile gas). While most resources are available at outpatient surgical centers (e.g., medications, spinal kits, ultrasound), the team must adjust the quantity to meet project demand. The project members will assess resource expenses and discuss them with the finance department.

Stakeholder Identification and Responsibilities

The project involves multiple stakeholders, including anesthesia providers, surgeons, perioperative nurses, prescribing providers for PACU, pharmacists, pharmacy, supply and distribution, QI, IT, finance, and the education department. The primary anesthesia provider is accountable for selecting and administering analgesics based on the EBP guidelines during the intraoperative period and documenting interventions in the patient's EMR. The anesthesia provider will collaborate with surgeons and hospitalists to guarantee compliance with EBP guidelines during the perioperative setting. The orthopedic surgeon and hospitalist will work with the anesthesia team to ensure that medications conform to EBP guidelines before and after surgery. The nurses will record the preoperative and postoperative metrics of patients in the EMR at pre-determined intervals. The maintenance of a reliable and secure medication inventory in the operating room's medication dispensing system is a critical aspect of ensuring patient safety. The pharmacy department and pharmacists play a crucial role in managing the supply and restocking of medications. The supply and distribution team will ensure that

the project has appropriate and stocked supplies needed for peripheral nerve blocks. The IT department will work with project managers to incorporate metrics into the EMR for simplified documentation and create an electronic audit to evaluate each metric. Additionally, IT will aid in analyzing data. The QI department will assist in gathering data and analyzing metrics through auditing to ensure the project's success.

Implementation Plan

Project managers lead the educational in-service, which lasts two hours. Before utilizing the project's EBP guidelines, the project team schedules a mandatory educational in-service in collaboration with the education department—the educational in-service aims to provide further education on the change in workflow to essential stakeholders. While anesthesia providers are typically well-versed in administering peripheral nerve blocks and utilizing ultrasound, an additional resource in the form of an in-service will cover the specific peripheral nerve block and neuraxial anesthesia procedures outlined in the EBP guideline, along with different medications to utilize. During the in-service, a skill check-off is conducted. In addition, implementing metric charting affects the perioperative nurses' workflow. The in-service meeting will cover necessary charting adjustments. The educational in-service is offered on two separate days in the month prior to project implementation. Offering the in-service on two separate days allows stakeholders to select the most optimal day for their attendance. This approach effectively promotes continued professional development within project management.

Workflow

Preoperative Period

Project implementation occurs over six months, including 50 adults undergoing elective hip arthroplasty. Before elective hip arthroplasty, patients will undergo a series of preoperative evaluations conducted by the nursing staff. The first assessment will involve asking the patient if they are experiencing pain, to which they can respond with either a "yes" or "no" answer. The nurse will use the

NRS to quantify pain intensity if the patient reports pain. Next, the nurse will assess the patient's current level of nausea by utilizing the PONV intensity scale. Nursing staff will meticulously record measurements in the electronic health record. The orthopedic surgeon and anesthesia provider will adhere to EBP recommendations when ordering preoperative analgesics—acetaminophen, either celecoxib or ibuprofen, a gabapentinoid, and a peripheral nerve block are the recommended adjuncts during the preoperative period (see Appendix C). The nursing staff will give the prescribed analgesic medications preoperatively. Additionally, the anesthesia provider will administer a peripheral nerve block in adherence to the EBP recommendations preoperatively to help manage pain during the procedure.

Intraoperative Period

The anesthesia provider is responsible for pain management throughout the surgical procedure. The anesthesia provider must adhere to EBP guidelines and consider the patient's medical history and intervention contraindications (see Appendix C). Upon arrival to the operating room, the anesthesia provider initiates a spinal anesthetic. Then, the anesthesia provider administers dexamethasone and ketamine at the beginning of surgery. If the recommended analgesic management proves inadequate, the anesthesia provider may need to resort to supplementary opioid options.

Postoperative Period

After surgery, the nursing staff in the PACU will monitor the patient's pain levels. The frequency of checks will be on initial arrival to PACU, at 15 minutes, and on PACU discharge. Nurses will assess the patient's pain intensity with the NRS. The orthopedic surgeon and anesthesia provider collaborate to prescribe analgesics in adherence to the EBP recommendations—acetaminophen and ibuprofen (see Appendix C). The nurse will administer the analgesics in the PACU. The EBP guidelines are utilized prior to the administration of an opioid. After analgesic administration, nursing staff will reassess the patient's pain using the NRS at an appropriate time for the medication's onset. For instance, an oral analgesic

reassessment occurs at 30 minutes, while an intravenous reassessment occurs at 10 minutes. If pain persists, an opioid may be necessary. The nursing staff also evaluates the patient's PONV using the PONV intensity scale on initial arrival to PACU, at 15 minutes, and on PACU discharge. Nursing staff will record medication for preventing nausea or vomiting in the patient's electronic health record.

The project leader will conduct a monthly audit of project metrics. The IT and QI departments will develop an algorithm to convert opioid usage into total MME for evaluating opioid consumption. Project managers will conduct monthly audit analyses with assistance from the QI department. Stakeholders receive monthly audit analysis results through an email dashboard sent by the project managers. In addition, stakeholders provide feedback to project managers every month via email.

Labor Impact

Implementing EBP perioperative analgesic guidelines for elective THA patients can significantly impact labor. The guidelines require increased communication among prescribing providers, which means that physicians, nurses, and other healthcare professionals must work together more closely to ensure patients receive the appropriate pain management. Additionally, the guidelines require increased documentation and assessment by nurses, likely leading to an increased workload for nursing staff. Anesthesia providers will also need to take on more responsibility and clinical awareness to implement EBP recommendations as appropriate.

Project Timeline

The timeline for project implementation is one year and consists of four phases: preparation, implementation, analysis of findings, and dissemination of project results. The preparation for project implementation occurs between the first and fourth months. Approval for implementing the project at the clinical site takes place during the first month. In addition, project managers collaborate with organizational leaders and the financial department every week during the first month to evaluate resource needs and finalize a project budget. In the second month, project managers meet with

essential stakeholders weekly to secure project funding and resources. In the third month, the project managers collaborate with the IT and QI departments to customize the EMR system for metric documentation. Stakeholders receive a two-hour educational in-service regarding the project during the fourth month. During months five through 10, the project managers implement the project at the clinical site. Stakeholders must adhere to project guidelines and document metrics during the six-month implementation period. During project implementation in months five through 10, project managers analyze monthly audits of the project metrics and gather stakeholder feedback. In the eleventh month, the project managers undertake a comprehensive audit analysis of the project implementation phase to evaluate project outcomes. After evaluating project results, project managers disseminate the findings and future recommendations to the public.

Budget

The budget estimate for the project encompasses all financial needs for implementation (see Appendix I). Project managers include compensation for stakeholders' time spent in the educational in-service to the project budget estimate. The project's educational in-service cost includes $4,665.54 for stakeholder compensation and $16.80 for educational handouts.

In addition, the project budget estimate includes pharmaceutical expenses for 50 individuals following the EBP guidelines. The total cost of acquiring all medications ranges from $8,006.35 to $8,048.35. The budget estimate also includes an adjusted medication cost. The adjusted medication cost considers the clinical site's current pharmaceutical supply by applying a 50% reduction to the total medication cost estimate. During regular shift hours, project managers will determine and assist the pharmacy in ordering project supplies and stocking. Therefore, the project's adjusted total medication cost range is $4,003.18 to $4,024.18.

The clinical site needs to acquire an additional ultrasound machine for project efficiency. The project budget includes a $3,119 estimate for a portable ultrasound machine with the required user

membership fee (see Appendix I). The total project estimate ranges from $11,783.52—$15,849.69, which includes adjusted and non-adjusted medication estimates.

Outcome and Analysis

Project managers will utilize IT's algorithm throughout the six-month implementation process to audit postoperative outcome metrics daily. These metrics include pain occurrence with an associated NRS, PONV intensity score, and total MME. The findings of each daily audit are recorded in a secured Excel spreadsheet. The project managers will also work alongside the QI department to conduct a monthly analysis using the daily metric audit data saved in the spreadsheet. Project managers and the QI department will evaluate audit results each month for common themes in outcomes. After the six-month project, a final audit analysis is conducted using data collected throughout the process. Results are documented in the secured Excel spreadsheet. This Excel spreadsheet will contain three tabs: one for daily metric audit data, one for monthly audit data, and one for the six-month audit analysis results.

In order to evaluate the effectiveness of new guidelines for postoperative outcomes in elective THA, project managers must also gather comparable data from patients who have received anesthesia/analgesia through traditional provider preferences. Working closely with the IT department, the project managers will utilize the same audit methods for the traditional provider group and the project guideline audits while reviewing the medical records. The data will be gathered and recorded in a separate secured Excel spreadsheet as a reference point for the traditional provider preference group. This procedural step will facilitate a comprehensive comparative analysis between patient cohorts who received the intervention under traditional provider preferences and those who underwent THA after implementing the latest guidelines.

Statistical Analysis

After gathering all the necessary data, two statistical tests—t-test and Chi-square test—will be employed to compare the impact of the interventions on the outcomes. The Chi-square test analyzes

the correlation between categorical variables, revealing patterns and trends in data (du Prel et al., 2010). In other words, the chi-square test assists in calculating the probability of differences being chance occurrences, thus helping project managers assess the significance of the intervention on the measured outcomes. When analyzing the data, project managers will also utilize the t-test—a statistical technique used to evaluate whether the means of the two groups are significantly different (du Prel et al., 2010). By analyzing the averages of the two sets of data (e.g., traditional provider preference versus project guidelines), the t-test helps in ascertaining whether the observed differences in postoperative outcomes (e.g., pain scores, opioid consumption, and PONV) between the groups are due to chance or are statistically significant. Therefore, this statistical approach helps to identify differences in outcomes between the traditional provider preference group and the project's EBP guideline group. In statistical analysis, a p-value less than 0.05 indicates statistical significance and a low likelihood of chance causing observed results (du Prel et al., 2010). Therefore, project managers consider analysis results with a p-value less than 0.05 statistically significant.

Evaluation

The success of a project is contingent upon a project manager's ability to navigate outcome results. If monthly audits and final audit analysis demonstrate a significant decrease in postoperative outcomes, project managers will promote the guidelines as future recommendations for practice. Alternatively, if the guidelines result in no significant change in outcomes, project managers will proceed with implementation while continuously assessing areas for improvement. Lastly, if daily audits or monthly audit analyses reveal increased postoperative complications, the implementation process will immediately be halted to mitigate potential harm. Upon halting implementation, project managers will reflect on project goals and revisit the literature review to identify areas for improvement.

If statistical analysis reveals guideline implementation as superior to traditional provider preference, then project managers will endorse the guidelines rather than the traditional provider

preference. If the implementation of guidelines provides a statistically significant reduction in postoperative outcomes but yields equal to traditional provider preference, project managers will recommend the guidelines as a beneficial alternative. However, if traditional provider preference is superior to project guidelines and the project guidelines yield no significant effect on outcomes, project managers will not recommend the guidelines for future use.

Upon completion of the project implementation and outcome analysis, project results are disseminated to essential stakeholders and public health officials via email, poster presentation, and article publication—dissemination of project results occurs in the last month of the project timeline.

Potential Liability

Professional liability is a crucial aspect of healthcare, especially when implementing interventions. While these interventions have been proven beneficial within the literature, providers must be aware of any possible contraindications (see Appendix C). Using these interventions in patients with clear contraindications can lead to severe consequences and potential legal action. Additionally, patient refusal should always be respected and taken into consideration. It is of utmost importance to restrict the application of the analgesic guideline solely to elective THA procedures in adults. By being diligent and mindful of these factors, healthcare professionals can help to mitigate their liability risks.

Barriers and Limitations

Possible barriers to the project include lack of available resources, project cost, lack of education, and stakeholder support and compliance. Two main challenges to project success are acquisition of required supplies (e.g., medications, equipment) and staff participation to finish the project within budget and on time. Project cost is another barrier to project success. Potential costs for the project include medications, ultrasound equipment, alterations to electronic charting, and education. Another potential challenge is stakeholder support and compliance. To address the concern of stakeholder support, project managers hold educational meetings to discuss project needs, EBP

guidelines, and workflow changes. Educational in-services provided by project managers also address the possible barrier of insufficient knowledge among stakeholders.

The implementation of a project aimed at improving analgesic interventions in healthcare settings is subject to several limitations that warrant attention. One of the primary limitations is the high dependency on provider compliance in implementing and documenting the recommended analgesic interventions. Due to comorbidities and analgesic contraindications, not all patients can follow guidelines for intervention. Thus, the ability of patients with contraindications to receive the analgesic guidelines is another limitation.

Conclusion

Hip arthroplasty is a joint orthopedic surgery gaining popularity. However, postoperative pain, opioid utilization, nausea, and vomiting are common side effects associated with this procedure. A comprehensive literature review reveals an optimal analgesic regimen consists of a multimodal drug approach. An EBP project was developed using the JHEBPM to implement perioperative analgesic management guidelines during elective hip arthroplasty in adults. Statistical analysis will measure outcomes based on pain scores, total MME, and PONV intensity scores using the chi-square and t-test. By implementing the EBP guidelines, the project aims to decrease postoperative pain, opioid consumption, nausea, and vomiting in adults undergoing elective hip arthroplasty.

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Appendix A

Literature Table

NSAID: COX2-I								
APA citation: Jiang, M., Deng, H., Chen, X., Lin, Y., Xie, X., & Bo, Z. (2020). The efficacy and safety of selective cox-2 inhibitors for postoperative pain management in patients after total knee/hip arthroplasty: A meta-analysis. *Journal of Orthopedic Surgery & Research, 15*(1), 1-12.								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions if any***	***Outcome Measurements***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	MA • Databases (PubMed, Embase, Cochrane Library, Baidu Scholar, Google Scholar, CNKI, VIP) from inception to May 2019 using PRISMA guidelines	N = 17 RCT (N = 2,919 patients) **Exclusion Criteria:** • Retrospective trials, animal experiments, non-RCT, reviews, series, case reports, erroneous or incomplete data, focus not on TKA or THA, COX2-I allergy **Attrition:** NR **Setting:** • Patients undergoing THA or TKA in perioperative period	**IV1:** COX2-I **IV2:** CG • Placebo or No COX2-I **DV:** NR	**Post-Op:** • Pain: VAS score within 3 days • MS within 3 days **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • Stata 12.0 • SMD • 95% CI • I2 test **Qualitative analysis:** • Cochrane Risk of Bias Criteria • RR **Statistical significance**: • P-Value < 0.05	**COX2-I:** • Lower at rest VAS score at 24hr (SMD -1.17; 95% CI -1.96 to -0.37) and 48 hr (SMD -1.15; 95% CI -1.92 to -0.38)* • No difference in at rest VAS at 72hr (SMD -1.47; 95% CI -3.02 to -0.08) or MS at 72hr (SMD -0.34, 95% CI -0.75 to 0.06, I2= 91.8%) • Lower VAS with ambulation at 24hr, 48hr, 72hr (SMD -1.15, 95% CI -1.60 to -0.71; SMD -1.13, 95% CI -1.71 to -0.55; SMD -1.43, 95% CI -2.10 to -0.76)* • Lower MS at 24hr (SMD -1.70, 95% CI -2.59 to -0.81, I2=96.3%) and at 48hr (SMD -0.59, 95% CI -1.05 to -0.13, I2=94.1)	I	**Strengths:** • First MA to explore safety and efficacy of COX2-I for postop pain control in THA **Limitations:** • Mixed bias risk due to variability among baseline characteristics • Relatively small sample sizes within studies **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • Selective COX2-I highly effective and safe for postoperative pain control after TKA/THA
APA citation: Xiao, K., Yu, L., Xiao, W., Peng, H., Bian, Y., Wu, Z., & Weng, X. (2019). Pain management using perioperative administration of parecoxib for total hip arthroplasty: A randomized, double-blind, placebo-controlled trial. *Pain Physician, 22*(6), 575-582.								

Conceptual Framework or Model	*Design or Method*	*Sample & Setting*	*Major Variables Studied & their Definitions if any*	*Outcome Measurements*	*Data Analysis*	*Findings*	*LOE*	*Quality of Evidence: Critical Worth to Practice*
NA	Prospective, randomized, double-blinded clinical trial	N = 141 patients **Exclusion Criteria:** • Age < 18, prior ipsilateral hip surgery, acute trauma, alcohol, or drug abuse, diabetic, knee arthritis, spinal problems, pregnant or breastfeeding, uncooperative, allergy to drugs in study **Attrition:** NR **Setting:** • Patient undergoing unilateral THA from October 2014 to June 2015	**IV1:** PS (N = 69) • Prior to incision 40 mg; Q12h post-op for 2 days **IV2:** CG (N = 72) • Normal Saline **DV:** • GA, surgeon, posterolateral surgical approach, PCA morphine post-op	**Post-Op:** • Pain: VAS score • CMC (α = 0.05) • Functional Recovery • Inflammatory markers • Perioperative Bleeding Risk **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • SPSS version 25.0 • Shapiro-Wilks Test • t-test • Tukey post hoc test **Qualitative analysis, if any:** • Chi-square test • Fischer exact test **Statistical significance**: • P-Value < 0.05	**PS:** • Lower at rest VAS score at 4hr, 12hr, and 24hr (all P < 0.001)* • Lower VAS w/movement at 4hr, 12hr, 24hr, 36h, 48hr (all P< 0.001)* • Lower CMC (P < 0.001) • Lower body temperature (p=0.003) post-op day 1 • Lower IL-6 (P =0.007) and IL-10 (P=0.006) post-op day 1 • LOHS shorter (P=0.019) **CG:** • Higher PONV (P = 0.021) • NS difference in urinary retention, rashes straight-leg raise, bleeding risk	II	**Strengths:** NR **Limitations:** • Did not evaluate long term follow-up **Risk or harm if implemented:** • PS less antiplatelet effect **Feasibility of use in the project practice area:** • Effective preemptive and sequential regimen to alleviate post-op pain and inflammation in early post-op period after THA • PS can be administered intravenously or intramuscularly
APA citation: Kuang, M. J., Ma, J. X., Wang, Y., Zhao, J., Lu, B., & Ma, X. L. (2016). Efficacy of perioperative celecoxib use in primary total knee and hip arthroplasty: A meta-analysis. *International Journal of Clinical and Experimental Medicine, 9*(5), 7719-7728.								
Conceptual Framework or Model	*Design or Method*	*Sample & Setting*	*Major Variables Studied & their Definitions, if any*	*Outcome Measurement(s)*	*Data Analysis*	*Findings*	*LOE*	*Quality of Evidence: Critical Worth to Practice*
NA	MA • Databases (Medline, PubMed, Embase, Cochrane Central Register of Controlled Trials,	N = 6 RCT (N=464 patients) **Exclusion Criteria:** • History of coagulopathy, thromboembolic	**IV1:** Celecoxib • Dose 200mg-400mg **IV2:** CG Placebo or nothing	**Post-Op:** • Pain: VAS score • ME • PCS • KSS • Physical functioning	**Statistical Analysis:** • RevMan 5.3 • RR • MD • 95% CI • P-Value • I2 test	**Celecoxib:** • Lower at rest pain VAS score at 24hr (MD= -0.96, 95% CI -1.91 to -0.74, P<0.00001)*, and at 72hr (MD= -0.88,	I	**Strengths:** • RCT studies are high quality **Limitations:** • Small sample size

	Google Scholar) from 1966 to November 2015 using Cochrane Collaboration guidelines	event, malignant disease, acute infection, MI, unstable angina, NSAID allergy, peptic ulcer, mental disorder, severe metabolic or endocrine disorder, severe renal or hepatic disease **Attrition:** NA **Setting:** • Patients undergoing TKA or THA in the perioperative period	**DV:** NR	• Post-op Complications **Reliability information (*alphas*, if any):** NA	**Qualitative Analysis:** • CHSRI • Chi-square test • Q test **Statistical significance**: • P-Value < 0.05	95% CI -1.46 to -0.30, P= 0.003)* • Lower ME (MD= -35.64, 95% CI -45.61 to -25.67, P < 0.00001)* • Higher ROM (MD=4.70, 95% CI 3.96 to 5.44, P< 0.00001)* • NS difference in PONV (RR=0.68, 95%CI 0.40 to 1.16, P=0.16) or total blood loss		• Short follow-up time, • Only English studies included **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • Recommended as standard analgesia protocol for pain for THA
Acetaminophen								
APA citation: Guo, H., Wang, C., & He, Y. (2018). A meta-analysis evaluates the efficacy of intravenous acetaminophen for pain management in knee or hip arthroplasty. *Journal of Orthopaedic Science*, *23*(5), 793–800. https://doi.org/10.1016/j.jos.2018.04.008								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions if any***	***Outcome Measurements***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	MA • Databases (PubMed, Web of Science, Embase, Cochran Library) searched from 1974 to September 2017 using Cochrane Systematic Review Method	N = 11 Studies (6 RCT, 5 non-RCT) **Exclusion Criteria:** • No CG, non TKA or THA surgery, review article, conference abstract, letters, case reports, unobtainable studies, acetaminophen P.O. **Attrition:** NR **Setting:** • Patients undergoing THA or	**IV1:** Paracetamol or Acetaminophen • 1000mg to 2000mg **IV2=** CG **DV:** NR	**Post-Op:** • Pain: VAS score or NRS • Opioid Consumption • LOHS **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • RevMan 5.3 • SMD • 95% CI • OR • I2 test **Qualitative analysis:** • Chi-square test **Statistical significance**: • P-Value < 0.05	**Acetaminophen or Paracetamol:** • Lower opioid consumption (SMD = −0.66; 95% CI −1.13 to −0.20)* • NS difference in LOHS or VAS score	II	**Strengths:** NR **Limitations:** • Incorporates both TKA and THA studies • Non-RCT included **Risk or harm if implemented:** • Acetaminophen relatively safe when used in joint arthroplasty **Feasibility of use in the project practice area:**

		TKA receiving I.V acetaminophen in perioperative period						• Acetaminophen beneficial as analgesic adjunct
APA citation: Liang, L., Cai, Y., Li, A., & Ma, C. (2017). The efficacy of intravenous acetaminophen for pain control following total knee and hip arthroplasty: A systematic review and meta-analysis. Medicine, 96(46), e8586. https://doi.org/10.1097/MD.0000000000008586								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	MA • Databases (PubMed, Embase, Web of Science, Medline, Cochrane Library) searched using PRISMA guidelines	N = 4 studies (3 RCT; 1 non-RCT) **Exclusion Criteria:** • Incomplete data, case reports, conference abstract, review articles **Attrition:** NR **Setting:** • Patients undergoing TKA or THA in the perioperative period	**IV1:** Acetaminophen (N =534 patients) • 1000mg IV dose **IV2:** CG (N= 332 patients) • Placebo or normal saline **DV:** • GA (N= 2 studies) • SA (N = 2 studies)	**Post-Op** • Pain: VAS score • Opioid Consumption • LOHS • PONV **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • Stata 11.0 • RD with 95% CI • WMD with 95% CI • I2 test **Qualitative Analysis:** • GRADE • MINORS scale • Chi-squared test **Statistical significance**: • P-Value < 0.1 • I2 > 50%	**Acetaminophen:** • Lower pain VAS score at 24hr (WMD=-0.926, 95% -1.71 to -0.681, P = 0.000)*, at 48hr (WMD= -0.905, 95% Ci -1.198 to -0.612, P = 0.000)*, and at 72hr (WMD= -0.279, 95% CI -0.538 to -0.021, P =0.034)* • Lower opioid consumption at 24hr (WMD= -4.043, 95% CI -5.041 to -3.046, P = 0.000)*, at 48hr (WMD= -5.665, 95% CI -7.383 to -3.947, P= 0.000)*, and at 72hr (WMD-6.338, 95%CI -7.477 to -5.199, P= 0.000)* • Lower PONV (RD -0.107, 95% CI -0.152 to -0.062, P= 0.000)* • NS difference LOHS (WMD= 0.037, 95% CI -0.083 to 0.157, P = 0.544)	II	**Strengths:** NR **Limitations:** • Study quality low • Small sample size • Unable to eliminate clinical heterogeneity **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • IV acetaminophen perioperatively effective for reducing post-op pain and opioid consumption in joint arthroplasty
NSAID / Acetaminophen Combination								
APA citation:								

Gupta, A., Abubaker, H., Demas, E., & Ahrendtsen, L. (2016). A randomized trial comparing the safety and efficacy of intravenous ibuprofen versus ibuprofen and acetaminophen in knee or hip arthroplasty. *Pain Physician*, *19*(6), 349–356.

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions if any***	***Outcome Measurements***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	Randomized, single center, trial of patients undergoing TKA or THA completed over course of 12 months	N = 78 patients Age 18-65 **Exclusion Criteria:** • Impaired cardiac, liver, renal function; history of substance abuse or chronic pain; hypersensitivity to IV ibuprofen or acetaminophen; patients on anticoagulation medication; age < 18y; uncooperative; pregnant or nursing; unsuitable per investigator discretion **Attrition:** NR **Setting:** • Perioperative period at a Tertiary care center in Philadelphia, Pennsylvania, United States	**IV1**: Group 1 (N=39) • 800mg IV ibuprofen at induction • post-op 800mg IV ibuprofen Q6h until discharge) **IV2**: Group 2 (N=39) • 800mg IV ibuprofen at induction, 1000mg IV acetaminophen at closure • post-op 800mg IV ibuprofen + 1000mg IV acetaminophen Q6h **DV:** • GA, PNB for TKA, single surgeon, standard of care analgesics	**Post-Op:** • Pain: VAS score • PACU LOS • Quality of Recovery Scale • Opioid consumption • Antiemetic Consumption • Opioid Related Adverse Events **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** SPSS for Windows version 20.0 SMD 95% CI **Qualitative Analysis:** t-test Chi-square test Man Whitney U Test **Statistical significance**: P-Value < 0.05	**Group 2:** • Lower CMC and opioid related adverse events in PACU (P < 0.001)* • Lower VAS on day 3 (P< 0.002)* • NS difference in VAS postop day 1, 2, 4, 5 • NS difference in PACU LOS (P=0.178) or LOHS (P=0.138) • NS difference in Quality of Recovery Scale score or antiemetic consumption	II	**Strength:** • First RCT to assess co-administration of IV ibuprofen and acetaminophen in perioperative setting **Limitations:** • Risk of convenience bias • small sample size • no cost analysis • Did not evaluate use of PNB in TKA studies on outcomes **Risk of harm, if implemented:** • NSAID may cause GI irritation, ulcers, and increase bleeding **Feasibility to use in project practice area:** • Co-administration of ibuprofen and acetaminophen is beneficial in postop pain management in THA

APA citation:
Thybo, K. H., Hagi-Pederson, D., Dahl, J. B., Wetterslev, J., Nersesjan, M., Jakobsen, J. C., Pedersen, N. A., Overgaard, S., Schroder, H. M., Schmidt, H., Bjorck, J. G., Skovmand, K., Frederiksen, R., Buus-Nielsen, M., Sorensen, C. V., Kruuse, L. S., Lindholm, P., & Mathiesen, O. (2019). Effect of combination of paracetamol (acetaminophen) and ibuprofen vs either alone on patient-controlled morphine consumption in the first 24 hours after total hip arthroplasty: the painsaid randomized clinical trial. *JAMA, 321*(6), 562-571. https://doi.org/10.1001/jama.2018.22039

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***

NA	Randomized, blinded, placebo-controlled, 4 group trial	N= 556 patients **Exclusion Criteria:** • Daily opioid use (except tramadol or codeine), contraindication to ibuprofen or paracetamol, ulcers, liver/heart/renal failure, thrombocytopenia, uncooperative, unable to understand Danish, concomitant participation in another trial, history of alcohol or drug abuse **Attrition:** NA **Setting:** • Patients undergoing elective THA among 6 Danish hospitals during the perioperative period from December 2015 to October 2017	**IV1:** PCM/IBU • 1000mg PCM and 400mg IBU **IV2:** PCM • 1000mg PCM and placebo **IV3:** IBU 400mg IBU and placebo **IV4:** HS-PCM/IBU • 500mg PCM and 200mg IBU **DV:** • P.O administration 1h prior to surgery and Q6h for 24h post-op • PCA morphine (1mg/ml, bolus 2mg, lockout 10min) for 24h post-op • No additional analgesics • Patients with chronic gabapentinoids, glucocorticoids, SSRI, tramadol, or codeine use continued perioperatively	**Primary Post-Op Outcome:** • ME **Secondary and Exploratory Outcomes:** • Serious adverse events: RR • Pain: VAS score **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • Van Elteren test • RR **Qualitative Analysis:** NR **All Analysis:** • STATA 15/MP **Statistical significance**: • P-Value < 0.0042 at 99.6% CI • P-Value < 0.0083 at 99.2% CI • P-Value < 0.025 at 97.5% CI • P-Value = or < 0.05 at 95% CI	**PCM/IBU vs. PCM:** • Lower ME at 24hr (99.6%CI 6.5 to 24, P<0.001)* • Lower pain VAS at 6hr (99.2% CI 0 to 15, P = 0.005)* and at 24hr (99.2% CI 2 to 19, P<0.001)* • Lower nausea risk at 24hr (RR 0.53, 95% CI 0.31 to 0.90, P=0.02)* **PCM/IBU v. IBU:** • Lower ME at 24hr (99.6% CI-1 to 16, P=0.002)* vs IBU • Reduce Nausea Risk at 24hr (RR 0.56, 95%CI 0.32 to 0.96, P=0.04)* **PCM/IBU v. HS-PCM/IBU:** • NS difference ME at 24hr (99.6%CI -1 to 16, P = 0.005) • Lower pain VAS score at 24hr (99.2% CI 5 to 17, P<0.001)* • Reduce nausea risk at 24hr (RR 0.45, 95% Ci 0.27 to 0.76, P=0.03)* **PCM v. IBU:** • NS difference ME at 24hr (99.6% CI -2 to 16; P=0.004) **IBU v. HS-PCM/IBU:** • NS difference ME at 24hr (99.6% CI -10 to 7, P=0.81)	II	**Strengths:** • Includes 90-day follow-up for safety **Limitations:** • Short intervention period • Varied anesthesia methods • No specific analgesic for follow-up period **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • Consider IBU for early post-op oral analgesia • PCM/IBU combo beneficial regimen for early post-op pain

						All Groups: • NS difference in serious adverse events		
Glucocorticoids								
APA citation: Li, X., Sun, Z., Han, C., He, L., & Wang, B. (2017). A systematic review and meta-analysis of intravenous glucocorticoids for acute pain following total hip arthroplasty. Medicine, 96(19), e6872. https://doi.org/10.1097/MD.0000000000006872								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	SR and MA • Databases (PubMed, Embase, Cochrane Central Register of Controlled Trials, Web of Science) search from inception to November 6, 2016	N= 6 RCT (N = 297 patients) **Exclusion Criteria:** • Non-RCT, quasi-RCT, retrospective studies, reviews, protocols, duplicates, no outcomes listed **Attrition:** NR **Setting:** • Patients undergoing THA in the perioperative period	**IV1:** Glucocorticoid • Administered pre-operatively IV **IV2:** Placebo **DV:** NR	**Post-Op:** • Pain: VAS score • PONV • CMC **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • Stata 12.0 • RR • 95% CI • WMD **Qualitative Analysis:** • GRADE Pro version 3.6 • Jadad Score **Statistical significance**: • P-Value < 0.05	**Glucocorticoid:** • Lower CMC (WMD= -15.68, 95% CI -24.60 to -6.75, P = 0.001)* • Lower initial PACU VAS score (WMD= -9.06, 95% CI -12.67 to -5.45, P =0.000)* • NS difference in VAS score at 24hr or 48hr • Lower PONV (RR= 0.46, 95% CI 0.26-0.82, P = 0.029)* • NS difference in LOHS or blood glucose	I	**Strengths:** • Only includes patients undergoing THA **Limitations:** • Small sample size • Varied surgical time, approaches, techniques, post-op pain protocols • Dose and type of glucocorticoid varies among studies **Risk or harm if implemented:** • Short term glucocorticoid use effects blood glucose, wound healing, infection risk **Feasibility of use in the project practice area:** • IV glucocorticoid can decrease early pain intensity and PONV in THA
APA citation: Li, F., Huang, X., Liu, W., Huang, W., Wang, C., & Yin, D. (2022). Application of dexamethasone combined with tranexamic acid in perioperative period of total hip arthroplasty. *Medicine, 101*(42), e31223. https://doi.org/10.1097/MD.0000000000031223								

Conceptual Framework or Model	*Design or Method*	*Sample & Setting*	*Major Variables Studied & their Definitions, if any*	*Outcome Measurement(s)*	*Data Analysis*	*Findings*	*LOE*	*Quality of Evidence: Critical Worth to Practice*
NA	RCT	N = 100 patients **Exclusion Criteria:** • DEXA allergy, age < 18y or > 75y, glucocorticoid use within 3 months prior, use of strong opioids within 1 week prior, NYHA > 2, liver or kidney failure, systematic rheumatic disease, ipsilateral hip surgery, lack of cognitive function or normal sensation, loss to follow-up **Attrition:** NR **Setting:** • Patients undergoing unilateral THA in the Perioperative period	**IV1:** TXA + DEXA (N=50) • TXA and DEXA 20mg IV after induction and at hour 24 **IV2:** Placebo (N=50) • TXA and Normal Saline via same timing as IV1 **DV:** • TXA 15mg/kg prior to incision and 3hr later • Surgeons • Anterolateral surgical approach • GA • no PNB or PCA in perioperative period	**Post-Op:** • C-reactive protein • IL-6 • Nausea: incidence and VAS score • Fatigue: VAS score • Pain: VAS score • Post-Op LOS • ROM • Cumulative Oxycodone Consumption **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • PASS 2011 software • SPSS 22.0 • t test • Wilcoxon Mann-Whiney U test **Qualitative Analysis:** Fisher exact test Chi-square test **Statistical significance**: P-Value < 0.05	**TXA & DEXA:** • Lower C-reactive protein at 24hr, 48hr, 72hr (P < 0.001)* • Lower nausea, fatigue, antiemetic consumption, LOS, ROM (all P < 0.05)* • Lower pain VAS with ambulation at 24hr and 48hr (P< 0.001)* • Lower at rest pain VAS at 24hr (P< 0.001)* • NS difference in HCT or total blood loss (P> 0.05)	II	**Strengths:** NR **Limitations:** • Short follow-up time • Small sample size • optimal dose combination and timing unclear **Risk or harm if implemented:** • Large scale prospective study needed to assess safety of DEXA in perioperative application **Feasibility of use in the project practice area:** • TXA + DEXA combo administration after anesthesia onset and at 24h effective and safe strategy in THA
APA citation: Fan, Z. R., Ma, J., Ma, X. L., Wang, Y., Sun, L., Wang, Y., & Dong, B. C. (2018). The efficacy of dexamethasone on pain and recovery after total hip arthroplasty: A systematic review and meta-analysis of randomized controlled trials. *Medicine*, *97*(13). https://doi.org/10.1097/MD.0000000000010100								
Conceptual Framework or Model	*Design or Method*	*Sample & Setting*	*Major Variables Studied & their Definitions, if any*	*Outcome Measurement(s)*	*Data Analysis*	*Findings*	*LOE*	*Quality of Evidence: Critical Worth to Practice*
NA	SR & MA • Databases (PubMed, Cochrane, Embase) searched from 1998 to June 2017 using PRISMA guidelines	N = 3 RCT Mean Age: 53.4 – 69y **Exclusion Criteria:** • Incomplete data, case reports, meeting summaries, review articles	**IV1:** DEXA (N = 110 patients) • 10-20mg IV pre-op **IV2:** CG (N= 107 patients) • Normal Saline, 4mg ondansetron IV, or placebo	**Post-Op** • Pain: VAS score • Opioid consumption • LOHS • Postop Nausea **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • RevMan 5.3 • SMD with 95% CI • OR • I2 test • P-Value **Qualitative Analysis:** • Chi-square test • CHSRI	**DEXA:** • Lower pain VAS score at 24hr (SMD= -0.95, 95%CI -1.24 to -0.66, P < 0.001)* • Lower opioid consumption at 48hr (SMD=-0.63,	I	**Strengths:** • First MA to evaluate efficacy and safety of DEXA in THA **Limitations:** • Small sample size • Short follow-up time

		Attrition: NR **Setting:** • Patients undergoing unilateral THA in the perioperative period	**DV:** • PCA with opioid • GA (N=1 RCT) • SA (N=2 RCT)			95% CI -0.91 to -0.35, P < 0.001)* • Lower LOHS (SMD=-0.94, 95%CI -1.49 to -0.40, P< 0.001)* **CG:** • Higher pan VAS at 48hr (SMD= -0.72, 95% CI -1.41 to -0.02, P= 0.04)* • Higher PONV (OR= 0.21, 95%CI 0.09 to -0.54, P= 0.001)*		• Publication bias risk • Unable to do subgroup analysis for pain VAS score at 48h **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • DEXA perioperatively reduces post-op pain, opioid consumption, and PONV in THA
Ketamine								
APA citation: Wang, P., Yang, Z., Shan, S., Cao, Z., & Wang, Z. (2020). Analgesic effect of perioperative ketamine for total hip arthroplasties and total knee arthroplasties: A prisma-compliant meta-analysis. *Medicine, 99*(42), e22809. https://doi.org/10.1097/MD.0000000000022809								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	MA • Databases (PubMed, Embase, Cochrane Library, Web of Science, China National Knowledge Infrastructure, China Biomedical Literature, Wanfang Data) searched by August 15, 2019	N = 21 RCT (N = 1,145 patients) **Exclusion Criteria:** • Non-controlled studies, duplicates, poor quality or illogical statistically studies, focus not on analgesic effect of ketamine in THA or TKA, provided data insufficient for WMD or 95% CI **Attrition:** NR **Setting:** • Patients undergoing THA or TKA in the	**IV1:** Ketamine Drug Route: • IV (N = 10 studies) • IA (N =2 studies) • Epidural injection (N= 5 studies) • PCA (N= 4 studies) **IV2:** CG • Placebo or Normal Saline via same mode as IV1 **DV:** NR	**Post-Op:** • Pain: VAS score • MEC • Side effects (sedation, dizziness, hallucination, sweating, pruritis, urinary retention, constipation, vision trouble, nightmares, delirium, PONV): OR **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • RevMan 5.3 • WMD • 95% CI • Cochran's Q test • Higgins I2 test • OR **Qualitative Analysis:** • CHSRI 5.0 **Statistical significance**: • P-Value < 0.05 • I2 > 50%	**Ketamine:** • Lower pain VAS score at 6hr (WMD= -1.54, 95% CI -1.71 to -1.18, P < 0.00001)*, at 12hr (WMD= -1.55, 95% CI -2.28 to -0.82, P < 0.0001)*, at 24hr (WMD= -0.78, 95% CI -1.25 to -0.31, P= 0.001)* and 48hr (WMD= -0.74, 95% CI -1.26 to -0.22, P= 0.006)* • Lower MEC at 24hr (WMD=-17.58, 95% CI -29.07 to -6.10, P= 0.003)* and 48hr (WMD= -16.82, 95% CI -	I	**Strengths:** NR **Limitations:** • Variable ketamine doses and anesthesia methods among studies • Outcomes are short term **Risk or harm if implemented:** • Toxicity of ketamine causes neurological, cardiovascular, psychiatric, genitourinary, and abdominal symptoms which

		perioperative period				27.75 to -5.89, P= 0.003)* • Lower PONV (OR= 0.54, 95% CI 0.37 to 0.77, P = 0.0008)* • NS difference in sedation, dizziness, hallucination, sweating, pruritus, urinary retention, constipation, vision trouble, nightmares, delirium		are dose-dependent **Feasibility of use in the project practice area:** • Perioperative ketamine can be effective and safe analgesic adjunct in the perioperative period for THA
APA citation: Xu, B., Wang, Y., Zeng, C., Wei, J., Li, J., Wu, Z, He, H., Lei, G., Xie, D., & Ding, X. (2019). Analgesic efficacy and safety of ketamine after total knee or hip arthroplasty: A meta-analysis of randomized placebo-controlled studies. *British Medical Journal, 9*(9), e028337. https://doi.org/10.1136/bmjopen-2018-028337								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	SR and MA • Databases (PubMed, Embase, Cochrane library) searched from inception to May 22, 2019, using PRISMA guidelines	N = 10 RCT **Exclusion Criteria:** • In vitro studies, animal studies, reviews, letters, case reports, experimental or CG receiving additional treatments, data unavailable, full text unavailable **Attrition:** NA **Setting:** • Patients undergoing THA or TKA in perioperative period	**IV1:** Ketamine • IV (N= 7 RCT) • Intra-articular or epidural (N= 3 RCT) **IV2:** CG • Placebo or Normal Saline **DV:** NR	**Post-Op:** • Pain: VAS score • CMC: ME **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • RevMan 5.2 • Stata 11.0 • WMD with 95% CI • RR with 95% Ci • Q test • I2 test **Qualitative Analysis:** • Begg's test **Statistical significance**: • P-Value < 0.05	**Ketamine IV:** • Lower pain VAS score at 0-8hr (WMD -1.21, 95%CI -1.45 to -0.98, P< 0.001)* • NS difference pain VAS score at 8-48hr • Lower ME at 0-24hr (WMD -17.76, 95% Ci -31.25 to -4.27, P=0.01)* and 0-48hr (WMD -21.97, 95%CI -25.46 to -18.11, P < 0.001)* **Ketamine intra-articular/epidural:** • NS difference pain VAS score 0-24hr (WMD -0.12, 95% CI -0.51 to 0.26, P=0.52) • Lower pain VAS score 0-48hr (WMD	I	**Strengths:** • Studies all RCT **Limitations:** • Heterogeneity present, • small sample size **Risk or harm if implemented:** • Efficacy and safety in patients vary by different administration **Feasibility of use in the project practice area:** • Ketamine IV perioperatively effective as analgesic adjunct

						-0.49, 95% CI -0.70 to -0.29, p< 0.001)* • NS ME in 0-24hr (WMD -4.10, 95% CI -1.83 to 1.03, P = 0.58) • Lower ME in 0-48hr (WMD -4.10, 95% CI -5.85 to -2.35, P<0.001)*		
Gabapentinoids								
APA citation: Han, C., Li, X. D., Jiang, H. Q., Ma, J. X., & Ma, X. L. (2016). The use of gabapentin in the management of postoperative pain after total hip arthroplasty: A meta-analysis of randomized controlled trials. *Journal of Orthopedic Surgery and Research, 11*(1), 79. https://doi.org/10.1186/s13018-016-0412-z								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	MA • Databases (PubMed, Embase, Ovid Medline, ClinicalTrials.gov, CENTRAL) searched up to December 2015 using PRISMA guidelines	N= 5 RCT **Exclusion Criteria:** • Patients with neoplastic etiology, infection, traumatic fracture, metal sensitivity, mental disease, article duplicates, irrelevant data, not in English **Attrition:** NA **Setting:** • Patients undergoing THA in the perioperative period	**IV1:** GABA • 600 – 800mg • Pre-Op administration (N=3 RCT) • Post-Op administration (N=2 RCT) **IV2:** CG (N= 304 patients) • Placebo **DV:** • SA, no other local anesthetic	**Post-Op:** • Pain: VAS • Narcotic Consumption **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • RevMan 5.3 • MD • I2 test • SMD w/95% CI **Qualitative Analysis:** • Cochrane Collaboration Tool • Chi-square test **Statistical significance**: • P-Value < 0.05	**GABA:** • Lower narcotic consumption at 24hr (MD= -6.06, 95%CI -10.50 to -1.62, P= 0.007)* • NS difference narcotic consumption at 48hr (MD= 3.80, 95%CI -8.30 to 0.70, P= 0.10) • Lower at rest pain VAS score at 48hr (MD=-2.63, 95%CI -4.4- to -0.86, P=0.004)* • NS difference pain VAS score at rest at 24hr (MD=1.44, 95% CI -0.69 to 3.57, P=0.18) or with movement at 24hr (MD=1.7, 95%CI -1.96 to 5.35, P=0.91) and 48hr (MD=1.47, 95% CI -2.28 to 5.21, P=0.44)	I	**Strengths:** NR **Limitations:** • Variability among studies in design, analytical approach, type of THA, surgical duration, complications, GABA admin time and dose **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • GABA may prove beneficial in reducing post-op pain and NC in THA
APA citation:								

Mao, Y., Wu, L. & Ding, W. (2016) The efficacy of preoperative administration of gabapentin/pregabalin in improving pain after total hip arthroplasty: a meta-analysis. *BMC Musculoskeletal Disorders, 17*(373). https://doi.org/10.1186/s12891-016-1231-4								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	SR and MA • Databases (Medline, Embase, PubMed, CENTRAL, Web of Science, Google) searched from inception to January 2016	N = 7 RCT (N= 769 patients) **Exclusion Criteria:** • Lack of outcomes, cadavers, artificial models, non-RCT, letters, comments, editorials, practice guidelines, insufficient data, duplicates **Attrition:** NA **Setting:** • Patients undergoing THA in the perioperative period	**IV1:** Gabapentinoid • GABA (N=3 RCT) 600-1200mg/day administered pre-op 1-2hr prior to surgery • PREGAB (N=4 RCT) 150-300mg/day administered pre-op 1-2hr prior to surgery **IV2:** CG • Placebo or Nothing **DV:** • SA (N= 6 RCT) • GA (N=1 RCT) • Post-Op analgesia (PCA, morphine, or celecoxib)	**Post-Op:** • Pain: VAS score • CMC • PONV **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • Stata 12.0 • RevMan 5.3 • RR • MD with 95% CI **Qualitative Analysis:** • Cochrane Collaboration Risk of Bias Tool • Chi-square test • Begg's Test **Statistical significance**: • P-Value < 0.05	**Gabapentinoid:** • Lower CMC at 24hr (MD=-7.82, 95%CI -0.95 to -0.52, P < 0.001)* and at 48hr (MD= -6.90, 95% CI -0.95 to -0.57, P=0.118) • Lower nausea rate (RR 0.49, 95% CI 027 to 0.92, P=0.025)* • NS difference in post-op vomiting (RR 0.95, 95%CI 0.47to 1.92, P=0.895) **GABA:** • Lower CMC at 24hr (P<0.001)* and 48hr (P<0.001)* • NS difference pain VAS score at rest for 24hr (SMD=0.15, 95%CI-0.17 to -0.48, P=0.360), at 48hr (SMD=0.22, 95%CI -0.25 to 0.69, P=0.363) or with activity at 24hr (SMD=046, 95%CI-0.19 to 1.11, P=0.164) and 48hr (SMD=1.15, 95%CI-0.58 to 2.89, P=0.193)	I	**Strengths:** NR **Limitations:** • Small sample size • Short term follow-up • Variable GABA/PREGAB dose, time of administration • Risk of publication bias **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • GABA beneficial as analgesic adjunct in THA during perioperative period
Regional Anesthesia: Peripheral Nerve Blocks, Local Infiltration, Periarticular Injection								
APA citation: Huda, A. U. & Ghafoor, H. (2022). The use of pericapsular nerve group (peng) block in hip surgeries is associated with a reduction in opioid consumption, less motor block, and better patient satisfaction: A meta-analysis. A meta-analysis. *Cureus*, *14*(9), e28872. https://doi.org/10.7759/cureus.28872								

Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	SR and MA • Databases (ScienceDirect, Medline) searched from November 2021 to December 2021 using PRIMSA guidelines	N= 6 RCT **Exclusion Criteria:** • Review articles, abstracts, comments, not in English **Attrition:** NA **Setting:** • Patients undergoing hip surgery in the perioperative period	**IV1:** PENG-B **IV2:** Other • FIB, FNB, LPB, no block, placebo, or normal saline **DV:** NR	**Post-Op:** • Pain: VAS score • Opioid Consumption • Time to Analgesic Request • Satisfaction • PONV **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • RevMan 5.4 • I2 test • SMD • OR **Qualitative Analysis:** • Revised Cochrane Risk of Bias Tool **Statistical significance**: • P-Value < 0.05	• NS difference in pain VAS score at 6hr, 12hr, 24hr (95%CI -0.38 to 0.22, P=0.59) • Lower opioid consumption at 24hr by 0.54mg (P=0.05)* • Lower time to analgesic request by 3.82hr (P=0.05)* • Higher satisfaction level (P=0.02)* • Lower incidence of motor block (p=0.0002)* • NS difference in PONV (P=0.26)	I	**Strengths:** NR **Limitations:** • Variable intervention timing during perioperative period, primary anesthesia, and comparative groups **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • PENG considerable as preferred PNB analgesic adjunct for hip surgery in the perioperative period
APA citation: Fillingham, Y. A., Hannon, C. P., Kopp, S. L., Sershon, R. A., Stronach, B. M., Meneghini, R. M., Abdel, M. P., Griesemer, M. E., Austin, M. S., Casambre, F. D., Woznica, A., Nelson, N., Hamilton, W. G., & Della Valle, C. J. (2022). The efficacy and safety of regional nerve blocks in total hip arthroplasty: Systematic review and direct meta-analysis. *The Journal of Arthroplasty, 37*(10), 1922-1927. https://doi.org/10.1016/j.arth.2022.04.035								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	SR and MA • Databases (Medline, Embase, Cochrane Central Register of Controlled Trials) published prior to March 24, 2020, searched using PICO format, PRISMA guidelines, AAOS Clinical	N= 11 RCT **Exclusion Criteria:** • Lacking full article, < 10 patients/groups, retrospective noncomparative case series, meeting abstracts, historical articles, editorials, letters, commentaries,	**IV1:** PNB v. Placebo • (PNB= FIB, LPB, or QLB) **IV2:** PNB v. PNB • (LPB v. FIB) • (FIB v. PAI) **DV:** NR	**Post-Op:** • Pain: VAS • CMC • PONV **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • STATA 12.1 • SMD 95% CI • I2 test • RR **Qualitative Analysis:** • GRADE	**PNB v. Placebo:** • Lower pain VAS and CMC* • NS difference in adverse events between FIB or LPB v. placebo **PNB v. PNB** • NS difference in FIB v. LPB or FIB v. PAI in pain VAS score or CMC	I	**Strengths:** • Included only high quality RCT **Limitations:** • Inability to perform MA for all outcomes due to study reported outcome variability • Variable dose, local anesthetic type,

	Practice guidelines, and SR methodology	confounded studies, case series with nonconsecutive enrollment of patients, very low quality of evidence, database studies, not peer-reviewed, <50% patient follow-up, not in English, in vitro studies, animal studies, biomechanical studies, cadavers **Attrition:** NA **Setting:** • Patients undergoing THA in the perioperative period						administration time, block technique • Risk of publication bias **Risk or harm if implemented:** • Risk of infrequent adverse events not included in study • LPB risk of bilateral spread, misplacement into epidural or intrathecal spaces, quadricep weakness • QLB and LPB risk of bleed if anticoagulated, block technique is advanced • FIB less risk of adverse events • PAI less risk of adverse events compared to PNB **Feasibility of use in the project practice area:** • Moderate support for FIB and LPB as analgesic adjuncts • Limited support for QLP as analgesic adjunct • Recommend consideration of PAI prior to PNB; FIB is recommended PNB • Patients with chronic pain may

								benefit from combo of PAI & FIB
APA citation: Jimenez-Almonte, J. H., Wyles, C. C., Wyles, S. P., Norambuena-Morales, G. A., Baez, P. J., Murad, M. H., & Sierra, R. J. (2016). Is local infiltration analgesia superior to peripheral nerve blockade for pain management after tha: A network meta-analysis. *Clinical Orthopedics and Related Research, 474*(2), 495-516. https://doi.org/10.1007/s11999-015-4619-9								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	SR and MA • Databases (Pubmed, Ovid Medline, Ovid Embase, Cochrane CENTRAL, Web of Science, Scopus) searched from inception to June 30, 2014	N= 35 RCT (N=2,296 patients) Age: 38 – 80 y **Exclusion Criteria:** • Grey literature, not in English **Attrition:** NA **Setting:** • Adult patients undergoing unilateral hip arthroplasty in the perioperative period	**IV1:** LI **IV2:** Placebo **IV3:** PNB • FNB, FIB, Psoas compartment block, LPB, 3 in 1 block, or continuous infusion **DV:** • Post-Op analgesia (paracetamol, NSAID, celecoxib, Parecoxib, or PCA opioid)	**Post-Op:** • Pain: NRS or VAS score • CMC: ME **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • RevMan V. 5.2 • WinBUGS 1.4.3 • WMD with 95% CI • Q statistic • I2 value **Qualitative Analysis:** • GRADE • Rank-order analysis • Cochrane Collaboration risk Assessment **Statistical significance**: • P-Value < 0.05	**LI vs. Placebo** • Lower pain score at 24hr (WMD -0.61, 95%CI -0.97 to -0.24, P=0.001)* • Lower ME at 24hr (WMD -7.16, 95%CI -11.98 to -2.35, P=0.004)* **PNB vs. Placebo** • NS pain score at 24hr (WMD -0.43,95%CI -0.99 to 0.12, P=0.12) or ME (WMD -3.14mg, 95%CI -11.30 to 5.02, P=0.45) **PNB vs. LI** • NS difference in pain score (WMD -0.36, 95%CI -1.06 to 0.31) or ME at 24hr (WMD -4.59mg, 95%CI -9.35 to 0.17)	I	**Strengths:** • Most comprehensive summary of the available evidence and evaluation of LI analgesia vs PNB as analgesic approach for THA **Limitations:** • Variable population characteristics • High heterogeneity • Variable administration methods, pain reporting methods, analgesic use **Risk or harm if implemented: NR** **Feasibility of use in the project practice area:** • Supports use of LI as an alternative to PNB as perioperative analgesic intervention
APA citation: Ma, H., Chou, T., Tsai, S. , Chen, C., Wu, P., & Chen, W. (2019). The efficacy of intraoperative periarticular injection in total hip arthroplasty: A systematic review and meta-analysis. *BMC Musculoskeletal Disorders, 20(*1), 1-9. https://doi.org/10.1186/s12891-019-2628-7								

Conceptual Framework or Model	*Design or Method*	*Sample & Setting*	*Major Variables Studied & their Definitions if any*	*Outcome Measurements*	*Data Analysis*	*Findings*	*LOE*	*Quality of Evidence: Critical Worth to Practice*
NA	SR and MA • Databases (PubMed, Web of Science, Embase, Cochrane Library) searched from earliest record to October 2018 using PRISMA guidelines	N = 11 RCT **Exclusion criteria:** • Non-RCT, comparative experimental trials, single armed follow-up studies, case series, case studies, duplicates, not in English, full text unavailable **Attrition:** NR **Setting:** • Patients undergoing THA in perioperative period	**IV1:** PAI **IV2**: CG • No PAI or Placebo **DV**: • GA (N = 5 RCT) • SA (N = 4 RCT) • SA or GA (N= 1 RCT)	**Post-Operative:** • Pain: VAS • Opioid Consumption • LOHS • PONV **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • CMA software version 3 • SMD • OR • I2 test **Qualitative Analysis:** • Jadad Score • Egger's Test **Statistical significance**: • P-Value < 0.05	**PAI:** • Lower at rest VAS score at 24hr (SMD -0.253; 95% CI -0.418 to -0.088; P=0.003)* and at 48hr (SMD -0.291; 95% CI -0.478 to 0.104; P=0.002)* • Lower VAS with activity at 24hr (SMD -0.238; 95% CI -0.435 to -0.041; P=0.04)* • Lower opioid consumption at 24hr (SMD -0.293; 95% CI -0.514 to -0.071; P=0.01)* • No differences in LOHS (SMD -0.052; 95% CI -0.215 to 0.110; P=0.526) or PONV (OR 0.574; 95% CI 0.268 to 1.228; P=0.153)	I	**Strengths:** • No significant publication bias **Limitations:** • Only includes articles in English • Heterogeneity of clinical settings between studies **Risk or harm if implemented:** • Future study needed for incidence of adverse events **Feasibility of use in the project practice area:** • Supports PAI as safe option for THA pain management
Primary Anesthesia								
APA citation: Liang, C., Wei, J., Cai, X., Lin, W. Fan, Y., & Yang, F. (2017). Efficacy and safety of 3 different anesthesia techniques used in total hip arthroplasty. *Medical Science Monitor, 23*, 3752-3759. https://doi.org/10.12659/MSM.902768								
Conceptual Framework or Model	*Design or Method*	*Sample & Setting*	*Major Variables Studied & their Definitions, if any*	*Outcome Measurement(s)*	*Data Analysis*	*Findings*	*LOE*	*Quality of Evidence: Critical Worth to Practice*
NA	RCS	N= 198 patients Mean Age: 67 **Exclusion Criteria:** • History of nervous system or cardiac surgery, mental disorder, severe defective vision, neurological	**IV1:** GA (N = 66 patients) • Induction: Midazolam (0.1mg/kg), propofol (1-1.5mg/kg), fentanyl (2-4mcg/kg), vecuronium	**Post-Op:** • Pain: VAS score • MMSE • B-Amyloid **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • SPSS 18.0 • ANOVA • SMD • Kruskal-Wallis test **Qualitative Analysis**: • Chi-square test	• Higher pain VAS score at 0-24hr in GA group vs CEA or SEA groups* • Higher pain VAS score at 3hr, 6hr, and 24hr in SEA group vs CEA groups*	III	**Strengths:** • First to compare effects of 3 anesthesia methods on perioperative outcomes during THA **Limitations:** NR

		disorder, refused to participate, Mini-mental stat examination score <23, long term use of sedatives or anti-depressants, history of alcohol consumption, preoperative hypovolemia, puncture site infection, delirium, or agitation, not successfully anesthetized within 15 minutes of drug injection **Attrition:** NA **Setting:** • Patients undergoing THA from March 2013 to March 2015 at Huadong Hospital	bromide (o.1-0.15 mg/kg) • Maintenance: propofol (6-8mg/kg) infusion **IV2:** CEA (N= 66 patients) • 0.5% bupivacaine **IV3:** SEA (N= 66 patients) • 1% lidocaine for skin infiltration • Spinal: 0.5% hyperbaric bupivacaine • Epidural injection: 10 ml 0.25% bupivacaine, 1 ml of clonidine (2mcg/kg), 1 ml fentanyl (25 mcg) **DV:** • Monitoring of ECG, pulse-oximeter, non-invasive blood pressure, heart rate		**Statistical significance**: • P-Value < 0.05	• Lower MMSE score at POD1 and POD5 in GA group vs. CEA group* • Higher MMSE score at POD1 and POD5 in CEA group vs SEA group* • GA higher B-Amyloid expression vs SEA or CEA* • NS difference in B-Amyloid in SEA vs CEA		**Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • SEA and CEA superior to GA in THA
APA citation: Kelly, M. E., Turcotte, J. J., Aja, J. M., MacDonald, J. H., & King, P. J. (2021). General vs neuraxial anesthesia in direct anterior approach total hip arthroplasty: Effect on length of stay and early pain control. *The Journal of Arthroplasty*, *36*(3), 1013–1017. https://doi.org/10.1016/j.arth.2020.09.050								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	Retrospective chart review	N= 500 patients **Exclusion Criteria:** • Bilateral THA, revisions, posterolateral approach **Attrition:** NA **Setting:**	**IV1:** SA (N= 376 patients) • Lumbar puncture with hyperbaric bupivacaine • Intrathecal fentanyl at anesthesiologist discretion • Propofol for sedation **IV2:** GA	**Post-Op:** • Pain: NRS • CMC: MME • LOHS **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • SPSS 25.0 • t-test • Multivariate linear regression **Qualitative Analysis:** • Chi-square test **Statistical significance**: • P-Value < 0.05	**SA:** • Lower MME in PACU (P < 0.001)* • Lower pain NRS score in PACU (P<0.001)* • Shorter LOHS (P = 0.003)*	III	**Strengths:** NR **Limitations:** • Conducted at a single institution • Selection bias risk • Small sample size • More complex cases received GA vs SA

		• Primary unilateral THA undergoing direct anterior approach between July 2017 to July 2018 at a single institution	(N=124 patients) • Inhaled anesthetics • IV opioids intra-op **DV:** • **Pre-Op:** Joint Replacement Center coordinated care • **Intra-Op:** Fluid protocol, PAI prior to closure, IV or topical tranexamic acid • **Post-Op:** Rapid recovery protocol with pain regimen of celecoxib, acetaminophen, pregabalin, PRN short-acting opioids • No PCA or PNB					**Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • Support use of SA in THA patients using direct anterior approach
APA citation:: Sansonnens, J., Taffé, P., Burnand, B., & ADS study group (2016). Higher occurrence of nausea and vomiting after total hip arthroplasty using general versus spinal anesthesia: An observational study. *BMC Anesthesiology*, *16*(1), 44. https://doi.org/10.1186/s12871-016-0207-0								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	Observational Study	N= 3922 **Exclusion Criteria:** • Age < 18y, bilateral THA, not discharge from PACU, required resuscitation during surgery or 24 hr post-op, died during surgery or within 24 hr post-op, anesthesia other than GA or SA, ASA status 4 **Attrition:** NA	**IV1:** SA (N= 1938 patients) **IV2:** GA (N= 1984 patients) **DV:** NR	**Post-Op:** • PONV via scoring system **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • Propensity score matching • Mahalanobis distance matching • OR • RD • STATA software 64-bit version 13.1 **Qualitative Analysis:** NR **Statistical significance**: NR	**SA** • PONV occurs 2% less with SA compared to GA	III	**Strengths:** • Utilized data from a registry that mandatory reports adverse events **Limitations:** • Does not account for unrelated confounders • Anesthetic technique variability during study • Study did not include antiemetic premedication

		Setting: • Elective THA performed between 1999-2008 in a Swiss orthopedic clinic						• Demographic variability **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:** • SA may provide favorable reduction in PONV compared to GA
APA citation: Yap, E., Wei, J., Webb, C., Ng, K., & Behrends, M. (2022). Neuraxial and general anesthesia for outpatient total joint arthroplasty result in similarly low rates of major perioperative complications: A multicentered cohort study. *Regional Anesthesia Pain Medicine, 47*, 294-300. http://dx.doi.org/10.1136/rapm-2021-103189								
Conceptual Framework or Model	***Design or Method***	***Sample & Setting***	***Major Variables Studied & their Definitions, if any***	***Outcome Measurement(s)***	***Data Analysis***	***Findings***	***LOE***	***Quality of Evidence: Critical Worth to Practice***
NA	Multicentered retrospective cohort study using the SROSE guidelines	N= 11,523 patients Average Age: 68 **Exclusion Criteria:** • Age < 18y, emergent, not compartmental, oncologic tumor, fracture related, revisions, bilateral joint arthroplasties, received both GA and NA **Attrition:** NA **Setting:** • Outpatient procedures performed in a hospital setting in Kaiser Permanente Northern California for patients undergoing unilateral primary THA or TKA	**IV1:** SA (N=10,003 patients) **IV2:** GA (N=1,520 patients) **DV:** NR	**Post-Op:** • Pain: NRS score • CMC: MME • PONV via scoring system • Complications: 30-day **Reliability information (*alphas*, if any):** NA	**Statistical Analysis:** • SAS 9.4 • t-test • Wilcoxon test • SAS version 9.4 **Qualitative Analysis:** • Chi-square test • Fishers exact test **Statistical significance**: • P-Value < 0.05	**GA** • Higher MME intra-op (P<0.01)* and in PACU (P<0.01)* • Higher pain NRS score in PACU (P<0.01)* • Higher PONV in PACU (P=0.01)* • NS difference in 30-day post-op complications (OR=0.85, 95%CI -.56 to 1.27)	III	**Strengths:** • Large sample size • Community-based setting • Strong statistical analysis **Limitations:** • Post-op complications should be viewed as exploratory not confirmatory due to inadequate power • Institution prefers NA over GA • Risk of bias due to retrospective design **Risk or harm if implemented:** NR **Feasibility of use in the project practice area:**

		patients between January 2017 to December 2019						• Support use of SA for outpatient Total joint arthroplasty

Note: ANOVA = one way analysis of variance; CHRSI = Cochrane Handbook for Systematic Reviews of Interventions; CI = confidence interval; COX2-I = cyclooxygenase 2 inhibitors; DV = dependent variable; FIB = fascia iliac block; GA = general anesthesia; GRADE = grading of recommendations, assessments, development, and evaluations; hr = hour; intra-op = intraoperative; IV = intravascular; IV1 = independent variable 1; IV2 = independent variable 2; IV3 = independent variable 3; IV4 = independent variable 4; LI = local infiltration; LOHS = length of hospital stay; kg = kilograms; LOS = length of stay; MA = meta-analysis; MBS = modified bromage score; mcg = micrograms; ME = morphine equivalent; mg = milligram; ml = milliliter; MME = morphine milligram equivalent; MMSE = mini-mental status examination; MS = morphine supplementation; NA = not applicable; NR = not reported; NRS = numerical rating scale; NS = not significant; NSAID = non-steroidal anti-inflammatory drug; OR = odds ratio; P.O = per oral; PACU = post-anesthesia care unit; PAI = periarticular injection; PNB = peripheral nerve block; Post-Op = postoperative; Pre-Op = preoperative; PRISMA = preferred reporting items for systematic reviews and meta-analysis; PS = parecoxib sodium; RCS = randomized controlled study; RCT = randomized controlled trial; RD = risk difference; RR = relative risk; SA = spinal anesthesia; SMD = standard mean difference; SR = systematic review; SROSE = strengthening the reporting of observational studies in epidemiology; THA = total hip arthroplasty; TKA = total knee arthroplasty; VAS = visual analog scale; vs = versus; * = statistically significant

Appendix B

JHEBP Hierarchy of Evidence Tool

Evidence Level	Types of Evidence
Level I	□Experimental study, randomized controlled trial (RCT) □Explanatory mixed methods design that includes only a Level I quaNtitative study □Systematic review of RCTs, with or without meta-analysis
Level II	□Quasi-experimental study □Explanatory mixed methods design that includes only a Level II quaNtitative study □Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis
Level III	□Nonexperimental study □Systematic review of a combination of RCTs, quasi-experimental and nonexperimental studies, or nonexperimental studies only, with or without meta-analysis. □Exploratory, convergent, or multiphasic mixed methods studies □Explanatory mixed methods design that includes only a Level III quaNtitative study □QuaLitative study □Systematic review of quaLitative studies with or without meta-synthesis
Level IV	Opinion of respected authorities and/or nationally recognized expert committees or consensus panels based on scientific evidence. Includes: □Clinical practice guidelines □Consensus panels/position statements
Level V	Based on experiential and non-research evidence. Includes: □Scoping reviews □Integrative reviews □Literature reviews □Quality improvement, program or financial evaluation □Case reports □Opinion of nationally recognized expert(s) based on experiential evidence

Appendix C

Evidence-Based Guideline

GUIDELINE DRAFT	
Title: Perioperative Analgesic Guideline for Adult Elective Hip Arthroplasty	**NUMBER:** 1
ISSUE DATE:	**EFFECTIVE DATE:**
DEVELOPED / REVISED BY: MaKyah Dittoe, BSN, RN, SRNA; Dr. Ruth Chavez, DNP, APRN-CNP; Dr. Brian Garrett, CRNA, DNP; Dr. Amy Bishop, DNP, AGCNS-BC	
REVIEWED BY:	**DATE REVIEWED:**
APPROVED BY:	

SCOPE – This guideline is in effect for an urban outpatient surgical center specializing in elective hip arthroplasty.

Statement of Purpose:
The purpose of this guideline is to provide evidence-based recommendations for selecting analgesic adjuncts during adult elective hip arthroplasty. The mechanism of action of certain analgesics can also alleviate postoperative nausea and vomiting. The guidelines outline analgesic medications that reduce postoperative pain, opioid utilization, postoperative nausea, and vomiting. When choosing an analgesic adjunct, it is vital to thoroughly assess its indications, contraindications, risks, and benefits. Of note patient refusal is considered an absolute contraindication.

DEFINITIONS:
- **Analgesia:** Absence of pain
- **PONV:** Postoperative nausea and vomiting
- **PENG:** Pericapsular nerve group block

POLICY:
This guideline is designed to assist anesthesia providers and orthopedic surgeons in selecting appropriate analgesia adjuncts for the preoperative, intraoperative, and postoperative phases. While it strives to ensure top-notch patient care, it cannot guarantee a particular result for each patient. It is not intended to replace clinical expertise, nor does it create any legal duties or obligations.

GUIDELINE

I. **Acetaminophen**
   a. Route:
      i. Intravenous
   b. Dose:
      i. 1,000 mg is the recommended dose
   c. Timing
      i. Preoperatively
      ii. Postoperatively

d. Recommended Criteria
    i. Inclusion Criteria:
        1. Adults over 18 years; elective hip arthroplasty
        2. Reduction of postoperative pain, opioid utilization and PONV
    ii. Common Exclusion Criteria:
        1. Severe hepatic impairment; allergy to acetaminophen
    iii. Considerations:
        1. Reduced elimination in renal impaired patients; patients may be taking medications at home that contain acetaminophen
        2. Total daily dose should not exceed 4,000 mg per 24 hours

II. **Cyclooxygenase 2 Inhibitor**
a. Route:
    i. Oral
b. Dose:
    i. 200 – 400 mg of Celecoxib is the recommended dose
c. Timing:
    i. Preoperatively
d. Recommendation Criteria:
    i. Inclusion Criteria:
        1. Adults over 18 years; elective hip arthroplasty
        2. Postoperative pain and opioid utilization
    ii. Exclusion Criteria:
        1. Severe kidney disease; malignancy; allergy to NSAID or COX2-I
    iii. Considerations:
        1. Risk versus benefit should be evaluated in patients with significant cardiac or stroke history

III. **Acetaminophen/NSAID combination**
a. Route:
    i. Intravenous Acetaminophen
    ii. Oral Ibuprofen
b. Dose:
    i. 1000 mg acetaminophen is the recommended dose over …
    ii. 400 – 800 mg Ibuprofen is the recommended dose
c. Timing:
    i. Preoperatively
    ii. Postoperatively
d. Recommendation Criteria:
    i. Inclusion Criteria:
        1. Adults over 18 years; elective hip arthroplasty
        2. Reduction of postoperative pain and opioid utilization
    ii. Exclusion Criteria:
        1. Severe coagulopathy disorders; allergy to ibuprofen.
    iii. Considerations:
        1. If celecoxib is given preoperatively, omit ibuprofen preoperative administration

2. Risk versus benefits of ibuprofen administration in asthma patients and patients with aspirin allergy

IV. **Dexamethasone**
   a. Route:
      i. Intravenous
   b. Dose:
      i. 8 – 10 mg is the recommended dose
   c. Timing:
      i. Intraoperatively
   d. Recommendation Criteria:
      i. Inclusion Criteria:
         1. Adults over 18 years; elective hip arthroplasty
         2. Reduction of postoperative pain, opioid utilization, and PONV
      ii. Exclusion Criteria:
         1. Severely immunocompromised patients; uncontrolled diabetics
      iii. Considerations:
         1. Controlled diabetics may need glucose monitoring post dexamethasone administration

V. **Ketamine**
   a. Route:
      i. Intravenous
   b. Dose:
      i. 0.1 – 0.3 mg/kg is the recommended dose
   c. Timing:
      i. Intraoperatively
   d. Recommendation Criteria:
      i. Inclusion Criteria:
         1. Adults over 18 years; elective hip arthroplasty
         2. Reduction of postoperative pain, opioid utilization, and PONV
      ii. Exclusion Criteria:
         1. High risk coronary or vascular disease; uncontrolled hypertension; elevated intraocular pressure; elevated intracranial pressure; psychosis; sympathomimetic syndrome; recent liver transplantation; porphyria; severe hepatic dysfunction
      iii. Considerations:
         1. Older adults may require reduced doses

VI. **Gabapentinoid**
   a. Route:
      i. Oral
   b. Dose:
      i. Gabapentin 600 mg is the recommended dose
      ii. Pregabalin 300 mg is the recommended dose
   c. Timing:
      i. Preoperatively
   d. Recommendation Criteria:
      i. Inclusion Criteria:

1. Adults over 18 years; elective hip arthroplasty
2. Adjunct in patients with chronic pain
3. Reduction of PONV

ii. Exclusion Criteria:
1. Myasthenia gravis; myoclonus

iii. Considerations:
1. Ensure consent prior to administration due to sedative side effect; older adults may require reduced doses; interactions with patient's home medications

VII. **Primary Anesthesia**

a. Route:
i. Spinal Anesthesia

b. Dose:
i. 0.5% bupivacaine is the recommended dose for spinal anesthesia
ii. 1 % lidocaine is the recommended dose for the skin infiltration

c. Timing:
i. Intraoperatively

d. Recommendation Criteria:
i. Inclusion Criteria:
1. Adults over 18 years; elective hip arthroplasty
2. Reduction of postoperative pain, opioid utilization, and PONV

ii. Exclusion Criteria:
1. Infection at site; shock; increased intracranial pressure; allergy to local anesthetic

iii. Considerations:
1. Risk versus benefit with coagulopathy disorders, spine deformity or hardware, increased intracranial pressure, indeterminant neurological disease

VIII. **Regional Anesthesia**

a. Route:
i. Peripheral nerve block
1. PENG or Fascia iliac

b. Dose:
i. Long-acting local anesthetic (e.g., ropivacaine or bupivacaine)

c. Timing:
i. Preoperatively

d. Recommendation Criteria:
i. Inclusion Criteria:
1. Adults over 18 years; elective hip arthroplasty
2. Reduction of postoperative pain and opioid utilization

ii. Exclusion Criteria:
1. Allergy to local anesthetic

iii. Considerations:
1. Risk versus benefit in coagulopathy disorders; preexisting neurological deficits; infection at site

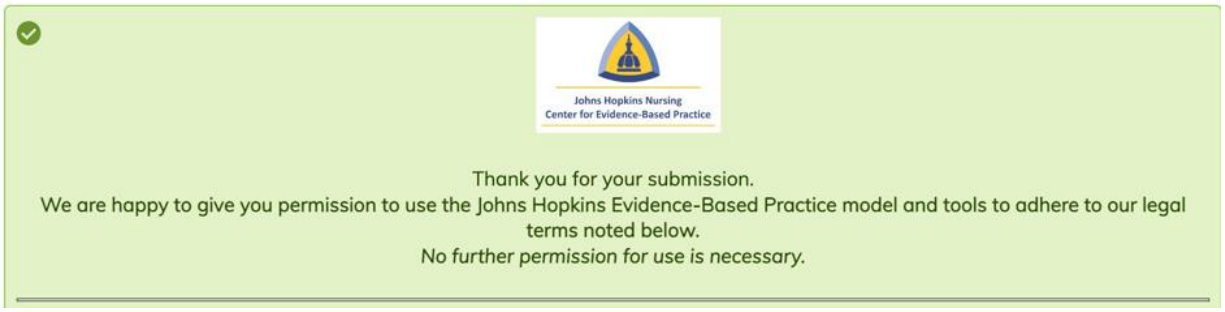
2. PENG block allows better preservation of quadriceps motor strength compared to the fascia iliac

Appendix D

Johns Hopkins Evidence Based Practice Model: PET Process

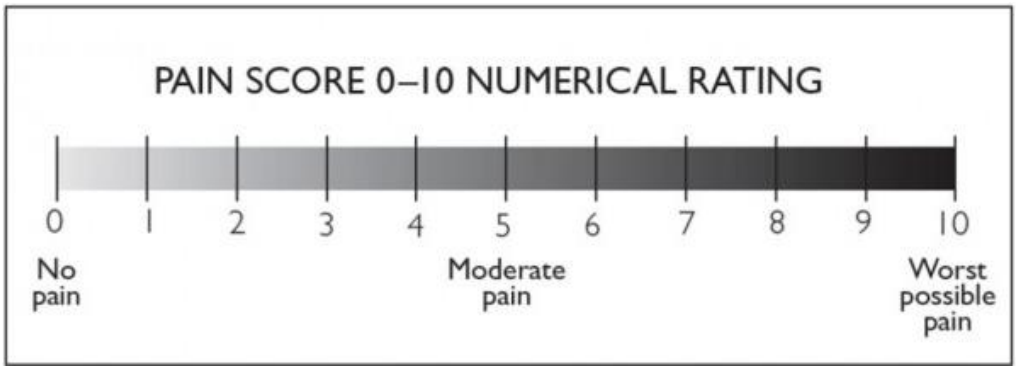
Appendix E

Johns Hopkins Evidence-Based Practice Permission



Appendix F

Visual Numerical Rating Scale



(Physiopedia, 2023)

Appendix G

Milligram Morphine Equivalent Conversion

Opioid	Conversion factor*
Codeine	0.15
Fentanyl transdermal (in mcg/hr)	2.4
Hydrocodone	1.0
Hydromorphone	5.0
Methadone	4.7
Morphine	1.0
Oxycodone	1.5
Oxymorphone	3.0
Tapentadol†	0.4
Tramadol§	0.2

Note: each opioid dose is multiplied by the conversion factor to determine the milligram morphine equivalents; mcg/hr, microgram per hour

(Dowell et al., 2022, p. 31).

Appendix H

Postoperative Nausea and Vomiting Intensity Scale

Assessment	Score
A. At 6 hours after surgery (or time of discharge if after ambulatory surgery)	
Q1 Have you vomited or had dry-retching*? a) No b) Once or twice c) Three or more times	 0 2 50
Q2 Have you experienced a feeling of nausea (“*an unsettled feeling in the stomach and slight urge to vomit”)?* If yes, has your feeling of nausea interfered with activities of daily living, such as being able to get out of bed, being able to move about freely in bed, being able to walk normally or eating and drinking? a) No b) Sometimes c) Often or most of the time d) All of the time	 0 1 2 25
Q3 Has your nausea been mostly: a) varying (“*comes and goes*”)? b) constant (“*is nearly or almost always present*”)?	 1 2
Q4 What was the duration of your feeling of nausea (in hours [whole or fraction])?	___ • ___ h
For Part A, if answer to Q1 = c), score A = 50; otherwise, select the highest score of Q1 or Q2, then multiply x Q3 x Q4	PONV intensity score (0-6 h) **A =**

**Count distinct episodes: several vomits or retching events occurring over a short time frame, say 5 min, should be counted as one vomiting/dry-retching episode; multiple episodes require distinct time periods without vomiting/dry-retching*

Scoring for Clinical Importance of PONV

Total Score	Score
Clinically important PONV is defined as a total score ≥50 at any time throughout the study period. Scores at 6 and 24 (and, if considered important in the clinical context, 72) hours can be added for quantification of the entire period, or sub-scales used for each period.	Final PONV intensity score (0-72 h)
A + B + C =	

(Wengritzky et al., 2009)

Appendix I

Project Budget Estimate

EDUCATION COMPENSATION

DEPARTMENT	Stakeholder	Mean Hourly Pay	Two Hour Pay Compensation	Attendance Number	Total Compensation Amount
ANESTHESIA	Anesthesiologist	$145.66	$291.32	2	$582.64
	CRNA	$95.01	$194.52	6	$1,167.12
EDUCATION	Training and Development Manager	$63.51	$127.02	1	$127.02
INFORMATION TECHNOLOGY	Computer System Analyst	$51.70	$103.40	1	$103.40
NURSING	Registered Nurse	$42.80	$85.60	18	$1,540.80
PHARMACY	Pharmacist	$62.22	$124.44	2	$248.88
QUALITY IMPROVEMENT	Quality Assurance Analyst	$50.84	$101.68	1	$101.68
SUPPLY AND DISTRIBUTION	Medical Equipment Preparer	$19.94	$39.88	2	$79.76
SURGEON	Orthopedic Surgeon	$178.56	$357.12	2	$714.24
					TOTAL EDUCATION COMPENSATION COST: $4,665.54

OTHER EDUCATION COST

ITEM	Cost Per Unit	Amount	Total Cost
EDUCATIONAL HANDOUTS COPIES	$0.20 per page	84 pages	$16.80
			TOTAL OTHER EDUCATION COST: $16.80

MEDICATIONS

MEDICATION	Cost Per Unit	# Needed Per Patient	Cost Per Patient	Cost for Sample Size (n = 50)
KETAMINE	$0.74 per ml (10 mg/ml)	1-2ml	$0.74 – $1.48	$37 - $74
IBUPROFEN	$0.087 per 600 mg capsule	1 capsule	$0.87	$4.35
CELECOXIB	$0.10 per 200 mg capsule	1-2 capsules	$0.10 - $0.20	$5 - $10
OFIRMEV	$41 per 100 ml bottle (10 mg/ml)	2,000 ml	$82	$4100

DEXAMETHASONE	$0.52 per 4 mg/ml	2 vials	$1.04	$52
BUPIVACAINE	$3.11 per 30 ml vial (5 mg/ml)	1 vial	$3.11	$155.5
ROPIVACAINE	$6.06 per 30 ml vial	1 vial	$6.06	$303
SPINAL KIT	$66.99	1	$66.99	$3,349.5
				TOTAL MEDICATION COST: $8,006.35 – $8,048.35 ADJUSTED TOTAL MEDICATION COST: $4,003.18 – $4,024.18
		EQUIPMENT		
EQUIPMENT	**Cost Per Unit**	**Amount Needed**	**Total**	
BUTTERFLY ULTRASOUND	$2,699	1	$2,699	
MEMBERSHIP FOR ULTRASOUND	$420	1 year	$420	
				TOTAL EQUIPMENT COST: $3,119
				PROJECT ESTIMATE: $15,807.69– $15,849.69 ADJUSTED PROJECT ESTIMATE: $11,804.52- $11,783.52
			TOTAL PROJECT ESTIMATE: $16,416.06 - $20,461.23	

Note: CRNA, certified registered nurse anesthetist; #, number. The estimate for the total cost of acquiring all medications is included in the medication cost calculation. The total medication cost is reduced by 50% to accommodate the current pharmaceutical supply at the clinical site and is portrayed as the adjusted total medication cost. The project estimate includes the total cost for the acquisition of all material. The adjusted project estimate incorporates the adjusted total medication cost into the project total. Cost estimates are from the United States Bureau of Labor Statistics (2022), Staples (2023), and Cardinal Health (2023).