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Final Scholarly Project: Development of Evidence-Based Practice Guidelines for Utilizing Erector Spinae Plane Blockade for Patients Undergoing Cardiac Surgery

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Abstract

In the United States, the aging population and high rates of cardiovascular disease leads to increased cardiothoracic surgeries. Analgesia for cardiac surgeries often involves high-dose opioids. However, with an ever-increasing opioid epidemic and adverse effects on the postoperative healing process, recent literature seeks to decrease opioid consumption by utilizing alternative methods of analgesia. The American Association of Nurse Anesthetists recommends the use of regional anesthesia techniques to reduce the incidence of undertreated postoperative pain that can occur from opioid-sparing methods of analgesia. This project aims to create an evidence-based analgesia guideline for adult patients undergoing cardiac surgery. Interventions will include an erector spinae plane block and an opioid-sparing postoperative guideline; evidence shows that erector spinae plane blocks decrease postoperative opioid consumption and improve postoperative outcomes, specifically decreased postoperative mechanical ventilation time. The Johns Hopkins Evidence-Based Practice Guideline Model for Nurses and Healthcare Professionals will guide this process.

Keywords: cardiac surgery, anesthesia, opioids, erector spinae plane block, regional anesthesia

Final Scholarly Project

Introduction of the Problem

Adequate pain control is pivotal in successful anesthesia administration. Appropriate analgesia in cardiac surgery patients is especially critical, with inadequate pain control potentiating life-threatening consequences such as increases in cardiovascular and respiratory complications and increased stress response, ultimately resulting in increased morbidity and mortality (Athar et al., 2021). Ineffective pain management in cardiac surgery patients can also lead to tachycardia and hypertension in response to pain, increasing myocardial oxygen consumption and hemodynamic impairment (Cosarcan et al., 2022). A pivotal point of discussion for years is methods for adequate and safe analgesia, with opioids remaining a mainstay for pain control since the mid-19th century (Velasco et al., 2019). Opioids are valued highly in anesthesia because they can reliably and rapidly suppress pain and sympathetic stimulation throughout the body (Velasco et al., 2019). However, opioids, while effective in relieving pain, are accompanied by side effects that increase postoperative complications (Grant et al., 2020). The opioid epidemic in the United States, along with the adverse effects of opioids, led to Enhanced Recovery After Surgery (ERAS) programs nationwide and worldwide to adopt opioid-sparing, multimodal analgesia techniques to manage postoperative pain (Athar et al., 2021), showing that decreased opioid consumption in the perioperative period to be beneficial.

While opioids are effective in managing pain, the ever-growing opioid epidemic worldwide and the adverse effects of opioid use require clinicians to examine the benefits of opioid-sparing techniques. Drug overdose is the leading cause of accidental death in adults in the United States, with overprescribing of opioids by clinicians named as a significant cause (Hirji et al., 2019). Surgical patients, especially cardiac surgery patients, are at an increased risk of developing chronic pain and long-term use of opioids (Jiang et al., 2021). In addition, opioid use is frequently linked to opioid-induced hyperalgesia (Kwanten et al., 2019). Opioid-induced hyperalgesia is defined as decreased pain thresholds or painful

responses to previously non-nociceptive stimuli following the consumption of opioids (Kwanten et al., 2019). Furthermore, opioids are more often associated with adverse drug events than other analgesics, including negative gastrointestinal effects such as nausea, vomiting, and constipation, central nervous system effects including somnolence and altered mental status, respiratory depression leading to respiratory failure, urinary retention, and pruritis (Allen et al., 2020). These potential complications increase hospital stay length and healthcare costs (Allen et al., 2020). Overall, decreases in opioid consumption allow for earlier extubations, reduction in postoperative complications, and decreased ICU and hospital stays, all leading to decreased overall costs of cardiac surgery perioperative care (Cosarcan et al., 2022). Decreasing opioid consumption perioperatively is imperative to decreasing healthcare costs, opioid-related adverse effects, and contribution to the opioid epidemic.

Cardiovascular disease affects a significant amount of the population. Cardiovascular disease, including predominately coronary artery disease, cerebrovascular disease, and peripheral artery disease (World Health Organization, 2021), is the leading cause of mortality worldwide (Jiang et al., 2021). The aging population in the United States led and will continue to lead to an increase in cardiothoracic procedures (Jiang et al., 2021). Cardiac procedures cause unique pain sensations from soft tissue incisions and bony injuries (Cosarcan et al., 2022). Sources of pain in open-heart patients include sternotomy, sternal retraction, internal mammary dissection, posterior rib dislocation or fracture, potential brachial plexus injury, and mediastinal and pleural drains (Cosarcan et al., 2022). Patients undergoing cardiac surgeries also cause a shift in the peripheral and central nervous systems following their surgery caused by DNA methylation and gene expression of proteins that modulate opioid analgesia (Cosarcan et al., 2022). Some cardiac surgery cases may also lead to gene-driven expression of inflammatory pain modulators (Cosarcan et al., 2022). Analgesia to cover all sources of pain and pain modulation is imperative to adequate perioperative comfort in open-heart patients.

Combating pain in surgical patients requires the utilization of many pharmaceutical and analgesic adjuncts. Inadequately treated pain in open-heart patients leads to the inability to expand the lungs fully, leading to atelectasis (Jannati & Attar, 2019). This atelectasis leads to ischemia and ischemia-related dysrhythmias and requires preventative treatments to avoid postoperative complications (Jannati & Attar, 2019). High doses of long-acting opioids are often used in cardiac surgery cases for their efficacy in blocking the sympathetic response from surgical pain while still exuding hemodynamic stability (Jiang et al., 2021). The use of high-dose opioids in open-heart patients often leads to delayed recovery, respiratory depression, prolonged ventilation, increased ICU stays and costs, and increased postoperative complications (Kwanten et al., 2019). The negative implications of opioid use in the open-heart population lead clinicians to seek alternative methods of analgesia.

Current pain control efforts in open-heart surgery shifted away from high-dose opioids to using multimodal pain regimens or opioid-sparing guidelines. Multimodal pain regimens make use of combinations of nonnarcotic analgesics such as ketamine, dexmedetomidine, acetaminophen, ketorolac, and gabapentin to decrease opioid requirements (Nazarnia & Subramaniam, 2021). However, using these opioid-sparing guidelines is not always effective due to the inability to use all the adjunct analgesics for all patient populations (Nazarnia & Subramaniam, 2021). For example, acetaminophen is not recommended for patients with liver disease, and ketorolac is discouraged in patients with increased glomerular filtration rates or increased bleeding risks (Nazarnia & Subramaniam, 2021). These analgesics also trigger side effects, such as the potential for hypotension and bradycardia with dexmedetomidine (Nazarnia & Subramaniam, 2021). Another barrier to multimodal pain regimens is provider limitations due to prescribers' beliefs that opioids are superior analgesics, feelings of inconsistent analgesic effects with opioid alternatives, limited experience with opioid alternatives, discomfort with using multiple pain adjuncts on patients with co-morbidities, and negative experiences

with opioid alternatives (Valasco et al., 2019). These barriers led clinicians to investigate other pain control methods.

Neuraxial and regional anesthesia was added to many guidelines to increase the analgesic efficacy of opioid-sparing pain management efforts. The gold standard neuraxial method in cardiac surgery patients are thoracic epidurals (Cosarcan et al., 2022). Thoracic epidurals can lead to shorter ICU stays, decreased anesthesia costs, and decreased hospital stays (Cosarcan et al., 2022). However, thoracic epidurals risk spinal and epidural hematomas in any patient population, especially patients with increased coagulopathy after cardiopulmonary bypass (Cosarcan et al., 2022). There is also an increased risk of hypotension from thoracic epidurals in patients with severe coronary artery disease, increasing their risk for further ischemia (Jiang et al., 2021). The risk of complications of thoracic epidurals and the increased availability of ultrasounds leads practitioners to focus on using peripheral nerve blocks in neural planes for multimodal pain management in cardiac surgery patients (Cosarcan et al., 2022). It is imperative to use this advanced technology in clinical practice to improve patient outcomes.

Background

Opioids are a pillar in the medical field for pain control, dating back to the mid-19th century. Opioids are a mainstay in treating pain in anesthesia due to their ability to reliably and rapidly suppress pain and sympathetic stimulation at multiple levels, including the brain, spinal cord, and peripheral nervous system, as well as their ability to decrease consciousness and reduce the minimum alveolar concentration of inhaled anesthetics (Velasco et al., 2019). However, opioids lead to a plethora of adverse side effects, such as excessive sedation, respiratory depression, ileus, and nausea and vomiting, that lead to increased postoperative complications, increased hospital length of stay, and increased healthcare costs (Velasco et al., 2019), leading to negative patient outcomes and increased healthcare costs.

Cardiovascular disease is the leading cause of mortality in the world. An ever-aging population in the United States will inevitably increase cardiovascular disease prevalence, requiring more cardiothoracic procedures (Jiang et al., 2021). Even with years of successful cardiac surgeries, poorly controlled postoperative pain and the development of chronic pain occurs in 20-50% of patients following sternotomy and thoracotomy (Jiang et al., 2021). Physical causes of pain after cardiac surgeries include but are not limited to sternotomy, sternal retraction, internal mammary dissection, posterior rib dislocation or fracture, potential brachial plexus injury, and mediastinal and pleural drains (Cosarcan et al., 2022). Cardiac surgeries often lead to a shift in pain modulation systems following surgery (Cosarcan et al., 2022). Cardiac surgery patients also experience an inflammatory cascade that induces the expression of inflammatory pain modulators in the spinal cord (Cosarcan et al., 2022). The combination of all of these factors can often lead to ineffective pain management. While pain is inevitable after cardiac surgery, ineffective pain management can lead to systemic and pulmonary complications with severe cardiac consequences. These consequences include tachycardia and hypertension, leading to increased myocardial oxygen consumption and hemodynamic impairment (Cosarcan et al., 2022). Patients with inadequately managed pain do not expand their lungs fully, leading to atelectasis, inevitable ischemia, and consequent dysrhythmias (Jannati & Attar, 2019). The adverse effects of inadequate pain control make it essential for healthcare providers to ensure proper analgesia in cardiac surgery patients.

Appropriate analgesics in cardiac surgery are crucial to combat the large amounts of pain involved with cardiac surgery. Analgesic medications inhibit pain sensations (Jannati & Attar, 2019). Cardiac surgery analgesia often relied on large doses of intravenous opioids (Cosarcan et al., 2022). Since the early 1990s, high-dose opioids were used to blunt the sympathetic response from surgical pain and promote hemodynamic stability (Jiang et al., 2021). While opioids are effective analgesics, they coincide with significant adverse effects such as increased mechanical ventilation times and ICU stays

(Jiang et al., 2021). Opioid use also comes with concerns about the overuse of prescription opioids, with an associated increase in morbidity and mortality (Jelacic et al., 2016). Due to the adverse effects of opioids and "fast-tracking," or the process of quickly extubating patients shortly after admission to the ICU to promote reduced lengths of stay and earlier discharges, guidelines to decrease opioid use gained popularity (Cosarcan et al., 2022). However, even with opioid-sparing guidelines in place, patients' pain is often uncontrolled, and regardless of treatment results, many patients still suffer from pain and still require opioids (Jannati & Attar, 2019). For example, Jelacic et al. (2016) found that intravenous acetaminophen as an adjunct pain medication in postoperative cardiac surgery patients decreased opioid use and improved patient satisfaction. However, opioid side effects did not significantly decrease.

Multimodal opioid-sparing guidelines make use of pain adjuncts but also incorporate the use of regional and neuraxial anesthesia. Regional anesthetic techniques reduce postoperative pain and the potential for developing chronic pain by reducing sensitization from noxious surgical injury and opioid-induced hyperalgesia (Cosarcan et al., 2022). Utilization of ultrasound-guided regional anesthesia increased tremendously with goals to reduce opioid consumption, facilitate early extubation, often in the operating room, and reduce opioid side effects (Cosarcan et al., 2022). Neuraxial blockades are shown to decrease opioid requirements and pain scores, lead to fewer pulmonary complications, lower stroke and myocardial ischemia rates, decrease the incidence of kidney failure, lower infection rates, decrease stress response, shorter ICU stays, lower overall costs, and earlier discharge. Regional anesthesia increases hemodynamic stability, higher safety profiles, opioid-sparing, and improved patient coughs (Cosarcan et al., 2022**).** The benefits of regional and neuraxial anesthesia are unprecedented, and increased utilization of alternative analgesia techniques in clinical practice is essential to improve patient outcomes.

Since implementing multimodal pain management guidelines, thoracic epidural analgesia was the gold standard for cardiac surgery patients. The advantages of thoracic epidural analgesia include

fewer cardiovascular events such as stroke and myocardial ischemia, respiratory complications, decreased occurrences of renal failure, lower infection rates, shorter ICU stays, decreased anesthesia costs, and decreased hospital stays (Cosarcan et al., 2022). However, more recently, concerns about spinal and epidural hematomas led to increased controversy over thoracic epidural analgesia and subsequent decreased use, especially with added concerns of increased coagulopathy after cardiopulmonary bypass (Cosarcan et al., 2022). The risk of hypotension from thoracic epidural analgesia in patients with severe left main disease or triple vessel disease who depend on higher blood pressure for coronary perfusion is at an increased risk for further ischemia (Jiang et al., 2021). Potential complications of thoracic epidural analgesia have shifted focus to using peripheral nerve blocks in neural planes under ultrasound guidance for multimodal pain management in cardiac surgery patients (Cosarcan et al., 2022). Peripheral nerve blocks have the potential to provide effective analgesia without the side effect profile that accompanies thoracic epidural analgesia.

A fascial plane block gaining popularity in multimodal postoperative pain management in cardiac surgery patients is the erector spinae plane block (Chanowski et al., 2019). The erector spinae plane block involves injecting local anesthetic between the erector spinae muscle and the transverse process (Chanowski et al., 2019). The erector spinae plane technique involves the blockade of the dorsal and ventral rami of the thoracic spinal nerves and sympathetic fibers, with local spread into the ipsilateral paravertebral space (Chanowski et al., 2019). The benefits of the erector spinae plane block compared to epidural or paravertebral blocks are it is a superficial and compressible site with less bleeding risk (Chanowski et al., 2019). The erector spinae plane block has shown success in chest wall procedures, thoracotomy, thoracoscopic procedures, and spine surgery and is being used more frequently for other cardiac procedures (Chanowski et al., 2019). The benefits of erector spinae plane blocks make them favorable for opioid-sparing efforts.

Research shows that erector spinae plane blocks are effective in pain management for cardiac surgery patients. Benefits of erector spinae plane blocks in cardiac surgery patients include decreased opioid consumption and sedation with improved pain scores, decreased duration of mechanical ventilation and length of intensive care unit stay, and improved peak inspiratory flows (Hong et al., 2022). Erector spinae plane blocks are esteemed for their relative safety and simplicity over the thoracic paravertebral or epidural blocks, which are associated with risks of hematomas, hypotension, neural injury, or pneumothorax and are technically challenging (Hong et al., 2022). The efficacy, safety, and improved outcomes from erector spinae plane blocks show an imperative need to introduce them into analgesic plans.

Significance to Profession

Anesthesia is essential in the perioperative setting in providing adequate care for patients undergoing procedures. Anesthesia in surgical procedures ideally provides analgesia, amnesia, akinesia, and autonomic control (Basto & Machado, 2020). These pillars of anesthesia are equally essential in cardiac surgeries. While analgesia is vital to alleviate suffering, anesthesia providers must ensure that the pain control methods allow for early mobilization after surgery, reduced hospital stays, and improved patient satisfaction and functional recovery (Dost et al., 2022). Anesthesia providers are often in a conflict with cardiac surgery patients between providing adequate pain control and allowing for a quick recovery. Often opioids are used in cardiac surgery patients but result in adverse effects such as nausea, vomiting, sedation, urinary retention, respiratory depression, and delayed tracheal extubation, leading to increased healthcare costs and delayed recovery (Krishna et al., 2018). However, decreased opioid use must be met with adequate alternative analgesics to combat pain and avoid systemic and pulmonary complications arising from ineffective pain control (Cosarcan et al., 2022). Multimodal analgesic plans are an alternative used to combat this inevitable pain.

As alternative options for pain control, multimodal analgesic plans are a mainstay in managing postoperative pain. Multimodal analgesic plans consisting of combinations of non-opioid pharmacologic and non-pharmacologic interventions to minimize opioid use and subsequent opioid side effects attempt to solve the issue of adequate pain control and quick return of function that anesthesiologists face so often (Bhatia & Buvanendran, 2019). However, multimodal pain management techniques can leave patients with undertreated postoperative pain. Using regional anesthesia with multimodal analgesic efforts can achieve the required analgesia that anesthesiologists strive for while minimizing opioid use (American Association of Nurse Anesthetists (AANA), 2018). Multimodal analgesic plans can lead to fewer opioid-related side effects, improved patient recovery, faster discharge, and improved utilization of resources (Bhatia & Buvanendran, 2019). Multimodal analgesic methods have become vital components of ERAS protocols to assist anesthesia professionals in helping patients recover faster and contribute to higher patient satisfaction (AANA, 2018). Multimodal analgesic methods are essential to improve patient outcomes.

PICO(T)

Problems in practice often lead to changes in policy and procedure to address said problems and implement beneficial improvements. PICO(T) questions help summarize research questions based on these problems to explore the efficacy of therapy change (Riva et al., 2012). The PICO(T) question consists of the population in question (P), the intervention applied to the population (I), what the intervention is being compared to (C), the outcomes to measure the effectiveness of the changes (O), and the duration of time the data will be collected over (T; Riva et al., 2012). This doctoral project will address the following question: *In adult patients undergoing anesthesia for open-heart surgeries (P), how would developing and implementing pain management evidence-based practice guidelines with erector spinae nerve blocks (I) versus the traditional approach with no erector spinae plane block (C)*

affect opioid consumption in the first 24 hours postoperatively and duration of mechanical ventilation in the immediate postoperative period (O)?

Project Objectives

Many facilities adopted ERAS protocols. ERAS protocols often include pain management services through anesthetists, leading to faster recovery and higher patient satisfaction scores (AANA, 2018). Surgical patients receiving opioid-sparing multimodal pain management techniques experience improved recovery. However, research shows that postoperative pain is often undertreated (AANA, 2018). Using regional anesthesia techniques in addition to opioid-sparing analgesia techniques can reduce the incidence of undertreated postoperative pain (AANA, 2018). This scholarly project will determine the outcomes of using erector spinae plane blocks for analgesia in cardiac surgery patients. The objectives for this project are as follows:

- Perform a systematic literature review of cardiac surgery patients receiving erector spinae plane blocks for analgesia
- Develop evidence-based practice analgesia guidelines for anesthesia for patients undergoing cardiac surgery
- Develop a comprehensive plan to implement evidence-based guidelines
- Develop a comprehensive plan on how to monitor and measure the evidence-based guidelines
- Develop a comprehensive plan on how to adjust the evidence-based guidelines if the outcomes are less than desirable.

Literature Synthesis and Analysis

Literature Search Strategy

A systematic literature search was completed for the project. Databases in the literature search ultimately included Medline, PubMed, CINAHL (EBSCO), ProQuest, and Cochran. These databases were searched from conception to June 2023. The strategy of these searches included a combination of the

following search terms, searching all fields or titles: cardiac surgery, open-heart surgery, opioid-sparing, opioid alternatives, regional anesthesia, and erector spinae. The search terms were chosen based on the project's PICO question. In addition to the search terms, the Boolean operators included "AND" to group the search terms for a more thorough search and "NOT" to exclude pediatric studies. The inclusion criteria for this literature review included the following:

- Randomized controlled trials (RCT), meta-analyses/systematic reviews, retrospective cohort studies, and prospective cohort and observational studies
- Articles supplied in full text and written in English
- Studies including adult patients
- Studies including patients undergoing cardiac surgeries
- Studies undergoing general anesthesia
- Studies including a date range from 2018-2023

Exclusion criteria for this study included studies written in foreign languages, pediatric studies, and minimally invasive cardiac surgeries. Articles outside of the five-year window were also excluded.

Synthesis of the Literature

Literature Comparing Regional Anesthesia Techniques in Cardiac Surgery

Traditional pain control in cardiac surgery patients often includes high-dose opioid use with the occasional use of thoracic epidural analgesia to decrease opioid consumption. However, more recent literature highlights the benefits of using regional anesthesia in cardiac surgery patients to decrease opioid consumption and improve overall health outcomes. Existing literature studies the effects of several types of blocks, most commonly erector spinae plane blocks, pectoralis nerve blocks 1 and 2 (PECS 1 and PECS 2), thoracic paravertebral blocks, serratus anterior plane blocks, and parasternal intercostal blocks. Several studies in this literature search show that regional anesthesia can aid in pain control and that erector spinae plane blocks are superior to other block options in cardiac surgery

patients (Dost et al., 2022, Najaraja et al., 2022, and Cosarcan et al., 2022). The following articles study the effectiveness of various methods of regional anesthesia in controlling pain in cardiac surgery patients.

Dost et al. (2022) hypothesized that the effects of single-shot ultrasound-guided regional anesthesia techniques would have superior pain control and reductions in 24-hour postoperative opioid consumption compared to placebo or systemic analgesics alone in those undergoing open cardiac surgery. Dost et al. (2022) conducted a systematic review and meta-analysis with 849 adult patients over 15 studies undergoing cardiac surgery requiring median sternotomy. Independent variables in the analysis included regional anesthesia techniques, including pecto-intercostal fascial block, transverse thoracic muscle plane block, erector spinae plane block, and PECS 1 compared to a placebo or no intervention group. Dependent variables studied included opioid consumption during the first 24 hours after surgery, pain after extubation at 12 and 24 hours, postoperative nausea and vomiting, extubation time, intensive care unit (ICU) discharge time, and length of hospital stay. Dost et al. (2022) determined that all regional anesthesia techniques studied significantly reduced postoperative opioid consumption at 24 hours. The erector spinae block group was the only regional anesthesia technique shown to decrease ICU length of stay, making it the most effective.

Najaraja et al. (2018) compare thoracic epidural analgesia, the previous mainstay for alternative pain control techniques in cardiac surgery, to erector spinae plane blocks. In a prospective, randomized comparative clinical trial, Najaraja et al. (2018) studied 50 adult patients undergoing elective cardiac surgery with median sternotomy. Twenty-five patients received continuous thoracic epidural analgesia; the other 25 received erector spinae plane blocks. Najaraja et al. (2018) studied pain assessments, incentive spirometry, ventilator, and ICU duration. Najaraja et al. (2018) confirm that both thoracic epidural analgesia and erector spinae plane blocks decrease pain assessments, increase peak inspiratory flows, decrease breakthrough pain, decrease rescue analgesia requirements, and ventilator and ICU

duration, showing that erector spinae plane blocks are an effective alternative to thoracic epidural analgesia with the decreased adverse effects such as epidural hematoma and hypotension.

Cosarcan et al. (2022) conducted a retrospective cohort study with 221 cardiac surgery patients, with 179 receiving regional anesthesia. The purpose of the study was to compare the effectiveness of regional anesthesia techniques for perioperative pain management in patients undergoing cardiac surgery and the effects of different analgesic methods in terms of contributing to recovery. Cosarcan et al. (2022) studied the independent variables of dual-injection erector spinae plane blocks, thoracic paravertebral blocks, and a serratus anterior plane and parasternal intercostal block combination. The dependent variables identified in the study consisted of intraoperative opioid consumption, opioid consumption after 24 hours, length of stay in the cardiac ICU, first mobilization time, and time to discharge. Cosarcan et al. (2022) proved that opioid consumption was lower in patients undergoing regional anesthesia, with those receiving erector spinae experiencing the lowest opioid requirements, extubation times and first mobilization times, length of stay in the ICU, and time to discharge in those receiving regional anesthesia.

Literature Supporting Erector Spinae Plane Blocks

The comparison of erector spinae plane blocks to control groups not receiving any regional coverage is imperative in showing that the block is beneficial in comparison to traditional methods already in place. The following articles compare patients receiving erector spinae plane blocks to control groups. The articles collectively show decreased chronic post-surgical pain, pain severity, opioid use, mechanical ventilation time, ICU and hospital duration, sedation, time to mobilization, and overall decreased adverse events.

Athar et al. (2021) conducted a randomized, double-blind, controlled trial comparing cardiac surgery patients receiving bilateral erector spinae plane blocks to those receiving sham blocks with normal saline. The trial studied 36 adult patients undergoing elective on-pump single-vessel coronary

artery bypass graft or valve replacement under general anesthesia. Athar et al. (2021) looked at mean analgesic requirements in the first 24 hours postoperatively, mean time to rescue analgesia, mechanical ventilation duration, and sedation scores. Using statistical analysis, the authors showed that patients receiving erector spinae plane blocks had lower mean analgesic requirements in the first 24 hours post-surgery and decreased mechanical ventilation times, risks of pain, and sedation scores.

Güven et al. (2022) conducted a prospective, randomized, single-blind, controlled trial to examine the effectiveness of bilateral erector spinae plane block in adult patients undergoing cardiac surgery. The authors studied 54 patients undergoing cardiac surgery with open median sternotomies, half receiving bilateral erector spinae plane blocks and the other half in a control group receiving no block. Güven et al. (2022) examined the length of stay in the ICU, pain in the first 24 hours after extubation, and morphine consumption. The authors' findings showed that patients in the erector spinae plane block group had longer times before the first analgesic, shorter total lengths of stay in the ICU, and lower rates of nausea. The erector spinae plane block group also had lower total morphine consumption and pain scores than the control group.

Krishna et al. (2019) seek to examine the analgesic efficacy of bilateral erector spinae plane block compared with conventional treatment for pain after cardiac surgery in a prospective, randomized, controlled, single-blinded study. The study compares the use of paracetamol and tramadol with no nerve block, a traditional method of pain management following cardiac surgery, to the use of erector spinae plane block with a total sample size of 110 adult patients undergoing elective cardiac surgery with cardiopulmonary bypass. Krishna et al. (2019) looked at pain levels at rest after extubation and duration of analgesia, time to extubation, total opioid usage, total rescue analgesia used, duration of analgesia during which the pain score was <4/10, time to ambulation, time to first oral intake, and the total length of ICU stay. The authors determined that those receiving blocks had a longer duration with

low pain levels, were extubated earlier, could eat earlier, mobilized earlier, discharged from the ICU faster, and had less time requiring analgesia.

Vaughan et al. (2021) conducted a retrospective cohort study to test whether continuous bilateral erector spinae plane blocks placed preoperatively would reduce opioid consumption and improve outcomes compared with standard practice in open cardiac surgery patients. The authors used a sample size of 78 patients undergoing elective primary coronary artery bypass grafting, aortic valve, or ascending aortic surgery. A historical control group was compared to one receiving bilateral continuous erector spinae plane block. The amount of opioid consumption, non-opioid analgesic consumption, time to extubation, ICU length of stay, hospital length of stay, and patient's highest pain score reported on each postoperative day were studied. Vaughan et al. (2021) revealed that patients receiving erector spinae plane block consumed fewer opioids over their hospital stay and had shorter extubation times and ICU and hospital stays.

Wiech et al. (2022) conducted an observational cohort study to assess the severity and incidence of chronic post-surgical pain in patients undergoing off-pump coronary artery bypass grafting via sternotomy with preemptive bilateral erector spinae plane block. The study included 74 patients undergoing off-pump coronary artery bypass graft, one group receiving bilateral erector spinae plane blocks and the other a control group. Dependent variables studied by Wiech et al. (2022) included chronic post-surgical pain severity 1, 3, and 6 months after surgery using the Neuropathic Pain Syndrome Inventory (NPSI), cumulative oxycodone dose, acute pain intensity, mechanical ventilation time, hospital length of stay, and postoperative complications. Using statistical analysis, Wiech et al. (2022) determined that while there were no differences in postoperative complications between the control and erector spinae block groups, those receiving regional anesthesia had significantly lower chronic post-surgical pain, acute pain severity, and cumulative oxycodone doses with shorter mechanical ventilation times and hospital stay durations.

Cosarcan et al. (2021) conducted a retrospective cohort study with 30 patients undergoing coronary artery bypass graft surgery in the beating heart. The authors were investigating the analgesia efficacy of the dual injection technique of erector spinae plane block in beating heart coronary bypass surgeries in patients receiving dual injections of erector spinae plane blocks. Cosarcan et al. (2021) looked at the total opioid consumption doses and pain scores in these patients. The authors determined that patients receiving erector spinae plane blocks had no secondary pain responses in all surgical periods, including skin incision and sternotomy, and had low pain scores in the postoperative period with no opioid use between the 24- and 48-hour postoperative period. Limitations to this study are that there was no comparison to patients without regional anesthesia, and therefore, statistical analysis was not feasible. However, the study allows for positive data for future studies on perioperative utilization of erector spinae blockade.

Literature Supporting Bundles of Care with Erector Spinae Plane Blocks

Macaire et al. (2019) hoped to determine if open cardiac surgery patients receiving a bundle of care using continuous erector spinae plane block would have decreased perioperative opioid consumption and improved early outcome parameters. The authors conducted a consecutive, patient-matched, before-and-after study with 67 consecutive patients undergoing elective cardiac surgery with cardiopulmonary bypass. The independent groups compared in the study were patients receiving a continuous bilateral erector spinae block to a historical group that did not receive a continuous bilateral erector spinae block. Macaire et al. (2019) looked at morphine consumption in the first 24 hours, time to chest tube removal, first mobilization, pain values, and postoperative adverse events, including hypotension episodes, nausea and vomiting, and hyperglycemia. Statistical analysis showed that morphine consumption in the first 48 hours and intraoperative sufentanil were significantly decreased in the erector spinae plane group compared to the control group, along with shorter times to chest tube removal, first mobilization, pain values 2 hours after chest tube removal, and pain values at rest one

month after surgery. Postoperative adverse events decreased significantly in the erector spinae plane block group.

Kurowicki et al. (2020) compare the perioperative course of patients undergoing off-pump coronary artery bypass graft receiving standard fentanyl and sevoflurane anesthesia with those using an ERAS protocol with remifentanil, sevoflurane, and bilateral erector spinae plane block in a prospective, open-label, observational study of 30 patients. The standard group received anesthesia with etomidate, fentanyl, and rocuronium for induction and fentanyl and sevoflurane for maintenance. The ERAS protocol group received a bilateral single-shot erector spinae plane block with etomidate, remifentanil, and rocuronium for induction and remifentanil and sevoflurane for maintenance. Dependent variables studied in the trial were time to extubation, length of ICU stay, and troponin concentration. Kurowicki et al. (2020) determined that the ERAS group had a shorter time to extubation, ICU stay length, and hospital discharge time. The postoperative troponin concentration was significantly lower in the ERAS group.

A cohort study conducted by Borys et al. (2020) was unique. The authors tested if bilateral erector spinae plane block combined with intraoperative remifentanil infusion could be effective and safe in patients undergoing off-pump CABG. Borys et al. (2020) had a sample size of 57 patients, 29 of whom were undergoing off-pump coronary artery bypass grafting in an ERAS group, receiving bilateral erector spinae plane block, remifentanil infusion, and patient-controlled analgesia (PCA) with oxycodone compared to 28 patients in a retrospective standard care group before the implementation of the ERAS group. Borys et al. (2020) looked at postoperative mechanical ventilation time, ICU and hospital stay, postoperative drainage time, postoperative troponin T level, pain severity, and opioid PCA pump demands. The authors determined that mechanical ventilation time was significantly shorter in the ERAS group than the standard care group, with the ERAS group having shorter ICU and hospital stay durations.

The ERAS group also had lower pain intensities with less PCA demand, less postoperative chest tube drainage time with lower drainage volume, and significantly lower troponin T concentrations.

Limitations

A common limitation throughout the literature is the limited sample size. The sample size was a limitation in several studies, including Athar et al. (2021), Kurowicki et al. (2020), Macaire et al. (2019), and Cosarcan et al. (2021). There were several studies with the limitation of not following up on long-term pain control. Studies with this limitation include Athar et al. (2021) and Güven et al. (2022). Another limitation is articles that were retrospective and not blind controlled trials including Cosarcan et al. (2022), Najaraja et al. (2018), Wiech et al. (2022), Borys et al. (2020), Vaughan et al. (2021), Cosarcan et al. (2021), Kurowicki et al. (2020), and Macaire et al. (2019). Retrospective studies can lead to missed data as well the potential for selection and recall biases.

Summary of Findings

Based on the literature review, it is evident that using erector spinae plane blocks in adult cardiac surgery patients is beneficial to the overall perioperative healing process. Common themes throughout the literature show that erector spinae plane blocks lead to decreased pain, decreased perioperative opioid consumption, and improved outcome parameters**,** such as decreased mechanical ventilation times, decreased ICU duration, decreased times to mobilization, and ultimately decreased hospital stays. The literature overwhelmingly recommends erector spinae plane blocks to improve cardiac surgery patient satisfaction and decrease hospital costs. A literature review table is available in Appendix A.

Theoretical Framework

The underlying goal of the scholarly project is the use of evidence-based practice to improve patient outcomes. Evidence-based practice (EBP) became paramount to healthcare quality, improvement of patient outcomes, reduction in healthcare costs, and empowers clinicians (Melnyk &

Fineout-Overholt, 2019). EBP includes internal and external evidence to determine practice changes to improve clinical outcomes (Melnyk & Fineout-Overholt, 2019). The theoretical framework guiding this EBP scholarly project is the Johns Hopkins Evidence-Based Practice Model (JHEBPM). Electronic permission was obtained from the Johns Hopkins University School of Nursing (Appendix B). The JHEBPM is a tool for healthcare professionals to use evidence-based practice to solve problems faced by clinicians (Dang et al., 2022). The JHEBPM model is a powerful problem-solving approach to clinical decision-making and includes user-friendly tools to guide clinicians (Dang et al., 2022). The model hopes to incorporate the best practices and latest research findings into patient care (Dang et al., 2022). The JHEBPM uses an ever-rotating cycle of practice, evidence, translation, and reflection to determine best practices and clinical improvements that will serve as a basis for this scholarly project.

Design and Method

The basis of the methodology of this project is the Johns Hopkins Evidence-Based Practice Model (JHEBPM). Adverse problems correlated with opioid use in cardiac surgery patients guided the JHEBPM for this scholarly project. A review of the current literature showed that guidelines for using regional anesthesia in cardiac surgery patients to reduce opioid consumption are needed. This clinical problem guided the PET process (Practice Question, Evidence, Translation) of the JHEBPM. The PET process is the initial three-step process of the JHEBPM model used to facilitate the successful implementation of current evidence-based literature (Dang et al., 2022). The steps of the PET process for the project are explained below.

JHEBPM PET Process Step 1: Practice Question

The initial step of the JHNEBP PET process includes seven tasks: recruit an interprofessional team, determine responsibility for project leadership, schedule team meetings, clarify and describe the problem, develop and refine the EBP question, determine the need for an EBP project, and identify the stakeholders (Dang et al., 2022). In conjunction with advising faculty, the author defined the EBP

question by forming a PICO question, which directly coincides with the practice question step of the PET process. The aforementioned PICO question will guide and serve as a framework for further steps of the scholarly project. The project team and stakeholders required for the first step of the JHEBPM are listed below.

Project Team

The project would be fulfilled by the project team leader, the Chief Anesthesiologist, and the Chief Certified Registered Nurse Anesthetist (CRNA) of a hospital. This team would be responsible for educating anesthesia staff members, including anesthesiologists, CRNAs, and student registered nurse anesthetists (SRNAs), as well as communicating with and educating the cardiothoracic surgery team, including surgeons, physician assistants, nurse practitioners, and postoperative nursing staff. The project's key stakeholders would include the anesthesia team (anesthesiologists and CRNAs), the cardiovascular surgery team (surgeons, physician assistants, and nurse practitioners), the cardiovascular critical care nursing team for postoperative monitoring, and hospital leadership members. The project team and the primary stakeholders must decide on the project's goals and objectives, how to measure them, and a plan for determining the next steps based on the outcomes. The roles and responsibilities of each member and stakeholder will be defined and upheld throughout the project.

Target Population and Setting

The setting for developing and implementing this guideline would be an acute care hospital center with a cardiothoracic surgery department. This hospital should routinely perform open-heart surgeries with an average of at least five cases per week.

The target population for this guideline is patients over 18 years old undergoing elective open-heart surgery, including coronary artery bypass grafts or valve replacements under general anesthesia. Those excluded from the guideline are patients under the age of 18 years old, those undergoing emergency or redo cardiothoracic surgery, patients with a bleeding disorder or abnormal coagulation

profile or those on anticoagulants, patients with abnormal hepatic and renal function, uncontrolled diabetes, chronic obstructive pulmonary disease, and those with allergies to local anesthetics. The anesthesia provider should also consider excluding those with chronic pain and a history of drug abuse, as decreased opioid use may be unobtainable.

The target population for education on the guideline will include anesthesiologists and CRNAs. Education and discussions with the cardiothoracic surgery team, including surgeons, physician assistants, nurse practitioners, and nursing staff, must also be conducted to ensure all therapy teams are aligned.

JHEBPM PET Process Step 2: Evidence

The second step of the JHNEBP PET process is evidence. The evidence step requires an internal and external search for evidence, appraisal of the level and quality of each piece of evidence, a summary of the evidence, synthesis of the findings, and development of the best evidence recommendations (Dang et al., 2022). Through literature review, the most recent evidence points to the use of erector spinae plane blocks in pain management guidelines for cardiac surgery patients. Synthesis and analysis of the findings are reviewed in the "Literature Review" and "Synthesis of Evidence" sections within this scholarly project.

JHEBPM PET Process Step 3: Translation

The final step of the JHEBPM PET process is translation. The translation process encompasses eight steps, including identification of practice setting-specific recommendations, creation of an action plan, securing support and resources to implement the action plan, implementation of the action plan, evaluation of the outcomes of the action plan to determine if improvements are necessary, reporting of the results to the stakeholders, identification of next steps, and dissemination findings (Dang et al., 2022). Using the evidence found in the second step of the PET process, an EBP analgesia guideline incorporating erector spinae plane blocks in adult cardiac surgery patients will be developed and

implemented to decrease opioid consumption and, subsequently, opioid-related adverse events. Outcomes will be analyzed, and quality improvements will occur based on the successes and failures of the action plan. The final step of the JHEBPM, translation, is evident in this project's implementation and outcomes plans.

Implementation Plan

Following approval from the Institutional Review Board (IRB), the initial step in the implementation plan is introducing the plan to the key stakeholders, including the anesthesia team, the cardiothoracic surgical team, the cardiovascular critical care nursing team, and the hospital leadership members. An initial meeting with the project leader and the stakeholders will need to occur. During the initial team meeting, the roles and responsibilities of each team member will be defined and agreed upon with clear expectations for each project member. The meeting also allows for determining the project's goals and how the goals will be measured and analyzed. It is vital to gain the approval and agreement of the stakeholders in the initial meeting to continue with the implementation plan.

The primary responsibility of the project will fall on the anesthesia team to perform the erector spinae blockade before the induction of general anesthesia. Postoperatively, the cardiovascular critical care nursing team must perform meticulous pain assessments to ensure adequate analgesia. In the case of inadequate pain control with the erector spinae plane block and the available opioid-sparing order set, the nursing staff must contact both the anesthesia team and the cardiothoracic surgery team. In these cases, the anesthesia team may need to see the patient to assess for proper erector spinae blockade before prescribing increased doses of analgesics. Limitations to implementing the guidelines include nursing staff needing to comply with proper pain assessments and following opioid-sparing guidelines. The project leader will assess these limitations in the data collection and outcomes analysis.

Successful implementation of this scholarly plan also depends on other interdisciplinary teams within the hospital. The project lead will draft the online education module and notify the IT department

to develop it in the hospital's online learning system. The project also depends on guidance from the pharmacy department to ensure the proper dosing for the erector spinae block. The project lead will work with pharmacy management to ensure the necessary local anesthetics are easily accessible to perform the blockade, which may include increased ordering from suppliers. In addition, creating an opioid-sparing analgesic order set for postoperative pain control is necessary to allow for nurse-driven analgesia administration for each patient. The project team lead will work with the IT and pharmacy departments to load the order sets into the electronic medical system. Lastly, the project team will need to work with the quality improvement (QI) department to create outcome metrics for the project and determine the most efficient way to monitor and analyze the outcomes.

Once all team members understand their role in the implementation process, education can begin on performing erector spinae plane blocks. The initial education of the anesthesia team, including anesthesiologists and CRNAS, will consist of online education. The online education portion will allow team members to receive background education on regional anesthesia, why the erector spinae blockade is being introduced, and the steps to perform the block in practice. The online training for clinicians will be available for one month. Completing the online education allows the project team leader to begin working with the chief anesthesiologist and CRNA to complete hands-on education on performing erector spinae plane blocks. The in-person education will have a sign-in sheet to account for attendance. Education check-offs will occur during this training by the team leader, chief anesthesiologist, and chief CRNA. These education days also allow clinicians to clarify questions regarding the education or the implementation process to ensure that all content is understood. Prospective costs for the education of anesthesia providers are included in the proposed budget outlined below. Once providers finish online and hands-on education, the providers can perform erector spinae plane blocks on cardiac surgery patients. After proper education, the implementation of the project can begin. Initially, there should be "superusers" consisting of anesthesiologists and CRNAs who

feel comfortable and have experience in performing the erector spinae block and can serve as a resource to providers new to performing the skill.

The guidelines using erector spinae plane blockade will be compared to the initial outcomes of patients with traditional pain control methods after open-heart surgery to allow for the ability to ensure the guidelines show beneficial outcomes. A direct comparison showing erector spinae blockade's benefits in cardiac surgery patients allows for increased stakeholder support. The JHEBPM encourages reflection after all practice improvements. Under this model, a direct comparison of erector spinae blockade to traditional pain control efforts can also show if outcomes are successful or less than optimal. Suppose the results do not show the expected outcomes. In that case, the project team members and stakeholders can review the results and identify areas for improvement. In order to decide on changes to produce more optimal results, recycling through the inquiry and PET process of the JHEBPM may be necessary to improve practice outcomes. Outcomes should be monitored throughout the implementation process to determine if any improvements can occur to incorporate them sooner, promptly leading to successful outcomes.

Timeline

The proposed timeline is pictured in Appendix C. The anticipated time frame for the practice guideline implementation is two years. The initial six months of the project will focus on the practice guideline preparations. During the first four months of this period, the project team will connect with the pharmacy and the IT and QI departments. The IT department will ensure the online education module is ready to launch. The IT department and pharmacy will ensure the order sets for performing the erector spinae plane blockade and postoperative analgesia are complete and incorporated into the electronic medical record. The initial four months also allows for the opportunity to secure adequate outcomes monitoring and analyzing. The month following this time frame allows for online education for erector spinae plane blocks to the anesthesia providers. Once completed, the last month of the

initial six-month period into the implementation plan, allows for in-person training for anesthesia providers. The anesthesia providers will have time slots to sign up for, allowing for practice with ultrasound machines and hands-on training. During this time frame, an educational email should be drafted and distributed to the cardiovascular intensive care unit regarding the new guideline and how the new opioid-sparing order set will affect the postoperative care they provide to cardiac patients receiving erector spinae plane blocks. All education will be complete by the end of this initial six-month time period.

Once the education and preparation are complete in the first six months, clinical implementation of the guideline can begin. All patients undergoing elective cardiac surgeries meeting inclusion criteria should be eligible for the new guideline implementation and receive an erector spinae plane block before undergoing general anesthesia. This period allows for the data collection on the total opioid consumption in the first 24 hours postoperatively and time to extubation in all patients receiving erector spinae blockade. The guidelines will be implemented, and outcomes should be measured for approximately a year. The outcomes should be monitored throughout this time to gauge project successes and failures. If there is clear evidence that outcomes are less than desirable, changes should occur accordingly. After at least a year of implementing the guidelines, the project leader and the QI department will finalize the data and measure the outcomes. Outcomes will be analyzed and presented to the project team and stakeholders to determine the future of the project and any changes that need to ensue.

Budget

The overall estimated budget for the project is $39,713.72. The budget accounts for the salaries of the anesthesia team and the critical care nursing team for education and the salaries for the pharmacist, healthcare information technologist, and healthcare data analysis for forming order sets, online education, and outcome analysis. The most significant factor in the budget is the education of the

anesthesia team. The theoretical hospital would pay the wages for these staff members. The ultrasound training for the anesthesia team would count toward continuing education hours for eligible team members. The salaries and a complete budget outline are available in Appendix D. The budget assumes enough functioning ultrasounds owned by the hospital are readily available. The budget estimates what costs would be if the project were implemented in the future.

Outcome and Analysis Plan

Throughout the initial six-month period of the projected timeline allotted for guideline preparation and education, the project leader will collect data from cardiac surgery patients before implementing the practice guidelines utilizing the erector spinae plane block. The two outcomes to be measured are opioid consumption in the first 24 hours postoperatively and the duration of mechanical ventilation in the immediate postoperative period. The opioid consumption metric will include the type, dose, and route of all opioids administered to cardiac surgery patients in the first 24 hours postoperatively. This data will be collected from the patient's electronic medical records and stored in an Excel spreadsheet by the project manager. This same data will then be collected from all patients utilizing the new practice guidelines utilizing the erector spinae plane block. The project team leader will work with the hospital data analyst from the quality improvement department to monitor the project objectives. The outcomes will be analyzed using a paired sample T-test to determine if the data is statistically beneficial or not. Data will be collected through the implementation process. If outcomes appear less than desirable, such as increases in opioid consumption or mechanical ventilation time or adverse events related to the erector spinae blockade, changes can be discussed with the project team and occur as necessary.

Limitations and Barriers

Implementation of this project comes with limitations and barriers. This project's primary limitation and barrier would be staff compliance with the new guidelines. The utilization of erector spinae blockade would require more time and effort than the traditional anesthetic. This additional expectation and resistance to change may cause pushback from anesthesia providers. Ensuring that all providers understand the overwhelming benefits of erector spinae blocks will help alleviate any hesitation from providers upon implementation of the guidelines. Another potential limitation to the project would be access to resources. The project requires access to working ultrasound machines, and the lack of proper equipment could lead to significant limitations to the implementation of the project. Financial barriers may arise if new equipment is necessary as it would be an addition to the proposed budget. Overcoming barriers and limitations requires effective communication between all project team members and stakeholders and continual monitoring of project outcomes to combat any obstacles efficiently.

Conclusion

In conclusion, the literature shows that the erector spinae plane blockade benefits patients undergoing cardiac surgery. Utilization of erector spinae plane nerve blocks in cardiac surgery patients can decrease mechanical ventilation time and opioid consumption in the first 24 hours postoperatively. The Johns Hopkins Evidence-Based Practice Model guides this project in incorporating the abovementioned interventions into practice. Erector spinae plane blockades in patients undergoing cardiac surgery can assist in adequate postoperative pain control and minimize adverse effects associated with high-dose opioid consumption. Overall, erector spinae blockade in cardiac surgery patients optimizes patient outcomes and is recommended to enhance current practice. The researcher

hopes implementing the guidelines will aid in better outcomes for cardiac surgery patients in the immediate postoperative period.

Summary

Through the completion of this final scholarly project, the researcher has grown immensely. The researcher identified a clinical problem and searched the current literature for a solution. After analyzing the literature, the researcher developed a plan for implementing changes to clinical practice. A detailed implementation plan included how to introduce the intervention into clinical practice, the timeline, and the budget required to introduce the guidelines feasibly. The outcomes measured by the researcher determine the implementation plan's success. Having completed this project, the researcher has acquired the knowledge and skills to implement positive, evidence-based changes in clinical settings and hopes to utilize them as a doctorate-educated nurse anesthetist.

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Appendix A

Literature Review Table

Article	*Design or Method*	*Sample & Setting*	*Major Variables Studied & their Definitions, if any*	*Outcome Measurement(s)*	*Data Analysis*	*Findings*	*Level of Evidence*	*Quality of Evidence: Critical Worth to Practice*
Athar et al., 2021	Randomized double-blind controlled trial	**Number of Characteristics:** 36 patients, either sex, aged 18-60 years old, body mass index 19-30 kg/m2 undergoing elective on-pump single-vessel coronary artery bypass graft or valve replacement under general anesthesia qualified **Exclusion Criteria:** patients with spine deformities, local infection, known allergy to local anesthetics, psychiatric illness, neurologic deficit, alcohol and drug abuse, and chronic analgesic use **Attrition:** 96.8%, 30 out of 31 patients, due to 1 denying consent **Setting:** single-center, tertiary care hospital with	**Independent variables: IV1=** bilateral erector spinae plan block with 20 mL per side of 0.25% levobupivacaine **IV2=** sham block with 20mL of normal saline **Dependent variables:** mean analgesic requirements in the first 24 hours postoperatively, mean time to first rescue analgesia, duration of mechanical ventilation, sedation score	**Scale(s) used:** Mean analgesic requirements was measured in terms of fentanyl equivalents, mean time to first rescue analgesia measured in minutes, duration of mechanical ventilation measured in minutes, sedation score measured using Ramsay sedation score	Graph Pad Prism 5.00; Normality tested using Shapiro-Wilk test; continuous data was compared using a Student *t* test; median using Mann-Whitney test; categorical data using a chi-square test	Mean analgesic requirement (fentanyl equivalents) in first 24 hr postop were lower in the erector spinae group, duration of mechanical ventilation time was decreased in the erector spinae group along with decreased risk of pain and sedation scores	I	**Strengths:** randomized, double-blind controlled trial **Limitations:** single-centered, small sample size that only included simple and short surgeries, they also only followed up on pain up to 24 hours post op and therefore didn't test long term pain control **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** feasible but would require education to ensure providers understood proper technique to provide erector spinae block

		university affiliation						
Cosarcan et al., 2022	Retrospective Cohort Study	Number of Characteristics: 221, 179 of them received regional analgesia variables Exclusion Criteria: patients with a history of cerebrovascular events, scheduled carotid surgery, emergency coronary artery bypass surgery, Alzheimer's disease, dementia, inadequate cognitive functions, history of chronic pain, or in receipt of long-term opioid therapy Attrition: 100% of all patients meeting study criteria were analyzed Setting: single center	**Independent variables:** **IV1=** dual-injection erector spinae plane block **IV2=** thoracic paravertebral block **IV3=** serratus anterior plane block and parasternal intercostal block combination **Dependent variables:** intraoperative opioid consumption, opioid consumption after 24hr, length of stay in cardiac ICU, first mobilization time, time to discharge	**Scale(s) used:** opioid consumption was measured in milligrams for tramadol and morphine and micrograms for pethidine, length of stay in cardiac ICU, first mobilization time, and time to discharge were all measured in hours	IBM SPSS Statistics for Windows version 25.0; normality of variables investigated using Shapiro-Wilk test; Mann-Whitney U test applied in comparison of two dependent, non-normally distributed group; sample t-test used in comparison of two independent normally distributed groups	Opioid consumption was lower in patients undergoing regional anesthesia, those receiving erector spinae had the lowest opioid requirements, extubation times, length of stay in the ICU, time to first mobilization and time to discharge were lower in those receiving regional anesthesia	II	**Strengths:** large sample size, long term pain scores were looked at, compares other blocks in the population **Limitations:** the study is retrospective, And was not a blind controlled trial **Risk or harm if implemented:** the only complications occurring in the study had no relation to regional blocks **Feasibility of use in the project practice area:** the study is feasible if only one type of block is chosen, using several at the same time might be unrealistic at the start, erector spinae should be the block chosen due to its higher efficacy rates
Dost et al., 2022	Systematic review and meta-analysis	Number of Characteristics: fifteen studies with 849 patients undergoing	**Independent variables:** **IV1**= single-shot regional	**Scale(s) used:** opioid consumption measures in morphine	R version 4.1 and Facenetmeta package used for data meta-analysis	All regional anesthesia techniques significantly reduced	I	**Strengths:** large sample size across several studies **Limitations:** not very many studies

		cardiac surgery patients over 18 years old requiring median sternotomy Exclusion Criteria: the use of regional anesthesia techniques in combination, the use of continuous regional anesthesia techniques, minimally invasive cardiac surgery, and off-pump cardiac surgery Attrition: various Setting: various	anesthesia techniques **IV2**= placebo or no intervention **Dependent variables:** opioid consumption during the first 24hr after surgery, pain after extubation at 12 and 24 hr, postoperative nausea and vomiting, extubation time, intensive care unit discharge time, and length of hospital stay	milligram equivalents	Risk of Bias 2 Tool to evaluate quality of RCTs, grading recommendations assessment, development, and evaluation (GRADE) system used to rate certainty and quality of evidence for each outcome	postoperative opioid consumption at 24 hours with erector spinae being the most effective, only the erector spinae group was shown to decrease intensive care unit length of stay		were included and the blocks were compared with placebos rather than each other **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** project is feasible if one block is chosen rather than several to ensure providers are educated on proper technique
Najaraja et al., 2018	Prospective, randomized comparative clinical trial	**Number of Characteristics:** 50 adult elective cardiac surgical patients undergoing median sternotomy **Exclusion Criteria:** emergency surgery, left main coronary artery disease, left ventricular ejection fraction <40%, anomalies of vertebral column, blood or CSF tap during the procedure, failed blocks, patient on anti-coagulants, bleeding diathesis,	**Independent variables:** **IV1=** continuous thoracic epidural analgesia **IV2=** erector spinae plane block **Dependent variables:** pain assessment, incentive spirometry, ventilator, and intensive care unit duration	Pain assessment was performed using a 10 cm visual analog scale and was performed at rest and during coughing at 0 h (extubation), 3 h, 6 h, 12 h, 24h, 36 h, and 48 h; peak inspiratory flow spirometry was measured by the number of balls raised in the spirometer (1 ball = 600 ml, 2 balls = 900 ml, and 3 balls = 1200 ml), breakthrough pain was defined as visual analog pain	Independent Student's *t* test	All variables were statistically similar between the continuous thoracic epidural analgesia and the erector spinae plane block patients	II	**Strengths:** randomized trial, very clear definitions of how each variable was measured **Limitations:** unclear if it is a blinded trial and if there is risk of bias; does not have a control group so it is hard to compare results to other pain methods **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** project is feasible

		and patients who expired before extubation **Attrition:** N/A **Setting**: N/A		scale >4 at rest, rescue analgesia was administered if pain was >4, ventilator and ICU duration were measured in minutes; Alpha error (Type I) of 0.05 and calculated the beta error (Type II) being 80.4%				in practice; some settings may not have been using thoracic epidurals so the introduction of regional may be new but is feasible
Krishna et al., 2019	Prospective, randomized, controlled, single-blinded study	**Number of Characteristics:** 110 adult patients aged 20-70 years old undergoing elective cardiac surgery with cardiopulmonary bypass **Exclusion Criteria:** emergency surgery, redo surgery, patients with coronary artery disease with left main disease, moderate to severe left ventricular dysfunction, perioperative inotropic support, mitral stenosis with left atrial clot, patient with low cardiac output syndrome, perioperative intra-aortic balloon pump,	**Independent variables:** **IV1=** ultrasound-guided erector spinae block **IV2=** paracetamol and tramadol intravenously **Dependent variables:** pain level at rest after extubation and duration of analgesia, time to extubation, total opioid usage, total rescue analgesia used, duration of analgesia during which pain score was <4/10, time to ambulation, time to first oral intake, total length of ICU stay	Pain levels measured on numerical scale out of 10, rescue analgesia and opioid usage measured in milligrams, time measured in hours	Statistical Package for Social Services version 21 software, tested for normality using Kolmogorov-Smirnov test, unpaired Student *t* test, Pearson chi-squared test, and Mann-Whitney U test	Those receiving erector spinae plane block had longer time with pain levels <4/10, were extubated earlier, earlier time to first meal, mobilized earlier, discharged from the ICU faster, and less duration of time needing analgesia	I	**Strengths:** larger sample size, randomized, controlled single-blinded study **Limitations:** authors could not assess patients' pain before extubation; dynamic pain score and patient satisfaction was not measured **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** feasible in practice with proper education of providers

		bleeding disorder or abnormal coagulation profile, abnormal hepatic and renal parameters, uncontrolled diabetes, chronic obstructive pulmonary disease, atrial fibrillation on anticoagulation and allergy to ropivacaine **Attrition:** 117 eligible, 7 declined to participate leading to 110 sample, 4 lost to follow-up, 96.4% **Setting:** single tertiary teaching hospital						
Wiech et al., 2022	Cohort study	**Number of Characteristics:** 74 patients undergoing off-pump coronary artery bypass graft **Exclusion Criteria:** patients with chronic pain at admission, a history of alcohol or recreational drug abuse, known bleeding disorders, allergies to the drugs used during the study, antidepressant or epileptic drug	**Independent variables: IV1=** bilateral erector spinae plane block **IV2=** control group **Dependent variables:** chronic post-surgical pain severity 1, 3, and 6, months surgery, cumulative oxycodone dose, acute pain intensity, mechanical ventilation time, hospital length of stay, and	**Scale(s) used:** chronic post-surgical pain severity 1, 3, and 6, months surgery measured using Neuropathic Pain Syndrome Inventory (NPSI), cumulative oxycodone dose in milligrams, acute pain intensity using Numeric Rating Scale, mechanical ventilation time measured in hours, hospital	Student's *t*-test used for parametric data; nonparametric data calculated using Mann-Whitney *U* test; categorical variables analyzed using Fisher's exact test; all measurements performed using Statistica 13.1 software	Chronic post-surgical pain, acute pain severity, and cumulative oxycodone dose was significantly higher in the control group than the erector spinae plan block group, mechanical ventilation time and hospital stay time was shorter in the	II	**Strengths:** moderate size sample group, and uses control group **Limitations:** observational study so bias is possible, no blinding; low attrition rate **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** project is feasible with education on

		treatment, and chronic use of painkillers **Attrition:** 69.86%, 23 patients were lost to follow-up **Setting:** teaching hospital	postoperative complications	length of stay measured in days		erector spinae plane block group, no difference in postoperative complications		proper block placement technique
Borys et al., 2020	Cohort Study	**Number of Characteristics:** 57 patients total, 29 patients undergoing off pump coronary artery bypass grafting in ERAS group and 28 in standard care group from retrospective data **Exclusion Criteria:** **Attrition:** 98.25%, one patient declined to participate **Setting:** tertiary cardiac surgery department	**Independent variables:** **IV1=** ERAS group including bilateral erector spinae plane block, remifentanil infusion, and patient controlled analgesia (PCA) with oxycodone **IV2=** retrospective group before ERAS protocol implementation (standard care) **Dependent variables:** postoperative mechanical ventilation time, ICU and hospital stay, postoperative drainage time, postoperative troponin T level, pain severity, opioid PCA pump demands	**Scale(s) used:** postoperative mechanical ventilation time measured in hours, ICU and hospital stay measured in days, postoperative drainage time measured in hours, postoperative troponin T level, pain severity, opioid PCA pump demands measured by number of opioid boluses	Student's *t*-test; Mann-Whitney *U* test; all measurements performed using Statistica 13.1 software	Mechanical ventilation time significantly shorter in ERAS group than the standard care group; ERAS group spent less time in the ICU, discharged from the hospital before standard care patients with lower mean hospital stays; pain intensity was lower in ERAS group with less PCA demand, less postoperative drainage time in ERAS group with lower drainage volume, significantly lower troponin T concentration in ERAS group	II	**Strengths:** remifentanil versus fentanyl use in the patient population seemed to reduce heart rate and blood pressure fluctuations, erector spinae block was performed easily, average study size **Limitations:** not a randomized control trial increasing the risk of selection bias, more than one intervention differed in both groups, and pain assessments in the standard care group occurred later than the erector spinae block group because of the prolonged mechanical ventilation time **Risk or harm if implemented:** none

								Feasibility of use in the project practice area: performing the block is feasible in practice, however using remifentanil doesn't decrease opioid use
Vaughan et al., 2021	Retrospective Cohort Study	**Number of Characteristics:** 78 patients undergoing elective primary coronary artery bypass grafting, aortic valve, or ascending aortic surgery **Exclusion Criteria:** no prior history of chronic lung disease, opioid use, or substance abuse **Attrition:** N/A **Setting:** acute care facility	**Independent variables:** **IV1=** bilateral continuous erector spinae plane block **IV2=** historical control group **Dependent variables:** opioid consumption, non-opioid analgesic consumption, time to extubation, ICU length of stay, and hospital length of stay, patient's highest pain score reported on each postoperative day	Opioid consumption measured in oral morphine equivalents, time to extubation measured in minutes, ICU length of stay measured in hours, and hospital length of stay measured in days, patient's highest pain score reported on each postoperative day up to day 5 measured on numerical pain scale	Student's *t* test and Wilcoxon rank sum, R statistics package version 3.6.3	Patients receiving erector spinae plane bock consumed less opioids over their hospital stay and also had shorter times to extubation, shorter intensive care unit stays and hospital stays	II	**Strengths:** moderate size sample group **Limitations:** retrospective not randomized design, may have selection bias; staff was not blinded to patients receiving blocks **Risk or harm if implemented:** continuous nerve blocks do at times have higher risks of infection **Feasibility of use in the project practice area:** use of the block is feasible; use of continuous block may be less feasible due to surgeons' or facilities not wanting to use continuous catheters
Cosarcan et al., 2021	Retrospective Cohort Study	**Number of Characteristics:** 30 patients	**Independent variables:**	Opioid consumption measured in	None performed due to no group to compare to	Dual injection technique for erector spinae	II	**Strengths:** allows for data to use in future studies

		undergoing coronary artery bypass graft surgery in the beating heart **Exclusion Criteria:** emergency, or semi-emergency conditions, history of cerebral events, Alzheimer's dementia, plans for carotid surgery; those having regional anesthesia other than erector spinae plane block excluded **Attrition:** N/A	**IV1=** dual injection technique of erector spinae plane block **Dependent variables:** total opioid consumption doses and pain scores	milligrams; pain score rated on numerical rating scale		plane block appears to be effective in open heart surgery		**Limitations:** retrospective study, no comparison between classically defined erector spinae and modified erector spinae plane block and there was no comparison to those without regional anesthesia, no statistical analysis performed **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** feasible with education to providers on technique of block
Kurowicki et al., 2020	Prospective, open-label, observational study	**Number of Characteristics:** 30 patients undergoing off-pump coronary bypass graft surgery **Exclusion Criteria: Attrition:** 96.7%, one patient in the ERAS group lost due to a complication leading to transient	**Independent variables: IV1=** standard group with standard anesthesia with etomidate, fentanyl, and rocuronium for induction and fentanyl, sevoflurane for maintenance **IV2=** bilateral single shot erector	Time to extubation and length of ICU stay measured in hours, troponin concentration measured in ng/ml	Statistica 13.1, Mann-Whitney test	ERAS group had a shorter median time to extubation, shorter length of ICU stay and time to hospital discharge, postoperative troponin concentration was significantly lower in ERAS group	III	**Strengths:** measures important outcomes **Limitations:** small sample size, lack of randomization, ERAS group had a different opioid than the control group **Risk or harm if implemented:** none

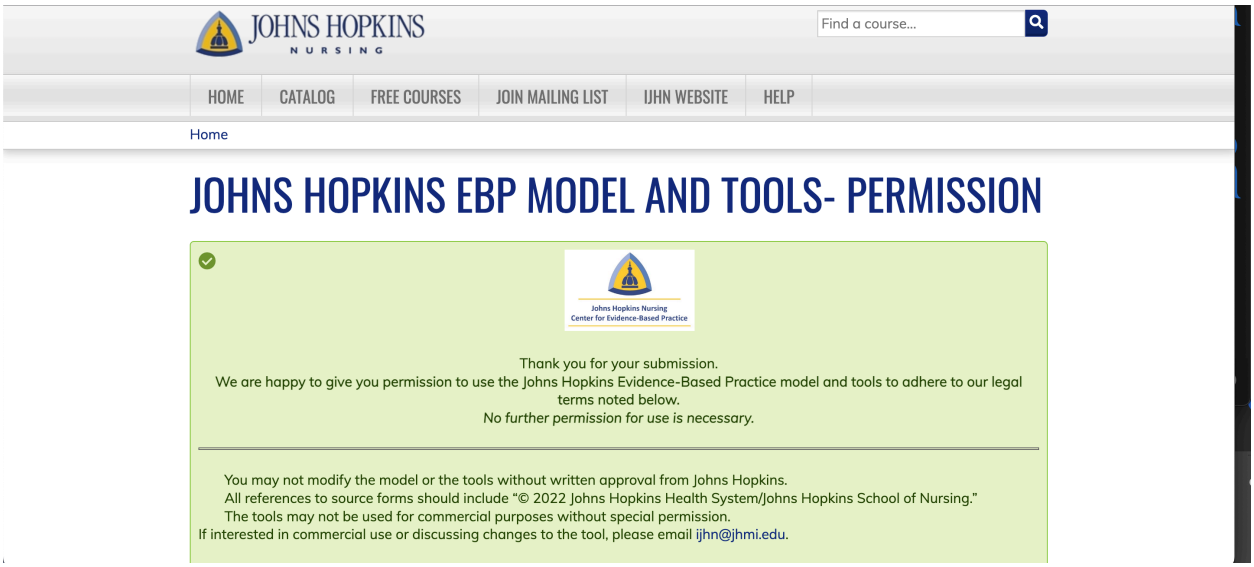
		myocardial ischemia **Setting:** tertiary health center, teaching hospital	spinae plane block, then etomidate, remifentanil, and rocuronium for induction and remifentanil and sevoflurane for maintenance **Dependent variables:** time to extubation, length of ICU stay, troponin concentration					**Feasibility of use in the project practice area:** feasible with proper education on technique
Güven et al., 2022	Prospective randomized, single-blind, controlled trial	**Number of Characteristics:** 57 patients undergoing cardiac surgery with open median sternotomy under general anesthesia **Exclusion Criteria:** emergency surgery ASA-3 and above, spinal deformities, failed blocks, bleeding diathesis, local anesthesia allergy, neurological deficit, chronic painkillers, or narcotic drugs use as well as patients taking thrombotic drugs and those with abnormal coagulation parameters **Attrition:** 92.9%, 4 patients excluded for to prolonged	**Independent variables:** **IV1=** bilateral erector spinae plane block **IV2=** control group, no block **Dependent variables:** length of stay in the intensive care unit, pain in the first 24 hours after extubation, and morphine consumption	Length of stay in the intensive care unit measured in hours, pain in the first 24 hours after extubation measured in numeric rating scale, and morphine consumption in milligrams	Kolomogoroc Smirnov test, student *t* test, and Mann-Whitney u test	Erector spinae plane block group had longer time before first analgesic, total length of stay in the ICU and rate of nausea was lower, total morphine consumption was lower, and pain scores were lower than the control group	II	**Strengths:** randomized, single-blind controlled trial, moderate sample size **Limitations:** no evaluation of long term postoperative pain could be made since nerve block was a single shot **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** project is feasible in practice area with proper education on technique

		intubation in the postoperative period						
Macaire et al., 2019	Consecutive, patient-matched, controlled before-and-after study	**Number of Characteristics:** 67 consecutive patients undergoing elective cardiac surgery with cardiopulmonary bypass **Exclusion Criteria:** hepatic or renal insufficiency, age younger than 18 and older than 65 years, allergy or intolerance to one of the study medications, body mass index (BMI)>40, ASA class IV, urgent surgery, hemodynamically instability, chronic opioid use **Attrition:** **Setting:** Two tertiary teaching hospitals	**Independent variables:** **IV1=** continuous bilateral erector spinae block **IV2=** historical group with no continuous bilateral erector spinae block **Dependent variables:** morphine consumption in the first 24 hours, time to chest tube removal, first mobilization, pain values, and postoperative adverse events	Morphine consumption was measured in milligrams, time to chest tube removal and first mobilization measured in hours, pain values were measured using the Visual Analog Scale, and postoperative adverse events included hypotension episodes, nausea/vomiting, and hyperglycemia	Shapiro-Wilk test, Student *t* test, Mann-Whitney test, chi-square or Fisher exact test	Morphine consumption in the first 48 hours and intraoperative sufentanil was significantly decreased in the ESPB group compared to the control group; times to chest tube removal, first mobilization, pain values 2 hours after chest tube removal, pain values at rest 1 month after surgery, and postoperative adverse events were significantly decreased in the ESPB group.	II	**Strengths:** controlled trial, consecutive so it prevents outside factors from impacting data, two hospitals **Limitations:** non randomized comparative design and the low sample size, spread of local anesthetic was not analyzed **Risk or harm if implemented:** none **Feasibility of use in the project practice area:** project is feasible with education on proper technique, however there may be limitations on availability of using continuous blocks

Key: ESPB: erector spinae plane block, ICU: intensive care unit; CABG: coronary artery bypass graft; ERAS: enhanced recovery after surgery

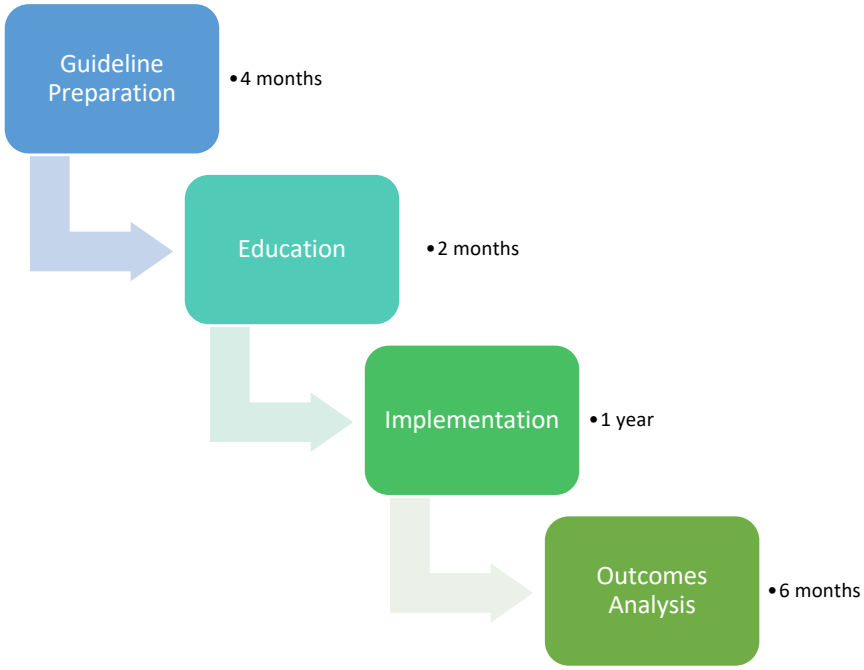
Appendix B

JHEBPM Permission



Appendix C

Proposed Timeline



Appendix D

Table of Expected Expenditures

Expenses	Cost
Anesthesiologist Hourly Rate	$145.66 x 3 hours of education x 25 staff members = $10,924.50
CRNA Hourly Rate	$98.93 x 3 hours of education x 40 staff members = $11,871.60
Critical Care RN Hourly Rate	$39.05 x 1 hour of education x 50 staff members = $1,952.50
Pharmacist	$63.82 x 40 hours x 2 staff members = $5,105.60
Healthcare Information Technologist (IT)	$28.01 x 80 hours x 2 staff members = $4,481.60
Healthcare Data Analyst (QI Department)	$28.01 x 8 hours data analysis weekly x 6 months = 5,377.92 **TOTAL BUDGET = $39,713.72** **All wages are estimated based upon U.S. Bureau of Labor Statistics data **