OPIOID-SPARING ANESTHESIA IN CARDIAC SURGERY: DISCOVERING CERTIFIED REGISTERED NURSE ANESTHETIST BARRIERS TO IMPLEMENTATION

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Abstract

Background: Opioids have been heavily used in cardiac surgery for decades and continue to be the mainstay in cardiac anesthesia despite their adverse effects. Priority has been placed on improved clinical outcomes and increased patient satisfaction scores with a value-based healthcare system. This has led to more Enhanced Recovery after Surgery Programs (ERAS), with opioid-sparing anesthesia (OSA) techniques pivotal to their success. Recently, these programs have been introduced to the cardiac surgery population. However, many anesthesia providers are reluctant to implement OSA techniques in this setting. **Purpose:** This project sought to assess the knowledge and attitudes of Certified Registered Nurse Anesthetists (CRNAs) on opioid-sparing anesthesia techniques in cardiac surgery and identify barriers to the implementation of opioid-sparing techniques at a level I trauma center. **Methods:** A qualitative pre-intervention and post-intervention online survey research design was used for this project. The pre-intervention survey assessed the existing knowledge and attitudes of CRNAs. An evidence-based educational intervention was created and presented to the CRNA staff based on the results of the pre-intervention survey. The post-intervention survey assessed the remaining barriers to the adoption of opioid-sparing anesthesia techniques in cardiac surgery. **Results:** Based on the post-intervention survey results, the OSA techniques in cardiac surgery educational intervention did decrease barriers to implementation. Key barriers identified were the lack of regional anesthesia techniques utilized due to 1) Regional techniques not being performed in this patient population 2) Time limits for training in regional techniques 3) Lack of buy-in from anesthesiologists and cardiac surgeons for implementing regional anesthesia techniques. **Recommendations and Conclusion:** An assessment of the knowledge and attitudes of CRNAs regarding OSA in cardiac surgery, followed by an educational intervention was successful in

identifying barriers to the adoption of OSA. Additional CRNA staff and physician education, coupled with organizational policy changes could increase the provision of regional anesthesia techniques and increase the adoption of opioid-sparing anesthesia techniques at this institution.

Keywords: CRNA, opioid-sparing, barriers

Background and Significance

Cardiac surgery is highly pain-provoking, making it challenging to achieve adequate pain control (Saffary et al., 2018). Opioids are recognized for rapidly suppressing pain and the sympathetic response to surgical stimulation (Velasco et al., 2019). However, they have numerous side effects, including respiratory depression, nausea, vomiting, ileus, delirium, hyperalgesia, and chronic neuropathic pain (Saffary et al., 2018). These adverse side effects are leading causes of prolonged intubation times, increased postoperative complications, increased ICU and hospital length of stay, cost of care, and chronic opioid use and addiction.

Opioids have been the mainstay in cardiac anesthesia and analgesia since the 1960s (Kwanten et al., 2018). The focus of healthcare is switching to a value-based system, where patient satisfaction and the quality of patient care are measured (Saffary et al., 2018). This change has led to Enhanced Recovery After Surgery (ERAS) programs that focus on multimodal analgesia and opioid-sparing techniques. ERAS protocols, when compared to traditional perioperative management protocols, have been shown to decrease complications and hospital length of stay by up to 50% (Engelman et al., 2019). Adequate pain control can lead to improved patient satisfaction and outcomes; this should be a priority for all providers involved in patient care. Yet, many anesthesia providers remain reluctant to use opioid-sparing techniques, especially in the cardiac surgery patient population.

Purpose

This project intended to assess the knowledge and attitudes of Certified Registered Nurse Anesthetists (CRNAs) regarding opioid-sparing anesthesia (OSA) techniques in cardiac surgery and to assess the barriers to their implementation at one level I trauma center. Certified Registered Nurse Anesthetists' (CRNAs) were surveyed to assess their knowledge and attitudes

towards opioid-sparing anesthesia techniques in cardiac surgery. An educational intervention was developed and provided based on the survey findings. The PICOT question was: Does assessing the knowledge and attitudes of CRNAs and providing an OSA techniques educational intervention in the cardiac surgery population decrease barriers to their implementation? Project objectives are to 1) Identify CRNAs knowledge and attitudes toward OSA in cardiac surgery; 2) develop an evidence-based educational intervention on OSA in cardiac surgery; and 3) conduct a one-month post educational intervention retrospective survey to assess remaining barriers to implementing OSA techniques in cardiac surgery.

Review of Current Evidence

The following databases were searched: PubMed, CINAHL Complete, Google Scholar, and UNCG Library. Keywords included: opioid-sparing, cardiac surgery, cardiac anesthesia, barriers, knowledge, and attitudes. Search results were limited to English language articles published between 2017 and 2021.

Despite limited research in the cardiac surgery population, OSA in noncardiac surgery shows positive results supported by high-quality evidence (Gregory et al., 2019). Due to the adverse side effects of opioids and the opioid epidemic, OSA is becoming a priority in all surgical populations. The individual opioid-sparing medications, techniques, and barriers to implementation are discussed below.

Acetaminophen

Acetaminophen is a safe analgesic and antipyretic, with few side effects. It inhibits central nervous system (CNS) prostaglandin synthesis, blocking pain pathways (Ochroch et al., 2020). Several administration routes are available including intravenous (IV), oral, and rectal. There is limited research in cardiac surgery comparing the efficacy of different routes (Saffary et

al., 2018). IV acetaminophen has been studied extensively in cardiac surgery, but is 400 times more expensive than oral acetaminophen, limiting its use (Ochroch et al., 2020). A recent meta-analysis of an Enhanced Recovery Program for Cardiac Surgery found preoperative oral and intraoperative IV administration of acetaminophen improved pain, lowered the number of opioids administered, and decreased delirium postoperatively (Grant et al., 2020). According to the Enhanced Recovery After Cardiac Surgery Society recommendations, IV acetaminophen, with a dosage of 1 g every 8 hours postoperatively, provides analgesia, is opioid-sparing, and has antiemetic properties (Engelman et al., 2019). Acetaminophen is a class I, level B-NR recommendation (Strong, moderate-quality evidence).

Gabapentin

The anticonvulsant gabapentin is a gamma-aminobutyric acid (GABA) analog. It binds to presynaptic voltage-gated calcium channels in the CNS, inhibiting neurotransmitter release by sensory neurons, decreasing currents in the spinal cord's dorsal root at the site of pain modulation (Ochroch et al., 2020). Studies have shown gabapentin is opioid-sparing and reduces the development of chronic pain after surgery (Ochroch et al., 2020). Administering 600 mg of gabapentin 2 hours before cardiac surgery significantly decreases postoperative pain scores, opioid requirements, and nausea (Engelman et al., 2019; Ochroch et al., 2020). Gabapentin is a class I, level B-NR recommendation (Engelman et al., 2019). Untoward effects include prolongation of sedation, respiratory depression, and mechanical ventilation postoperatively (Grant et al., 2020; Ochroch et al., 2020; Saffary et al., 2018).

Dexmedetomidine

Dexmedetomidine is a centrally acting, selective alpha-2 adrenergic agonist that exerts its sedative, anxiolytic, and analgesic effects by decreasing sympathetic outflow from the CNS and

increasing the activity of GABA (Wiatrowski, 2021). Several recent studies have found dexmedetomidine to have many beneficial effects in cardiac surgery, including decreased postoperative opioid use and delirium, earlier extubation times, decreased ICU and hospital length of stay, and cardioprotective results due to decreased myocardial oxygen demand, fewer myocardial ischemic events and reperfusion injuries (Grant et al., 2020; Ochroch et al., 2020; Wiatrowski, 2021). Dexmedetomidine also was given a class I, level B-NR recommendation from the Enhanced Recovery After Cardiac Surgery Society (Engelman et al., 2019). Their medium-quality meta-analysis demonstrated dexmedetomidine infusions reduced 30-day mortality and acute kidney injury after cardiac surgery, decreased postoperative delirium incidence, and shortened time to extubation.

Ketamine

Ketamine is a dissociative anesthetic that is highly amnestic. It antagonizes n-methyl-d-aspartate (NMDA) receptors and reduces pain transmission (Kumar et al., 2017; Ochroch et al., 2020; Saffary et al., 2018). Ketamine administered at higher anesthetic doses is associated with increased cardiovascular sympathetic effects including tachycardia, hypertension, negative inotropy, and increased myocardial oxygen demand (Ochroch et al., 2020). The sympathetic side effects of ketamine can be avoided at subtherapeutic doses (<0.5 mg/kg/hr.), while maintaining its analgesic and antihyperalgesic effects (Kumar et al., 2017; Ochroch et al., 2020; Saffary et al., 2018). Other benefits of ketamine administration are improved patient satisfaction, improved hemodynamics, decreased respiratory depression, and less frequent postoperative delirium (Engelman et al., 2019; Grant et al., 2020; Ochroch et al., 2020; Saffary et al., 2018).

Intravenous (IV) Lidocaine

Lidocaine is a local anesthetic and class 1b antiarrhythmic (Ochroch et al., 2020; Saffary et al., 2018). Recently studies have shown continuous IV administration of lidocaine has both analgesic and anti-inflammatory properties (Kumar et al., 2017; Ochroch et al., 2020; Saffary et al., 2018) . Research in cardiac surgical patients is limited, but lidocaine infusion has shown promising results in noncardiac procedures. One study of CABG patients showed significantly less opioid use and faster extubation times when a regimen of lidocaine, ketamine, and dexamethasone was administered intraoperatively (Ochroch et al., 2020). Secondary studies revealed other positive outcomes including less time until the return of bowel function, decreased length of hospital stay, and less nausea (Kumar et al., 2017; Saffary et al., 2018).

Regional Anesthesia

Neuraxial anesthesia has been researched extensively in cardiac surgery and is a class IIb recommendation from the European Association of Cardio-Thoracic Surgery (Ochroch et al., 2020). Systemic heparinization during cardiac surgery creates a disincentive for the use of neuraxial anesthesia due to an increased risk of developing an epidural hematoma and other hemodynamic complications associated with neuraxial anesthesia (Saffary et al., 2018). In more recent research, fascial plane chest wall blocks provide optimal postoperative pain control in patients after cardiac surgery. Fascial plane blocks are easily placed and have lower risks than neuraxial techniques (Kelava et al., 2020; Ochroch et al., 2020). However, there are barriers to facial plane chest wall blocks including decreased consistency of anesthetic spread and limited provider experience with the techniques (Ochroch et al., 2020; Saffary et al., 2018). Liposomal bupivacaine, a long-acting local anesthetic with a duration of action of up to 72 hours is a promising adjunct for regional anesthesia techniques in cardiac surgery (Ochroch et al., 2020). Most research on liposomal bupivacaine is in thoracic surgery patients with optimal results in

decreasing pain and opioid use postoperatively. Regional anesthesia in cardiac surgery remains an area of interest and growth, with more research recommended (Kelava et al., 2020; (Ochroch et al., 2020; Saffary et al., 2018).

Existing Barriers

Few studies address barriers to implementing opioid-sparing techniques in surgery (Velasco et al., 2019; Gregory et al., 2019). The common barriers discovered are the superiority of opioids, inadequate resources, lack of knowledge and understanding, patient co-morbidities, inconsistent and negative outcomes, and the requirement for additional research.

Conceptual Framework

Solberg's conceptual framework for practice improvement consists of 3 elements that must be present for change to occur and be sustainable: priority, change process capability, and care process content (Solberg, 2007). The desired change must be a priority and reinforced at all levels. The organization must possess certain factors to be capable of changing a process: strong leadership, a common framework to guide change, change management skills at all levels, adequate time and resources allocated to the change, an excellent clinical information system, teamwork, accountability, communication, and involvement at all levels. Care processes need to maximize their facilitators and minimize their barriers.

This framework will help guide the change to opioid-sparing anesthesia in the cardiac surgery population. Knowing the providers' baseline knowledge and attitudes will reveal the priority and barriers to implementation. This knowledge will help guide the development of educational initiatives to facilitate change.

Methods

Project Design

A qualitative pre-intervention and post-intervention online survey research design was used for this project. The pre-intervention survey was distributed on June 1st, 2021, with a one-month window for completion. It assessed Certified Registered Nurse Anesthetists' (CRNAs) knowledge and attitudes toward opioid-sparing anesthesia (OSA) techniques in general and in cardiac surgery. Twenty-two of the 30 invited CRNAs responded. An evidence-based educational intervention was developed and presented on September 3rd, 2021. On October 3rd, 2021, a post-intervention survey was distributed to the CRNAs who attended the educational intervention to assess barriers to implementing OSA techniques in cardiac surgery. Seventeen of the 19 CRNAs who attended the educational intervention responded.

Translational Framework

The Johns Hopkins Nursing Evidence-Based Practice Model is a tool used by clinicians to help guide and implement the most recent research findings into clinical practice (John Hopkins Medicine, 2017). This tool helps define the clinical problem, identify stakeholders, conduct and summarize research, develop recommendations, implement an action plan, and evaluate and report outcomes.

Permissions

Permission to implement this project was obtained from the project site's Assistant Chief CRNA. Permission to conduct this project was granted by the University of North Carolina Greensboro's (UNCG) Institutional Review Board (IRB) and the project site's IRB.

Sample and Setting

The study's sample consisted of a convenience sample of CRNAs employed at the site. The anesthesia department consists of 30 CRNAs. Student registered nurse anesthetists

(SRNAs), anesthesia assistants, anesthesiologists, residents, and medical students were excluded from participation.

The project site is a not-for-profit healthcare system with 941 beds and is designated as a Level I trauma center. In 2020, the system performed 725 cardiothoracic surgery cases, with an average of 56-71 per month and 2-4 cases per day.

Project Implementation

The educational intervention was developed based on the pre-intervention survey of the CRNAs knowledge and attitudes toward OSA techniques in cardiac surgery. The educational intervention was conducted in person at the site on September 3rd, 2021, with an interactive PowerPoint presentation (see Appendix D). The information presented was evidence-based knowledge derived from contemporary research and focused on gaps identified by the pre-intervention survey.

The project site has a newly implemented Enhanced Recovery after Cardiac Surgery program (ERACS) throughout the cardiac surgery care process. This project helped to reinforce and facilitate the current program elements, focusing on the impact CRNAs have and their barriers to ERACS implementation.

In addition to an email, flyers were made with an embedded QR code and placed in the common areas for CRNAs, bringing attention to the pre and post-intervention surveys and an easy way to complete them.

Instruments

The project used a pre-intervention survey, an in-person educational intervention, and a post-intervention survey as its instruments. The surveys were web-based and were developed and implemented through Qualtrics. The surveys were modeled after an interview guide by Velasco

et al. (2019), which assessed the perspectives of CRNAs on the use of intraoperative alternatives to opioids and found barriers and facilitators to their implementation. The interview guide was developed and reviewed by three doctorate-prepared nurses, one nurse scientist trained in qualitative methodology, and two CRNAs (Velasco et al., 2019).

The project's knowledge and attitude items were modified to be more applicable to OSA techniques in cardiac surgery. The project's team leader, UNCG IRB, and the site's IRB reviewed the surveys for appropriateness. The post-survey focused on knowledge and practice improvement after the educational intervention and identified barriers preventing the CRNA's at the site from implementing OSA techniques in cardiac surgery.

Data Collection

A recruitment email was sent to the CRNAs at the site by the Assistant Chief CRNA. It included the study's purpose, inclusion/exclusion criteria, and an information sheet detailing the anonymous and voluntary nature of participation. Consent was implied if participants chose to complete the survey.

Data Analysis

The surveys were conducted via Qualtrics; Qualtrics allows data to remain anonymous and be statistically analyzed. A thematic analysis was performed on the pre-intervention and post-intervention qualitative survey data. The quantitative data was analyzed by Qualtrics.

Timeline

IRB and project site approval were obtained on May 28th, 2021. The recruitment email and pre-survey were sent out on June 1st, 2021, with the results back by June 29th. It was presented at the site on September 3rd, 2021. One month after the educational intervention, the post-survey was sent out on October 3rd, 2021, with a one-month completion deadline.

Results

A total of 22 out of 33 CRNAs responded to the pre-intervention survey with a response rate of 67%. An additional reminder email was sent, and the assistant chief CRNA personally made CRNAs aware of the survey. The pre-intervention survey results indicated more female (14) than male (7) CRNAs were a part of the sample, and one preferred not to disclose their gender. A wide range of provider ages and years of practice were revealed in the demographic data. More than 70% of the sample surveyed were under 40 years of age, and 68% had been practicing for five years or less. Conversely, less than 5% had been practicing for greater than ten years. Over 80% of the sample was Caucasian, less than 10% African American or Black, and 9% did not respond (see Appendix A).

When the sample surveyed was asked, "do you feel opioid-sparing anesthesia (OSA) techniques in any surgical patient are effective in reducing intraoperative pain" almost 70% indicated "definitely yes." The remaining providers, approximately 30%, answered "probably yes" to the same question. Close to 55% of the sample surveyed answered "definitely yes" when asked, "Prior to August 2020, had you worked with Enhanced Recovery After Cardiac Surgery (ERACS) protocol before". Almost 5% answered "probably yes" and "might or might not," close to 23% answered "probably not," and 14% "definitely not." The sample was also asked, "do you believe OSA should be included in cardiac surgery programs." 68% answered "definitely yes," almost 23% "probably yes," 5% "might or might not," and 5% "definitely not" (see Appendix B).

A thematic analysis was run on the remaining qualitative data. Two key themes emerged specific to the administration of dexmedetomidine and ketamine. CRNAs perceived dexmedetomidine and ketamine as having adverse hemodynamic side effects in cardiac surgery. Statements like, "Ketamine can cause SNS stimulation and can worsen cerebral saturation,"

"Opioids are very cardiac protective. Ketamine plus pain can be an issue with demand ischemia", and "Concerns of inadequate pain control" were made. This led to focusing the educational intervention on these two drug profiles and how recent research is contrary to these perceptions in cardiac surgery anesthesia.

For the post-intervention survey, 17 of the 19 CRNAs who attended the educational intervention responded with a response rate of 89%. Seventy-five percent strongly agreed that the educational intervention improved their knowledge of OSA techniques in cardiac surgery, 25% somewhat agreed, and 0% neither agreed nor disagreed. Only 7 of the 17 CRNAs who responded to the post-survey answered the qualitative question about barriers to implementing OSA techniques in cardiac surgery, a response rate of 37%. After a thematic analysis of this qualitative question, three key barriers to implementing OSA techniques in cardiac surgery were found, 1) regional techniques are not performed in this patient population 2) time limits for training in regional techniques, and 3) not enough buy-in from anesthesiologists and cardiac surgeons. Supporting statements were: "We don't do…regional blocks. To implement these, it would require a lot of training, buy-in from the surgeons, as well as building a list of guidelines on what block and for what procedure" and "Surgeon preference."

Discussion

This DNP project assessed the knowledge and attitudes of CRNAs on opioid-sparing anesthesia (OSA) techniques in cardiac surgery at one level I trauma center. An educational intervention was deployed to identify and decrease barriers to an OSA protocol in cardiac surgery. The pre-survey results were able to identify the knowledge and attitudes of CRNAs. Most CRNAs at this site had a positive attitude toward OSA techniques in all surgeries, including cardiac surgery. Still, approximately 10% thought OSA should not be implemented in

cardiac surgery. The key themes that emerged focused on the lack of regional techniques being utilized and the adverse side effects of ketamine and dexmedetomidine. Participants made supporting statements such as "lack of blocks used preoperatively" and "more BP variability." Similarly, studies describing barriers to OSA techniques support these findings on the variable effects of opioid alternatives and conversely state regional anesthetic techniques as "facilitators to opioid-alternative administration" (Velasco et al., 2019, p.465).

Based on these themes, the educational intervention focused on the latest evidence-based practices and research surrounding regional anesthetic techniques, ketamine, and dexmedetomidine in cardiac surgery (see Appendix D). Ultrasound-guided regional anesthetic techniques provide an excellent opportunity to bridge the gap between opioid-driven and opioid-sparing cardiac anesthesia. Ultrasound-guided regional anesthetic techniques allow providers to not rely solely on multimodal medications for pain management. Many case reports of using fascial plane chest wall blocks have shown promising results, particularly in the case of minimally invasive cardiac surgery procedures (Kelava et al., 2020). These techniques have demonstrated improved time to mobility and "quicker recovery" (Velasco et al., 2019).

Participants' comments regarding the use of ketamine included, "Ketamine can cause SNS [sympathetic] stimulation and can worsen cerebral saturation." Recent studies have shown when ketamine and dexmedetomidine infusions are administered in synchrony, dexmedetomidine is expected to counteract the sympathetic stimulation, decreasing tachycardia, hypertension, salivation, and emergence delirium typically associated with ketamine (Mogahd et al., 2017). Little research has focused on ketamine's effects on cerebral oximetry during cardiac surgery. In studies conducted during spine surgery, ketamine did not cause a significant change in cerebral oxygen saturation (Campos et al., 2017). Additional research would provide

meaningful insights into the effects of ketamine on cerebral oxygen saturations during cardiac anesthesia.

Bradycardia and hypotension are commonly seen with the administration of dexmedetomidine, deterring many anesthesia providers from using it. Nonetheless, reports have shown a more stable hemodynamic profile during cardiac surgery when a dexmedetomidine infusion is utilized, along with reduced analgesic requirements, decreased delirium, reduced ventilator times, & shorter ICU stays when compared to propofol (Sheikh et al., 2018). Recent studies have also shown dexmedetomidine decreases the release of catecholamines while decreasing postoperative myocardial injury and arrhythmic events (Mogahd et al., 2017). As stated above, ketamine and dexmedetomidine infusions work in synchrony, counterbalancing the unfavorable hemodynamic effects of both. The most recent studies on mice and one human trial have shown dexmedetomidine to have cardioprotective effects against ischemia/reperfusion injury, ischemia/reperfusion-induced injury to the kidneys, and it protects the heart against maladaptive remodeling after an ischemic injury (Han et al., 2019). There are also promising murine studies on the neuroprotective effects of dexmedetomidine (Liaquat et al., 2021).

Post-intervention surveys did not identify as many barriers to OSA techniques in cardiac surgery as compared to the pre-intervention surveys. This result suggests the educational intervention did help to alleviate the barriers related to the adverse hemodynamic effects of ketamine and dexmedetomidine. Participants made statements such as, "I learned things about the techniques that furthered my understanding and knowledge to support [OSA techniques in cardiac surgery]." The post-intervention survey results did offer insights into the remaining barriers to implementing OSA techniques in cardiac surgery at this one level I trauma center. The identified ongoing barriers included regional techniques are not performed in the cardiac surgery

patient population at this site, there are time limits for training in regional practices, and there is not enough buy-in from the anesthesiologists and cardiac surgeons regarding regional anesthesia. Recent studies have shown that ultrasound-guided peripheral nerve blocks in cardiac surgery can be effective in reducing postoperative opioid requirements (Smith et al., 2020). Still, it does take skilled providers in these specific techniques to obtain high-quality results. This takes hours of training on the performing providers' part and buy-in from the anesthesiologists and surgeons. At this site, hours of training would have to be facilitated, and protocols would have to be made to ensure the correct nerve blocks were performed for each specific procedure. This investigation differs from similar studies identifying barriers to OSA techniques because these peripheral nerve blocks are not being performed in the cardiac surgery patient population at the project site. This is an area for future practice, education, and policy change for this site's Enhanced Recovery after Cardiac Surgery (ERACS) program.

Solberg's conceptual framework for practice improvement provides insights into the necessary changes which need to occur to advance the use of OSA during cardiac surgery at this site. There needs to be a desire for change at the project site which is reinforced at all levels. The site has strong leadership, teamwork, and adequate time and resources for ultrasound-guided peripheral nerve blocks in the cardiac surgery population to become a reality. Future recommendations need to focus on implementing ultrasound-guided peripheral nerve blocks in the cardiac surgery population.

Limitations

Only 7 of the 17 CRNAs who responded to the post-survey answered the qualitative question about barriers to implementing OSA techniques in cardiac surgery, a response rate of 37%. More female than male CRNAs participated in this project, and a significantly greater

number of "novice" CRNAs (practicing five years or less) participated, which are not representative of a more diverse CRNA population. This project was limited to only CRNAs, future studies should include all anesthesia providers at the site, Anesthesiologists, Student Registered Nurse Anesthetists (SRNAs), and Anesthesia Assistants (AAs).

Conclusion

Opioid-sparing anesthesia (OSA) techniques have been shown to produce excellent results in many surgical populations. These techniques are new to cardiac surgery but have been shown to produce promising results. This project assessed the knowledge and attitudes of CRNAs regarding OSA techniques in cardiac surgery at one level I trauma center and disclosed several implementation barriers. Most surveyed CRNAs had concerns about the hemodynamic effects of ketamine and dexmedetomidine. After an educational intervention, CRNA's knowledge and attitudes towards these two medications improved. There was no negative feedback, only comments about enhanced learning. Assessing the knowledge and attitudes of CRNAs and providing an educational intervention on OSA techniques in the cardiac surgery population decreases barriers to implementation of OSA techniques. The identified barrier- a lack of regional anesthesia techniques, in particular peripheral nerve blocks. These findings can guide future efforts in implementing more regional techniques in the cardiac surgery population.

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Appendix A

Table 1: Pre-Intervention Survey Demographics

Please indicate your gender	%	Count
Male	31.82%	7
Female	63.64%	14
Non-binary / third gender	0.00%	0
Prefer not to say	4.55%	1
Total	100%	22
What is your age?	%	Count
20-29	4.55%	1
30-39	68.18%	15
40-49	18.18%	4
50-59	9.09%	2
Greater than 59	0.00%	0
Total	100%	22
What is your ethnicity?	%	Count
African American or Black	9.09%	2
American Indian or Alaskan Native	0.00%	0
Asian or Pacific Islander	0.00%	0
Caucasian or White	81.82%	18
Other	0.00%	0
Prefer not to say	9.09%	2
Total	100%	22
How long have you been a CRNA?	%	Count
1-2 years	40.91%	9
3-5 years	27.27%	6
6-10 years	27.27%	6
Greater than 10 years	4.55%	1
Total	100%	22

Appendix B

Table2: Pre-Intervention Survey Quantitative Results

Do you feel opioid-sparing anesthesia techniques in any surgical patient are effective in reducing intraoperative pain?	%	Count
Definitely yes	68.18%	15
Probably yes	31.82%	7
Might or might not	0.00%	0
Probably not	0.00%	0
Definitely not	0.00%	0
Total	100%	22
Prior to August 2020, had you worked with Enhanced Recovery After Cardiac Surgery (ERACS) protocols before?	%	Count
Definitely yes	54.55%	12
Probably yes	4.55%	1
Might or might not	4.55%	1
Probably not	22.73%	5
Definitely not	13.64%	3
Total	100%	22
Do you believe opioid-sparing anesthesia should be included in cardiac surgery programs?	%	Count
Definitely yes	68.18%	15
Probably yes	22.73%	5
Might or might not	4.55%	1
Probably not	0.00%	0
Definitely not	4.55%	1

Appendix C

Pre-Intervention Survey Tool

Q1 Please indicate your gender

- ○ Male (1)
- ○ Female (2)
- ○ Non-binary / third gender (3)
- ○ Prefer not to say (4)

Q2 What is your age?

- ○ 20-29 (1)
- ○ 30-39 (2)
- ○ 40-49 (3)
- ○ 50-59 (4)
- ○ Greater than 59 (5)

Q3 What is your ethnicity?

- ○ African American or Black (1)
- ○ American Indian or Alaskan Native (2)
- ○ Asian or Pacific Islander (3)
- ○ Caucasian or White (4)
- ○ Other (5)
- ○ Prefer not to say (6)

Q4 How long have you been a CRNA?

- ○ 1-2 years (1)
- ○ 3-5 years (2)
- ○ 6-10 years (3)
- ○ Greater than 10 years (4)

Q5 Do you feel opioid-sparing anesthesia techniques in any surgical patient are effective in reducing intraoperative pain?

- ○ Definitely yes (1)
- ○ Probably yes (2)
- ○ Might or might not (3)
- ○ Probably not (4)
- ○ Definitely not (5)

Q6 Thinking about what you **know and understand** of opioid-sparing anesthesia, please identify positive factors that influences you to utilize it within your clinical practice.

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Q7 Thinking about what you **know and understand** of opioid-sparing anesthesia, please identify negative factors that influences you to utilize it within your clinical practice.

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Q8 Prior to August 2020, had you worked with Enhanced Recovery After Cardiac Surgery (ERACS) protocols before?

- Definitely yes (1)
- Probably yes (2)
- Might or might not (3)
- Probably not (4)
- Definitely not (5)

Q9 Do you believe opioid-sparing anesthesia should be included in cardiac surgery programs?

- Definitely yes (1)
- Probably yes (2)
- Might or might not (3)
- Probably not (4)
- Definitely not (5)

Q10 Thinking about your experience in opioid-sparing anesthesia in cardiac surgery, please identify positive aspects in your clinical practice.

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Q11 Thinking about your experience in opioid-sparing anesthesia in cardiac surgery, please identify negative aspects in your clinical practice.

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Q12 Tell me about any professional experiences you may have encountered that would shape your beliefs or affect your implementation of opioid-sparing anesthesia techniques in cardiac surgery.

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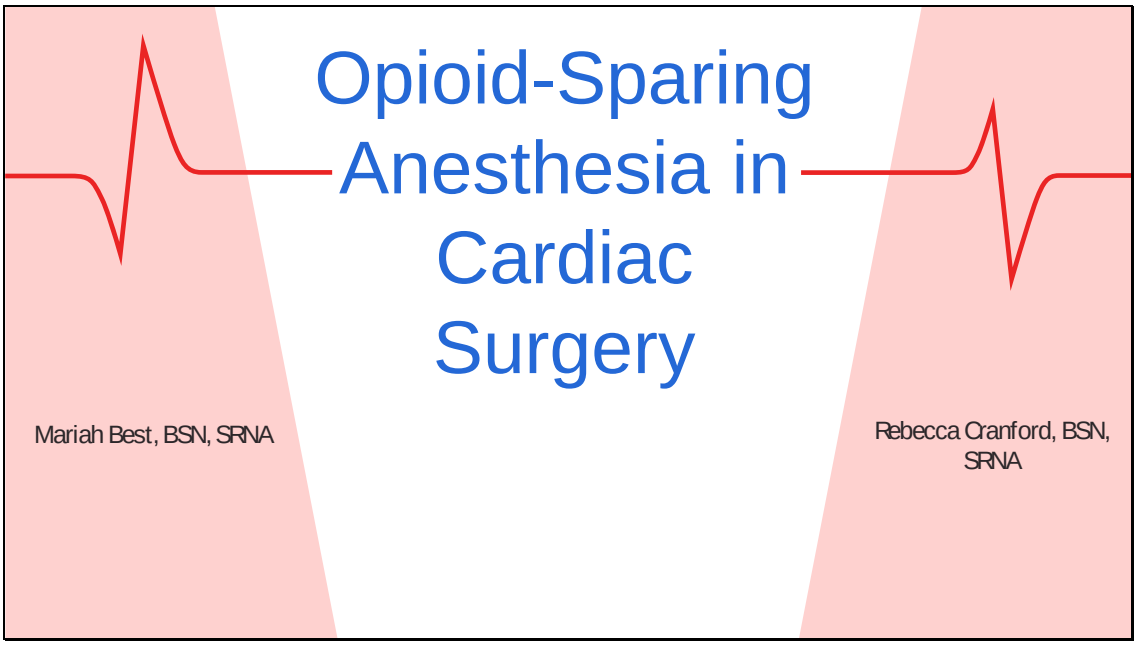
Appendix D

Educational Intervention Tool

Slide 1



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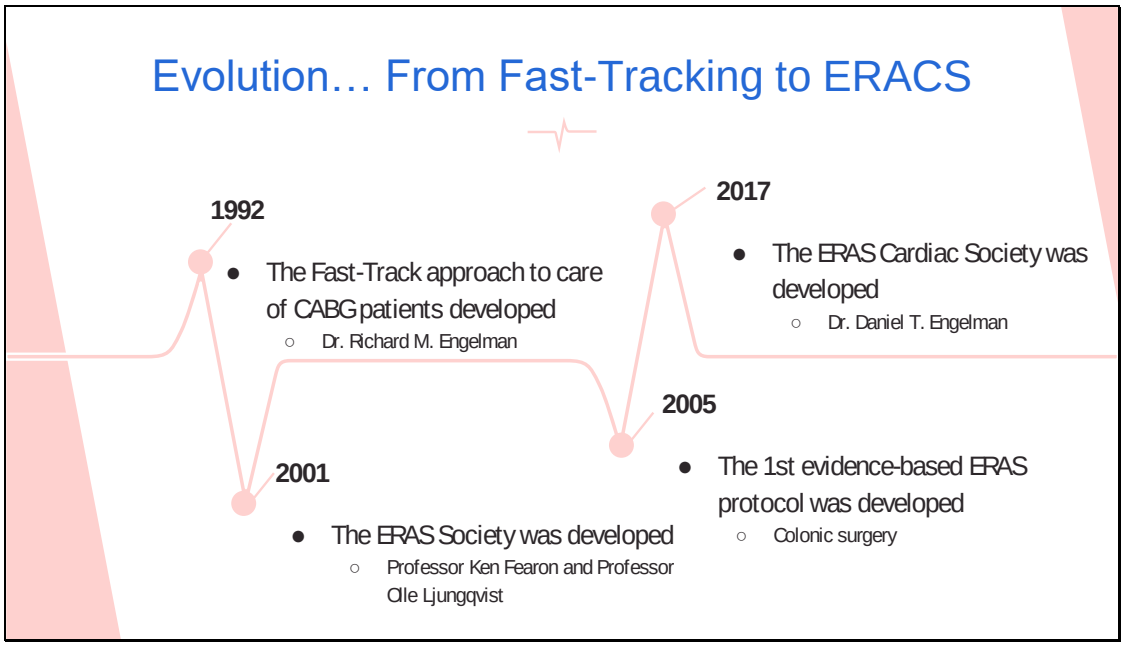


Slide 3

Current Trends: Pharmacological Agents

Acetaminophen

- Opioid sparing
- Decreased postoperative delirium
- Antiemetic properties

Gabapentin

- Opioid sparing
- Decreased development of chronic pain postoperatively

Lidocaine

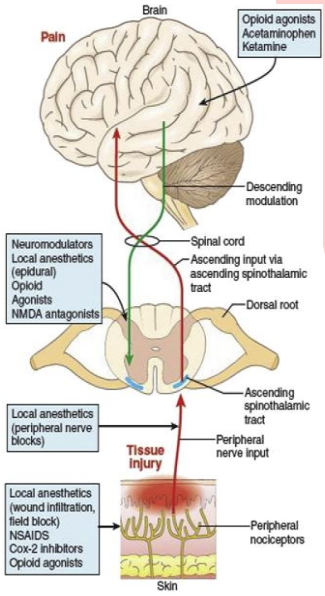
- Opioid sparing
- Early extubation
- Faster return of bowel function

Dexmedetomidine

- Opioid sparing
- Decreased postoperative delirium
- Early extubation
- Cardioprotective

Ketamine

- Opioid sparing
- Antihyperalgesia
- Improved hemodynamics
- Decreased respiratory depression
- Decreased postoperative delirium



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Slide 4

Current Trends: Regional Techniques

Erector Spinae Plane (ESP)

- Blocks spinal nerve dorsal and ventral rami
- Analgesia ALCW and posterior CW

Serratus Anterior Plane (SAP)

- Blocks lateral cutaneous branches of intercostal nerves apprx T3-T9
- Analgesia to LCW

Pectointercostal Fascial (PIF)

- Blocks anterior cutaneous branches of intercostal nerves
- Analgesia to parasternal CW

Pectoral I (PECS I)

- Blocks median and lateral pectoral nerves
- Analgesia to upper ALCW

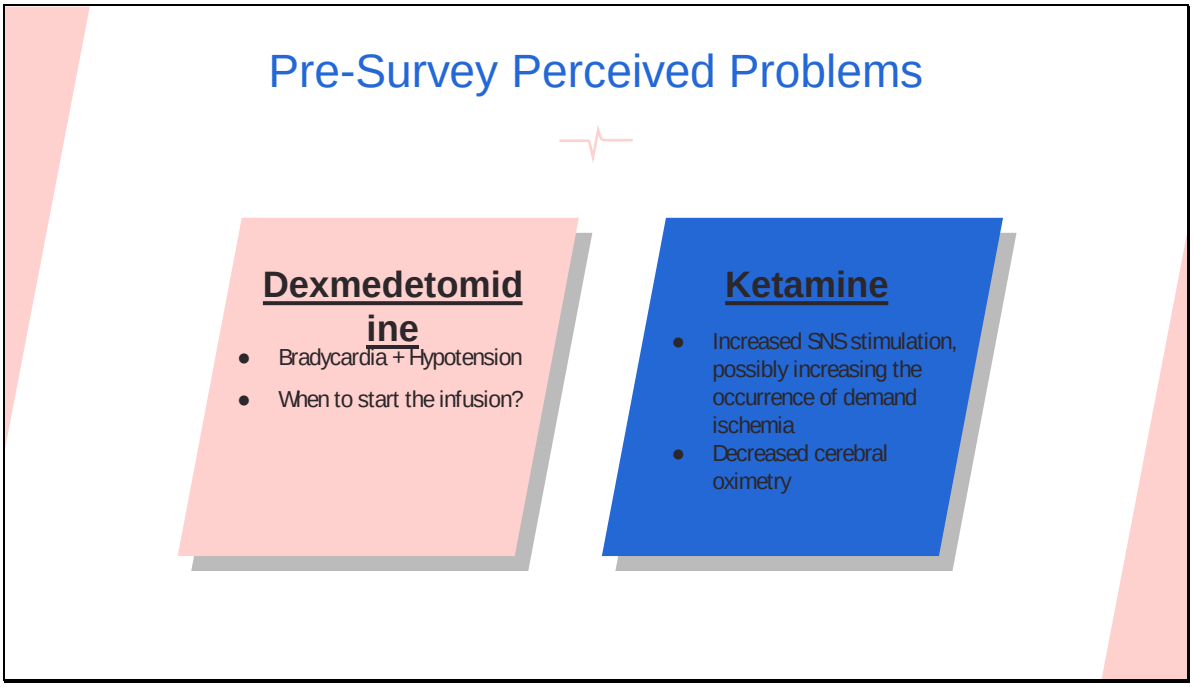
Pectoral II (PECS II)

- Blocks lateral cutaneous branches of intercostal nerves apprx T2-T6
- Analgesia to upper ALCW

Transverse Thoracic Muscle Plane (TTMP)

- Blocks anterior cutaneous branches of intercostal nerves
- Analgesia to parasternal CW

Slide 5



Slide 6

Slide 7

Slide 8

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Slide 9

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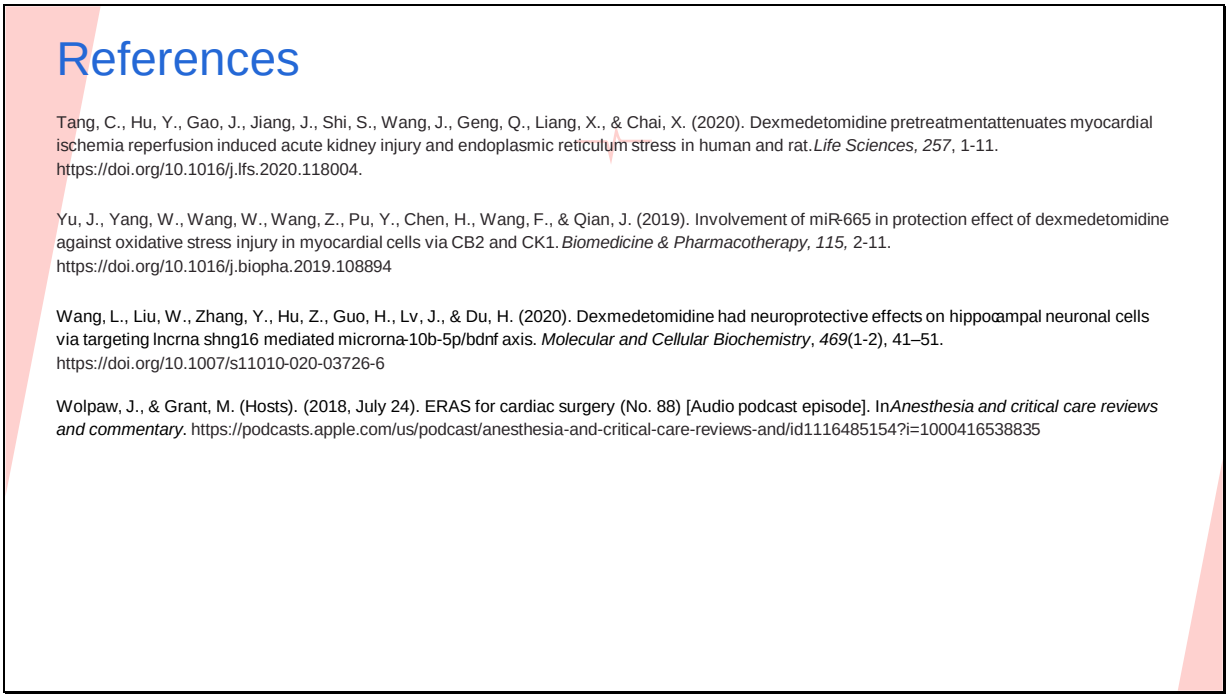
Slide 10



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Appendix E

Post-Intervention Survey Tool

Q1 Following the educational intervention held on September 3rd, 2021, I believe my knowledge on opioid-sparing techniques in cardiac surgery improved.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q2 Following the educational intervention held on September 3rd, 2021, I made changes to my clinical practice to support opioid-sparing techniques in cardiac surgery.

- ○ Strongly agree (7)
- ○ Somewhat agree (8)
- ○ Neither agree nor disagree (9)
- ○ Somewhat disagree (10)
- ○ Strongly disagree (11)

Q3 If you did not make changes to your clinical practice to support opioid-sparing techniques in cardiac surgery, what were the barriers that prevented you from changing?

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