Developing, Implementing, and Evaluating a Dexmedetomidine Infusion Protocol as an Opioid Sparing Technique During Spine Surgery

by

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Abstract

Background: Opioids have been the cornerstone treatment for surgical pain despite their negative side effects including the development of chronic postsurgical pain. Enhanced Recovery After Surgery helps to improve patient outcomes by using multimodal analgesics and limiting opioid administration. Dexmedetomidine is a sedative with notable opioid-sparing capabilities.

Purpose: This quality improvement project aimed to develop and implement an evidence-based protocol that incorporated a dexmedetomidine infusion for patients undergoing spine surgery. Data was collected to analyze whether the results were consistent with the literature.

Methods: Baseline data was collected prior to implementation of the protocol for 50 patients. An educational briefing regarding the protocol implementation was then completed for the anesthesia providers at Kalamazoo Anesthesiology to ensure familiarity with the protocol and benefits of dexmedetomidine as an analgesic. Post-implementation data was collected for all patients who received the full protocol correctly as well as any patients who received the correct dosage of dexmedetomidine.

Results: Only 11 patients received the protocol in full while another 19 received at least the correct total dosage of dexmedetomidine. Out of all of the outcomes assessed, none reached statistical significance. However, time to rescue analgesic *(p* = .835) as well as PACU discharge time (*p* = .50) was shortest in the full protocol group. Interestingly, average opioid administration in each area was lowest among the partial protocol group.

Conclusion: This quality improvement project's results did not align with the current evidence likely in part due to lack of provider adherence. This project did however show a possibility of a decreased time to rescue analgesic and PACU discharge times which could be a reflection of a more balanced anesthetic when a dexmedetomidine infusion is utilized.

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Background and Significance

Management of surgical pain is a cornerstone of anesthesia practice and must be tailored to each individual patient. Opioids have been the primary treatment method for surgical pain despite negative side effects associated with them, including the potentiation of chronic postsurgical pain (Rivat & Ballantyne, 2016; Steyaert & Lavand'homme, 2018). Pain that develops or increases in intensity after a surgical procedure, persists for at least three months, and is localized to the surgical field or related innervation territory is known as chronic postsurgical pain (Papadomanolakis-Pakis et al., 2021). It is estimated that 10-50% of patients are likely to develop this condition after surgery. Uncontrolled pain following spine surgery is so common that there is a condition known as Failed Back Surgery Syndrome, occurring in up to 20% of patients (Cho et al., 2017; Inoue et al., 2017). A risk factor for uncontrolled pain following major spine surgery is preoperative opioid use, which has been shown to be as high as 70% of patients presenting for spine surgery (Dunn et al., 2018).

Enhanced Recovery After Surgery (ERAS) is a protocol that aims to decrease patient length of stay through pain control, fluid management, and mobility exercises. ERAS protocols have historically minimized the use of opioids for analgesia and advocated for a multimodal approach. ERAS protocols typically advise against opioid coverage for analgesia because of the well-documented side effects associated with opioids, including but not limited to: respiratory depression, decreased gastric motility, nausea, vomiting, and the high addictive potential (Simpson et al., 2019). Any of these side effects may prolong length of hospital stay.

Similarly, multimodal analgesia includes various medications that may alleviate pain by inhibiting the transmission of pain or reducing the response to pain at different points on the pain

pathway (Kurd et al., 2017). One method of multimodal analgesia is the use of dexmedetomidine: a widely used intravenous anesthetic agent with sedative and analgesic properties, known for fostering hemodynamic stability, minimally reducing respiratory functions, and improving postoperative recognition and clarity (Zhao et al., 2020). While the exact analgesic mechanism of action is not fully understood, it is probable that dexmedetomidine acts by inhibiting peripheral sympathetic Aδ and C fibers. Inhibition of these fibers decreases the release of Substance P and other nociceptive peptides, halting the transmission of noxious stimuli, and ultimately terminating the signaling of pain (Weerink et al., 2017 & Zhao et al., 2020). Considering dexmedetomidine is a well-known drug with analgesic properties, its utilization as a multimodal analgesic could create an opportunity for Certified Registered Nurse Anesthetists (CRNAs) to decrease opioid use and enhance both short- and long-term outcomes in this patient population.

Problem Statement

The purpose of this quality improvement initiative was to develop, implement, and evaluate an intraoperative dexmedetomidine infusion for patients undergoing spine surgery at Ascension Borgess Hospital. The goal was to reduce perioperative opioid consumption, patient reported pain scores, and Post-Anesthesia Care Unit (PACU) length of stay. In this quality improvement initiative, the term perioperative pertained to the intraoperative and postoperative period exclusively. Through the implementation of this quality improvement initiative, our intention was to help CRNAs minimize opioid administration while maintaining adequate pain control and preventing chronic postsurgical pain.

Literature Review

A literature search was conducted using the Cumulative Index of Nursing and Allied Health (CINAHL) through EBSCOhost, PubMed, Cochrane Library, and Google Scholar. Terms used in the search were: enhanced recovery after surgery, spine surgery, postoperative pain, chronic surgical pain, and dexmedetomidine. Synonyms were also utilized including: back surgery, ERAS, anterior cervical discectomy and fusion (ACDF), posterior lumbar interbody fusion (PLIF), transverse lumbar interbody fusion (TLIF), and Precedex. Publications chosen for inclusion were written in English; included adult subjects; published in the past five years; randomized control trials or higher levels evidence; and focused on either dexmedetomidine infusions for pain in spine surgeries, dexmedetomidine for analgesia, ERAS protocols in spine surgery, or the prediction of chronic postsurgical pain in back surgeries as well as its prevention. Publications excluded were articles written in languages other than English, older than five years, or that included pediatric patients. A total of 58 articles were found that met the initial search criteria; of these, 44 articles were eliminated because they were low levels of evidence including editorials or expert opinions, were not specific to back surgery, or did not use dexmedetomidine as an infusion. This literature search has four distinct sections including ERAS as it relates to back surgery, chronic postsurgical pain, dexmedetomidine as an analgesic adjuvant, and dexmedetomidine in spine surgery.

Enhanced Recovery After Surgery

Debono et al. (2020) assessed the effects of ERAS protocol for patients who received anterior cervical discectomy and fusion (ACDF). A retrospective medical record review was conducted; the medical records of 202 patients who had an ACDF procedure following an ERAS protocol (the ERAS group) were compared to 202 medical records of patients prior to ERAS

protocol implementation (the conventional group). The providers of care for patients in the ERAS group adhered to a standardized set of guidelines for pre-hospitalization, hospitalization, and post-hospitalization treatments, techniques, medications, and other components of care. The 'conventional group' received care according to usual and customary standards at the time of their ACDF surgery.

Total length of hospital stay was the only outcome variable that achieved statistical significance; the conventional group 2.96 +/- 1.35 days versus 1.40 +/- 0.6 days for the ERAS group ($p < 0.001$). There was no statistically significant difference in regards to patient satisfaction or whether they would repeat the surgery between groups. Several limitations were noted within this study. First, there was a five-year time interval between the conventional group and the ERAS group. Second, the study is limited in its generalizability because it was conducted at only one hospital. Finally, the ERAS protocol utilized was not comprehensively described. This research alludes to the possibility of improved outcomes associated with the implementation of ERAS protocols in the realm of spine surgery evidenced by a decreased length of stay. Discharge criteria for surgery frequently includes adequate pain control, and considering the ERAS group had a decreased length of stay, it can be implied that their pain was controlled either earlier or better utilizing this protocol.

Tucker et al. (2021) implemented an ERAS based quality improvement project utilizing multimodal analgesics for spine surgery patients in an ambulatory surgical center located in the southeastern United States. The researchers compared a pre-implementation group ($n = 31$) to a post-implementation group ($n = 31$). Protocol for the post-implementation group included 300 mg of gabapentin preoperatively and 1 mg/kg of intravenous lidocaine prior to induction of anesthesia followed by a lidocaine infusion of 2 mg/kg/h. Intraoperatively, patients received 1

gram of intravenous acetaminophen, 0.5 mg/kg of ketamine, and 1 gram of intravenous magnesium sulfate. During surgical closure, patients received 30 mg of ketorolac with the exception of ACDF surgeries at the request of the surgeons. Data was then collected by retrospective chart review for both patient groups.

Through the results of this quality improvement project, it was found that both intraoperative intravenous opioids and postoperative oral opioid consumption were significantly decreased following implementation of the ERAS protocol ($p < 0.05$). Although this study did not incorporate dexmedetomidine as an analgesic adjuvant, the results highlight the fact that a multimodal pain regimen may reduce overall opioid consumption while maintaining similar pain scores for this patient population. Several limitations exist within this study. First, the project was undertaken on outpatient spine surgery patients, therefore, the results may not be applicable to larger back surgeries including those with instrumentation, or spine surgery in the thoracic region. Second, the sample size of this project is relatively small and further limits the generalizability. Finally, not all of the patients received the full medication regimen for a variety of reasons, which could have altered the results.

Chronic Postsurgical Pain

Papadomanolakis-Pakis et al. (2021) conducted a systematic review analyzing publications that assessed the prognostic capabilities of various models for the development of chronic postsurgical pain. A total of 16,697 patients undergoing a variety of surgeries were analyzed. Results of the study showed that most prediction models reported a moderate to good performance in their ability to predict chronic postsurgical pain. The predictors most frequently appearing were preoperative pain in the surgical area ($n = 11$), age ($n = 7$), preoperative pain in other areas distinct from the surgery site ($n = 6$), sex or gender ($n = 4$), and acute postsurgical

pain severity (n = 4). Spine surgery patients encompass three of these predictors including pain at the site, pain in other areas, and high postoperative pain scores. The results of this study show that extensive surgeries such as lumbar fusion or thoracotomy were more likely to experience chronic postsurgical pain. Limitations of this study included a high risk of bias in the models, heterogeneity amongst the tools used to assess chronic postsurgical pain, and cutoff scores to be considered chronic postsurgical pain.

Carley et al. (2021) conducted a systematic review regarding pharmacotherapy for the prevention of chronic pain after surgery. This review included 110 studies assessing primarily ketamine, pregabalin, gabapentin, intravenous lidocaine, and non-steroidal anti-inflammatory drugs (NSAID). Only pregabalin (5/17 studies), intravenous lidocaine (2/8 studies), and NSAID (1/7 studies) showed statistical significance compared with the placebo. Ketamine and gabapentin had 0 studies which showed superiority. These results are disappointing, as most of these drugs studied are currently used to treat acute pain in the perioperative period. Limitations of the studies included timing, dosage, duration of drug administration, whether multimodal techniques were used, surgical procedures, participants, and sample sizes. Finally, the presence of chronic postsurgical pain severity was not differentiated. This study highlights the need for other drugs with analgesic properties, such as dexmedetomidine, to be further studied to determine if they confer any long-term benefit. Since the treatment of acute pain continues to be a cornerstone of preventing chronic postsurgical pain, it may be beneficial for providers to use different medications for the management of acute pain, including dexmedetomidine.

Dexmedetomidine as an Analgesic Adjuvant

Wang et al., (2018) conducted a systematic review and meta-analysis of 40 randomized controlled trials (RCTs) that compared intravenous dexmedetomidine with normal saline in

2,394 adult patients receiving a general anesthetic. Outcomes assessed were pain intensity up to 24 hours postoperatively, and opioid administration following surgery. The methods of administration varied between RCTs. Continuous infusions were initiated with a bolus of 1 mcg/kg over 10 minutes followed by an infusion that ranged between 0.2-0.7 mcg/kg/h, while the boluses were 0.5-2 mcg/kg. Placebo doses were of 0.9% normal saline of an equal volume. The dexmedetomidine group showed significantly decreased pain intensity within six hours of the procedure and at 24 hours after the surgery ($p < 0.05$). Furthermore, the dexmedetomidine group displayed significantly reduced cumulative opioid consumption at 24 hours after surgery, decreased rescue opioid consumption after surgery, and a prolonged interval to first rescue analgesia ($p < 0.05$).

There were limitations in this study. First, sample sizes were small among several trials included, which may overestimate treatment effect of the included trials. Second, there was high heterogeneity among the timing, dosing, and administration between studies. Third, pain assessment scales, methods for general anesthesia, and opioids chosen for rescue analgesia varied between RCTs. Lastly, this meta-analysis only focused on pain related outcomes and did not include studies that evaluated other adverse events. Overall, this meta-analysis does illustrate the analgesic properties of dexmedetomidine and its potential as a versatile analgesic adjuvant.

Dexmedetomidine in Spine Surgery

The literature search yielded nine randomized controlled trials and one meta-analysis that analyzed the effects of dexmedetomidine on both postoperative pain scores as well as opioid sparing capabilities in spine surgery. Jain et al. (2019), performed a study to look at the effect of dexmedetomidine versus placebo on the recovery profile of patients undergoing ACDF surgery. In this study, 64 patients were randomized into either a dexmedetomidine or a volume matched

normal saline infusion group, with 62 completing the study. The dexmedetomidine group received a loading dose of 1mcg/kg over 10 minutes prior to induction followed by a continuous infusion at a rate of 0.2 mcg/kg/h. Results of this study showed a statistically significant decrease in intraoperative fentanyl requirements between the dexmedetomidine group compared to the normal saline group. Heart rate and blood pressure were also significantly reduced in the dexmedetomidine group ($p \leq 0.05$). Time to emergence and pain scores on a verbal analogue scale were significantly reduced while time to first analgesic was significantly prolonged in the dexmedetomidine group compared to the normal saline group ($p < 0.001$). Weaknesses of this article include a small sample size as well as the patient sample itself since it limits the generalizability to patients who are older, have a higher ASA class, or are undergoing spine surgeries in other regions such as thoracic or lumbar.

Naik et al. (2016) analyzed the effect of dexmedetomidine on postoperative opioid consumption and pain on 131 adult patients undergoing greater than three levels of thoracic or lumbar surgery and found different results than Jain et al. (2019). Preoperatively both the dexmedetomidine group and control groups received methadone. After induction, the dexmedetomidine group received a loading dose of 1mcg/kg followed by a continuous intravenous infusion at 0.5 mcg/kg/h of ideal body weight while the control group received a volume matched normal saline bolus and infusion. The dexmedetomidine group had a significantly decreased amount of fentanyl administered intraoperatively compared to placebo ($p = 0.04$). Postoperatively however, there was no significant difference found in regard to opioid consumption or pain scores. Limitations of this study include the use of methadone in both the dexmedetomidine and saline groups. The long half-life of methadone could have interfered with pain scores and opioid administration postoperatively. Another limitation was that the study was

terminated early due to the hypothesized effect size not being reached and a slow accrual rate. Finally, postoperative analgesia was not strictly standardized and was at the discretion of the intensive care unit team so there may have been variation between treatment thresholds based on different providers. Despite postoperative outcomes not being significant, dexmedetomidine still offered opioid sparing capabilities by decreasing intraoperative opioids.

Tsaousi et al. (2018) performed a meta-analysis of 15 randomized control trials to analyze the sedative and analgesic effects of dexmedetomidine in 913 adult patients undergoing spine surgery. Six out of eight studies reported a significant decrease in intraoperative opioid use ($p < 0.001$). Of the studies that analyzed pain intensity scores, dexmedetomidine showed an attenuation of pain intensity up to the first two hours postoperatively. Five of six studies found that dexmedetomidine decreased postoperative morphine equivalent consumption ($p < 0.001$). Limitations of this publication include moderate to high heterogeneity in the duration of administration and dosage of dexmedetomidine. Moreover, tools used to assess pain varied among the studies. Lastly, many of the studies included were limited to minor spine surgery, limiting the generalizability to major spine surgery.

Post-Implementation Literature Review

After the implementation and evaluation of the protocol, an additional literature review was conducted utilizing the same databases and key words as the first review to account for emerging data on the subject. One new meta-analysis, conducted by Srgianesh et al. 2023, incorporating dexmedetomidine infusions during spine surgery was found. Six randomized control trials were included to analyze differences in postoperative pain relief and adverse outcomes when non-opioid analgesics were implemented. Five of the six studies used dexmedetomidine as the primary non-opioid analgesic agent. The researchers assessed

postoperative pain scores at 1 hour and 24 hours, time to first requirement of rescue analgesia, and opioid use in the first 24 hours following spine surgery. The non-opioid groups had improved pain scores at 24 hours after surgery (MD=0.75 units, 95% CI [0.03 to 1.46], p=0.04), time to first analgesic requirement was prolonged (MD = 45.06 minutes, 95%CI, [72.50 to 17.62], p=0.001) and morphine consumption was lower for the first 24 hours (MD=4.54 mg, 95%CI, [3.26-5.82], p=0.00001). PACU discharge time was similar between groups. Limitations of this study were lack of uniformity among studies, methods of reporting pain outcomes, type of opioid and non-opioid analgesics included, and limited quality of RCTs included due to high risk of bias and heterogeneity.

Project Methodology and Framework

Methods and Framework

The Model for Improvement, which was developed by the Associates in Process Improvement (1996), is the framework used for this project. The model has two distinct parts: the first consists of three initial questions to aid in planning, the second consists of the Plan-Do-Study-Act cycle to assess whether any changes resulted in improvement.

The three questions proposed in the initial part of the model include “What are we trying to accomplish?”, “How will we know that a change is an improvement?”, and “What change can we make that will result in an improvement?”. The first question, “What are we trying to accomplish?”, outlines what specific outcomes we aimed to change. The outcomes we tried to change in this quality improvement included decreasing perioperative opioid consumption, improving postoperative pain scores, and decreasing PACU length of stay in spine surgery patients. The second question, “How will we know that a change is an improvement?”, outlines what measures were necessary to record in order to track success. Measures assessed in our

project included the amount of perioperative opioid consumption in morphine equivalents, time to first dose of rescue analgesic given in PACU in minutes, verbal pain score (0-10) at the time of rescue analgesic delivery, verbal pain score (0-10) at time of PACU discharge, and time to PACU discharge in minutes. The final question, "What change can we make that will result in an improvement?", is used to identify what change is being made to cause an improvement. The goal was to develop and implement an intraoperative dexmedetomidine infusion protocol to reduce perioperative opioid consumption, patient reported pain scores and PACU length of stay.

The second part of the Model for Improvement is the Plan-Do-Study-Act cycle. This is the most important component of the model because it outlines the continuous cycle of testing a change, assessing the change, and acting on the results to reach an optimal outcome. The "Plan" component of this quality improvement project was to analyze the existing body of evidence and develop a protocol for an intraoperative dexmedetomidine infusion for patients receiving spine surgery. The "Do" portion of this project is the implementation of the protocol. The "Study" portion of this project was accomplished by evaluating the results and deciding whether or not it improved the outcomes assessed. Finally, the "Act" component consists of the interpretation of our findings and the choice to incorporate our protocol into current practice or if further research is needed. To set our project up for success, we utilized the Plan-Do-Study-Act Model to help educate the anesthesia providers at Ascension Borgess Hospital on the importance of utilizing an intraoperative dexmedetomidine infusion protocol for patients receiving spine surgery.

Key Personnel

Key personnel in this project include Joshua Ayres BSN, RN, SRNA, principal investigator; Peter Galea BSN, RN, SRNA, co-principal investigator; Andrea Bittinger DNP, CRNA, DNP project chair; Kayla Donnay, DNP, CRNA, committee member; Robert Hilliard

MD, Director of Anesthesia; John McPheters MD, Co-Director of Anesthesia - Kalamazoo Anesthesiology.

Participants & Population

The participants for this project were the CRNAs and Anesthesiologists actively practicing in the Kalamazoo Anesthesiology group located in Kalamazoo, Michigan. The target population for this project included all patients greater than 18 years of age, who received a general anesthetic during spine surgery scheduled for greater than one hour. Exclusion criteria for this project were patients younger than 18 years of age, spine surgery scheduled for less than one-hour, kyphoplasties, and patients with a baseline heart rate of less than 50 beats per minute.

Design and Implementation

Initially, Robert Hilliard MD, endorsed our project for implementation at Borgess Hospital (Appendix A). Next, the Internal Review Board located at Western Michigan University's Homer Stryker School of Medicine approval was granted (Appendix B), and implementation of this project began with the collection of baseline data utilizing the tool listed in Appendix C for 50 patients who met the inclusion criteria. The patients had received spine surgery at least three months prior to initiation of the project and their de-identified case specific data was extracted from Cerner, the electronic medical record platform used at Ascension Borgess Hospital.

The next step involved an educational briefing for the anesthesia providers who work for Kalamazoo Anesthesiology. Dexmedetomidine is a Food and Drug Administration (FDA) approved drug, with well-known benefits regarding analgesia and anesthesia. Considering that these benefits provided an opportunity to improve outcomes in patients undergoing spine surgery, a discussion regarding the benefits of dexmedetomidine as an analgesic adjuvant was

undertaken September 1st, 2022, at a scheduled monthly meeting for Kalamazoo Anesthesiology. The anesthesia providers at Kalamazoo Anesthesiology have access to dexmedetomidine and use dexmedetomidine for their patients on a regular basis. The educational debriefing included analgesic properties of dexmedetomidine, the literature to support the protocol, and the protocol implementation plan. After this educational briefing, the Quality Improvement project was officially implemented.

All patients that qualified for this protocol were included in the intervention plan. Development of the protocol began with an extensive evaluation of the current evidence-based literature. Patients were to receive a 1 mcg/kg of ideal body weight bolus dose of dexmedetomidine over a 10-minute period immediately following induction (Wang et al., 2018; Jain et al., 2019; Naik et al., 2016). Next the dexmedetomidine infusion was to be initiated at a set rate of 0.2 mcg/kg/h of ideal body weight (Wang et al., 2018; Jain et al., 2019).

Other aspects of care were at the discretion of the anesthesia provider, including the titration of anesthetic gas, management of hemodynamics, and the administration of other multimodal analgesics such as lidocaine or ketamine. Timing for the termination of the dexmedetomidine infusion was based on the context-sensitive half time of dexmedetomidine, and therefore determined by the length of the surgery. If the surgery lasted longer than two hours in duration, the infusion was terminated between 45-75 minutes prior to emergence. If the surgery was shorter than two hours in duration, the infusion was terminated between 15-45 minutes prior to emergence (Lirola et al., 2012). Upon arrival to the PACU, pain scores were documented in the electronic medical records per the PACU protocol.

The project was initiated for a total of three months to obtain sufficient data required to make an accurate comparison between pre- and post-intervention groups. Following the three-

month period, the researchers were to select the first 50 patients who received the protocol and extracted data from their electronic medical record utilizing the data extraction tool listed in Appendix C.

Measurement Instruments and Data Collection

To gather data and assess compliance with this protocol, a spreadsheet was utilized as a data collection tool (Appendix C). Items measured included compliance with protocol, length of surgery, time to rescue analgesic in PACU, intraoperative and postoperative opioid use in morphine equivalents, total perioperative opioid use in morphine equivalents, length of PACU stay, and the use of a lidocaine infusion or ketamine boluses. The data collection tool was used for both pre-intervention and post-intervention groups so the results were compared utilizing statistical analysis and a conclusion regarding the efficacy of the protocol was defined.

Ethical Considerations

The Western Michigan University Homer Stryker School of Medicine Internal Review Board (IRB) approved this doctoral nursing practice project prior to its initiation (Appendix B). Patient data remained ambiguous by extracting only demographic and case specific data to protect their identity. This process ensured that the Health Insurance Portability and Accountability Act of 1996 (HIPAA) rules were appropriately followed. Barbara Mulder, the Director of Quality & Patient Safety at Ascension Borgess, was also consulted to ensure patient protection and integrity of protocol.

Risks and Benefits

The identifiable risks associated with the implementation of this protocol were secondary to the side effect profile of dexmedetomidine. These possible side effects include bradycardia, hypotension, and excessive sedation in PACU, all of which are treated by CRNAs,

anesthesiologists, and RNs in the PACU. Benefits of this protocol included the potential for decreased perioperative opioid consumption, decreased pain scores postoperatively, and decreased PACU length of stay. There were no identifiable ethical issues, as dexmedetomidine is regularly given in the perioperative setting, including the intraoperative period for both sedation cases as well as during general anesthetics.

Timeline

The approval of the proposed Doctoral project by the Oakland University-Beaumont Graduate Program of Nurse Anesthesia faculty was in the Summer of 2021. In December of 2021, the DNP students met with their project chair to discuss their project. The principal investigators proposed their project to the IRB at the Western Michigan University Homer Stryker School of Medicine for approval in June of 2022. Pre-implementation patient data was collected from surgeries that took place within the three months prior to the protocol start date– July 2022 through September 2022. The educational debriefing took place during the Kalamazoo Anesthesiology monthly meeting on September 1st, 2022. Implementation of the protocol took place between October 2022 and December 2022. Final analysis of the project occurred between January 2023 and April 2023. Final dissemination of project findings occurred between May 2023 and July 2023.

Results

Measurement and Data Collection

The main objectives we aimed to accomplish were to decrease perioperative opioid consumption, decrease postoperative pain scores on arrival to PACU as well as discharge from PACU, and decrease time spent in PACU. The initial plan was to compare 50 patients who underwent spinal surgery prior to implementation of the protocol (no protocol group) to 50

patients post implementation (full protocol group). However, due to lack of participation and adherence to the protocol, only 11 patients received the protocol in full which included a correct bolus and infusion of medication as well as the correct stop time. This led to the decision to incorporate all patients who had received at least the correct bolus and infusion of dexmedetomidine in the analysis to see if there was any significant effect on observed patient outcomes (partial protocol group). Nineteen patients received the correct dosage of dexmedetomidine and thus were included in the partial protocol group. The impact of the protocol on the patient outcomes were presented to the anesthesia providers of Kalamazoo Anesthesiology and the Oakland University - Beaumont Graduate Program of Nurse Anesthesia faculty.

Statistical Analysis

Data were organized by the researchers and analyzed for statistical significance by a statistician. After compiling the data in an excel document, the researchers shared results with the statistician and analysis via SPSS v.29 was completed. Statistical analysis was completed via utilization of the ANOVA model for a majority of the outcomes. Some of the groups had a violation of normality, however, ANOVA was utilized because it is robust against violations in normality as long as homogeneity of variances are maintained. To determine if ketamine or lidocaine administration had an effect on opioid use as a covariate, ANCOVA was utilized.

Patient Demographics

The sample consisted of 80 patients; over half of the patients were over the age of 64. Sixty percent were male and 64% had an ASA score of 3, however there were no higher ASA scores. Thirty (38%) patients received the correct dosage of dexmedetomidine of which another

38% received the full implementation of the intraoperative dexmedetomidine protocol. Thirty-six percent received a lidocaine infusion and 78% received ketamine boluses.

Total Opioid Administration

Opioid doses were measured in morphine equivalents. The results were insignificant indicating no differences in means for the protocol groups in intraoperative $F(2,77) = .294$, $p = .746$, PACU $F(2,77) = .096$, $p = .909$, and total opioid doses $F(2,77) = .309$, $p = .735$. The means were nearly identical between the full and no protocol groups for intraoperative, PACU and total opioid doses (Table 1). The partially implemented protocol group had the lowest means for opioid dosages.

Table 1

Protocol and Opioid Consumption Descriptives

Implementation of Protocol	N	M	SD	Std. Error
Intraoperative Opioid Dose				
Full	11	16.7	12.2	3.68
Partial	19	14.5	7.6	1.75
None	50	16.1	8.9	1.26
Recovery Unit Opioid Dose				
Full	11	13.4	10.7	3.24
Partial	19	12.5	7.9	1.82
None	50	13.5	9.4	1.33
Total Opioids Received				
Full	11	31.1	18.2	5.47
Partial	19	27.7	11.6	2.66
None	50	30.6	14.7	2.08

Length of Time to Rescue Analgesia

Length of time to rescue analgesic administration was measured in minutes. The ANOVA model was insignificant, $F(2,73) = .180$, $p = .835$. The fully implemented protocol group took the least amount of time in recovery to receive rescue analgesics (25.9 minutes) compared to the partially implemented (37.1 minutes) and no implementation (35.6 minutes) groups (Table 2).

Table 2
Protocol and Time to Rescue Analgesics

Implementation of Protocol	N	M	SD	Std. Error
Time to Rescue Analgesics				
Full	11	25.9	17.5	5.275
Partial	19	37.1	34.6	7.933
None	50	35.6	62.5	9.215

Pain Scores

Upon Arrival to the Recovery Unit

Pain scores upon arrival to the PACU were measured on a scale of 0-10. The model was not significant, $F(2,77) = .285$, $p = .753$. The pain score mean for the full protocol group was lowest with an average patient reported pain score of 5.45 compared to the partially implemented group (6.32) and no implementation group (6.22).

Upon Discharge from the Recovery Unit

Pain scores upon discharge from the PACU were measured on a scale of 0-10. The ANOVA model was not significant, F (2,77) = .964, p = .386. The pain score mean for the full protocol was lower (4.91) than the partial protocol (6.16) and no protocol (5.40) groups.

Length of Stay

Length of stay in the recovery unit was measured in minutes. There were no significant differences between the protocol implementation groups, F (2,77) = .7, p = .50. Despite the differences not being statistically significant, it is noted that the fully implemented protocol group had the shortest length of the stay (228.1 minutes) in the recovery unit with the least amount of variance (Table 3).

Table 3
Protocol and Length of Stay in Recovery Descriptives

Implementation of Protocol	N	M	SD	Std Error
Full	11	228.1	93.9	28.3
Partial	19	284.7	118.4	27.2
None	50	286.5	169.9	24.0

Effects of Other Multimodal Analgesia

Ketamine

An ANCOVA was run to determine the effect of the three protocol groups (pre-protocol, partial protocol, full protocol) on the amount of opioids used during the intraoperative, postoperative, and total perioperative periods. After adjustment for ketamine use (yes for 75.5%

of the participants), there was no statistical difference between the protocol groups, F (2,76) = .883, p=.418. partial η2 = .023.

Lidocaine

An ANCOVA was run to determine the effect of the three protocol groups on the amount of opioids used during the intraoperative, postoperative, and total perioperative periods. After adjustment for lidocaine use (yes for 36.3% of the participants), there was no statistical difference between the protocol groups, F (1,76) = .305, p=.738. partial η2 = .008.

Ketamine and Lidocaine

An ANCOVA was run to determine the effect of the three protocol groups on the amount of opioids used during the intraoperative, postoperative, and total perioperative periods. After adjustment for both ketamine and lidocaine use (yes for 33.8% of the participants), there was no statistical difference between the protocol groups, F (2,77) = .230, p=.795. partial η2 = .006.

Discussion

Historically, patients have had a high degree of uncontrolled pain following spine surgery (Cho et al., 2017; Inoue et al., 2017). Opioids have been the primary treatment method utilized for surgical pain. With the high amounts of uncontrolled pain scores and negative side effects of opioid use, there is a push towards a multimodal pain approach to improve patient outcomes. The goal of this quality improvement project was to develop and implement an intraoperative dexmedetomidine infusion protocol and evaluate the effect on patient outcomes.

Development and Implementation

The protocol was developed based upon evidenced-based literature which includes 9 randomized controlled trials and 1 meta-analysis. There was an initial educational briefing that occurred for the anesthesia providers in order to facilitate an understanding of dexmedetomidine as an analgesic agent as well as an introduction to the protocol. In addition to the familiarization of the protocol to the anesthesia providers, we collaborated with the Pharmacy Department to stock reconstituted dexmedetomidine bags in the OR dispensing system to ease access to the drug. Also, to ensure adequate access to the protocol, it was posted on all the anesthesia gas machines in the operating rooms, emailed to all the employees, and our contact information was given out if there were any questions (Appendix D).

Patient Outcomes

Opioid Usage

Opioid usage was compared between the pre-implementation group, and both the group that received the full protocol as well as the partial protocol group. In all three time periods which included intraoperative, postoperative, and total perioperative opioid usage, there was no significant difference observed between groups. Interestingly, the group that received the full dosage of dexmedetomidine had the lowest average opioid administration. After adjusting for the administration of ketamine and lidocaine, there was still no significant difference between protocol groups. Overall, our data was not consistent with the literature with regard to opioid sparing capabilities of dexmedetomidine in spine surgery.

Time to Rescue Analgesic

The results of the remaining outcomes which included length of PACU stay, pain scores upon arrival and discharge of PACU, and time to rescue analgesia were not associated with any statistical significance. It is important to note that time to rescue analgesic was trending towards significance with the length of time to rescue analgesia being shortest in the full protocol group (25.9 minutes) versus the partial (37.1 minutes) and pre-implementation group (35.6 minutes). This is in contrast to the literature, which shows that time to rescue analgesia is prolonged significantly when receiving a dexmedetomidine infusion during spine surgery (Jain et al., 2019 & Wang et al., 2018). This may be due to two reasons, the first being the fact that we stopped the dexmedetomidine according to the context sensitive half time since there was no consensus in the literature on when the infusion should be terminated. The second reason being the fact that when the dexmedetomidine infusion is utilized it may allow for a more balanced anesthetic including a decreased fraction of inspired inhaled anesthetic. When taking these two possibilities in consideration, it is possible for the patients in the protocol group to emerge quicker from their anesthetic, necessitating prompt analgesic administration. These possibilities are even more likely, considering there was no significant difference in the amount of opioids these patients received.

PACU Length of Stay

The PACU length of stay was another variable that was trending towards significance, but due to small sample sizes, did not reach it. This is reflected when looking at the average stay for the protocol group, which was much shorter in the full implementation group (228.1 minutes) compared to the partial implementation group (284.7 minutes) and the no protocol group (286.5 minutes). We found this interesting because a major concern expressed by the anesthesia

providers at Kalamazoo Anesthesia was that the length of PACU stay would be increased in excess, however, our data shows that it possibly expedited the patients' recoveries. This, combined with the trend towards significance for a decreased time to rescue analgesia in the protocol group, may further imply the likelihood that patients who received a dexmedetomidine infusion were more likely to emerge and recover from anesthesia in less time than a traditional anesthetic.

Recommendations and Limitations

Recommendations

Recommendations for quality improvement initiatives going forward should focus on improving provider adherence to project guidelines. It is clear that the success of quality improvement projects is paramount to the participation from providers. Strategies for improving provider adherence may include monthly feedback sessions, a midpoint questionnaire regarding current provider opinions, and constant communication with the interdisciplinary team regarding project satisfaction. The utilization of a dexmedetomidine infusion for spine surgery has the potential for patient and provider benefits as demonstrated in the literature search and in part by this quality improvement project.

The lowest dosage range listed in the literature was utilized in this quality improvement project, which may have limited the opioid sparing effect of dexmedetomidine. Future quality improvement projects could focus on increasing the dosage based on the current literature to determine if there is an enhanced effect on opioid sparing. Also, in this quality improvement project, spine surgeries of all types were utilized in analysis, however they were not differentiated in the data. Future quality improvement projects should differentiate between the different types of spine surgeries to look for possible effects between these groups.

In the future, it may be pertinent to utilize dexmedetomidine infusions for patients with increased anesthetic requirements to minimize anesthetic gas use; this may facilitate a quicker emergence and shorter PACU time. This may also be helpful in longer surgeries in which time to emergence is typically prolonged. Based on this quality improvement project however, utilizing dexmedetomidine as a way to spare opioids in the perioperative period cannot be recommended until further research and possibly different dosages are trialed during other quality improvement projects.

Limitations

There were several important limitations to this quality improvement project. First, the data was limited by a small sample size due to poor provider adherence to the protocol. Second, a small group of CRNAs repeatedly delivered the protocol correctly to a majority of the patients used in our partial and full implementation results. One CRNA in particular delivered over half of our full implementation results. This could have skewed the results as this anesthesia provider was not the major contributor to pre-implementation data. In addition to this, this provider occasionally administered large doses of narcotic to total intravenous anesthetic cases to ensure immobility.

Implications for Nursing Practice

This quality improvement project impacts nursing practice in a variety of ways and therefore has many implications. Nursing practice is based on critical thinking and understanding the theoretical background (Yip, 2021). Through the development and implementation of a quality improvement initiative, the nursing field may utilize research aimed at improving patient outcomes to alter current evidence-based practice for the benefit of the patient, or practitioners. This concept requires constant learning and modification to ensure patient outcomes improve

with the development of protocols that contain novel approaches to patient care. Therefore, the creation and implementation of a quality improvement project by members of the nursing profession has a significant impact on overall healthcare outcomes, and crucial importance for the profession of nursing.

An additional impact of this project would be the ability for nursing practice to decrease the cost of care by possibly enhancing the speed in which a patient emerges from anesthesia as well as possibly decreasing PACU discharge times. Also, shortening time spent in PACU may improve patient satisfaction as they emerge quicker from anesthesia and may be discharged from the hospital quicker, rather than sleeping for an extended period in PACU.

This quality improvement project has highlighted several other questions that need to be addressed, such as what the effects of different dosages of dexmedetomidine have on opioid sparing and patient outcomes, or when is the optimal time to conclude a dexmedetomidine infusion following spine surgery. Because of the constant growth in the field of nursing, it is crucial for nurses to stay up to date on the latest research. Furthermore, it is equally important that doctorate nurses take this research and implement further quality improvement projects to answer questions that have arisen from our project. This may continue to allow for critical findings that may ultimately improve patient outcomes, reduce healthcare costs, and improve patient satisfaction.

Contributions to the Doctorate of Nursing Practice Essentials

Throughout the development and implementation of this quality improvement initiative six of the DNP Essentials were met. The DNP Essentials are eight competency pillars that must be outlined in the curriculum of a doctoral degree in nursing practice. In order to receive accreditation from the Commission on Collegiate Nursing Education, a DNP program must

ensure that all eight of these competencies are met by building them into the program curriculum. During the development and implementation of this quality improvement project DNP essentials I, II, III, VI, VII, and VIII were met.

Essential I: Scientific Underpinnings for Practice was met through the incorporation of the understanding of dexmedetomidine's mechanism of action on enhancing analgesia. It was also met through the utilization of research and how positive change could be initiated through the utilization of this drug.

Essential II: Organizational and Systems Leadership for Quality Improvement and Systems Thinking was met through the constant collaboration and approval of leadership and quality improvement bodies at Ascension Borgess Hospital, Western Michigan University IRB, Directors of Anesthesiology, and the Director of Quality & Patient Safety at Ascension Borgess Hospital. This ensured that our protocol would meet HIPAA requirements and established our protocol as a legitimate quality improvement initiative for Borgess patients.

Essential III: Clinical Scholarship and Analytical Methods for Evidence-Based Practice was met through the processes of in-depth literature review, both pre and post-implementation, as well as through the collection of data and its interpretation through statistical analysis.

Essential VI: Interprofessional Collaboration for Improving Patient and Population Health Outcomes: was met through the recruitment of the pharmaceutical department to ensure participation with the quality improvement project and the incorporation of a mixed practice anesthesia team that includes CRNAs and Anesthesiologists.

Essential VII: Clinical Prevention and Population Health for Improving the Nation's Health was met through identifying spinal surgery patients as an at-risk population for the

development of chronic postsurgical pain and developing a quality improvement project with the overall goal of mitigating that risk.

Finally, Essential VIII: Advanced Nursing Practice was met through the entire process of developing and implementing a quality improvement project. Specifically, Essential VIII was met through the recognition of a need for improvement, the integration of data from the literature to develop a quality improvement protocol, the recognition of and attempts to mitigate barriers, the implementation of the protocol, and the interpretation of the resulting data.

Conclusion

Spine surgery patients often present with chronic pain and this pain is often compounded and complicated by high pains scores experienced after surgery. The traditional use of opioids for treatment of pain perioperatively confers several negative side effects and does not align with the current trend of ERAS which includes the use of multimodal analgesics to manage pain. The current literature shows that dexmedetomidine may be beneficial to spine patients by allowing for intraoperative and postoperative opioid sparing. This quality improvement project included a literature review, development of an intraoperative dexmedetomidine infusion protocol for spine patients, implementation of the protocol, and evaluation in the aims to help improve outcomes in patients undergoing spine surgery.

Unfortunately, this quality improvement project did not reflect the current literature in regard to opioid sparing, however, it did reflect a possible improvement in time to recovery from anesthesia and discharge from PACU. The data overall was not well balanced in the implementation group due to lack of provider adherence which likely affected the results. Dexmedetomidine has great potential for improving outcomes as shown in the literature as well

as this quality improvement project, with benefits ranging from opioid sparing to decreased PACU discharge times. However, in order to ensure the highest quality of care for our patients in the future, more quality improvement projects need to be performed to assess differing doses of dexmedetomidine and ways of improving provider adherence.

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Appendix A

Endorsement from the Anesthesia Group

Kalamazoo Anesthesiology, P.C.
900 Peeler Street
Kalamazoo, MI 49008

269.345.8618
kalamazooanesthesiology.com

June 20, 2022

To whom it may concern:

I am familiar with Peter Galea and Joshua Ayres quality improvement project titled Dexmedetomidine Infusion for Spine Surgery. I understand that Ascension Borgess' involvement is to allow the trial of a new ERAS protocol for our neurosurgical patients that is very similar to that which we use for many other surgical patients.

I understand that this quality project will be carried out following HIPPA regulations and confidentiality will be maintained using de-identification strategies as described in the proposal.

Therefore, as a representative of Ascension Borgess, I agree that Peter Galea and Joshua Ayres QI project may be conducted at our institution.

Sincerely,

[redacted]

Robert D Hilliard, MD
Surgical Services Medical Dyad
Ascension Borgess Hospital

Appendix B

IRB Approval Letter

WESTERN MICHIGAN UNIVERSITY
Homer Stryker M.D.
SCHOOL OF MEDICINE

Full Accreditation

NON-HUMAN RESEARCH DETERMINATION

June 22, 2022

Peter Galea, BSN, RN, SRNA
Nurse Anesthesia DNP-NA Candidate
Oakland University

TYPE OF REVIEW: NON HUMAN RESEARCH DETERMINATION

PROTOCOL TITLE: Developing, Implementing, and Evaluating a Dexmedetomidine Infusion Protoocl as an Opioid Sparing Technique During Spine Surgery

Dear Mr. Galea:

On 06/22/2022 it was determined that the proposed activity does not meet the definition of human subjects as defined by the Common Rule and FDA . The intent and scope of this project is to improve the quality of care at Ascension Borgess. When presenting or publishing it should be presented as quality improvement not research.

The quality improvement project will be conducted at Ascension Borgess Hospital with permission and under the oversight of Robert D. Hilliard, Surgical Services Medical Dyad. Per the HIPAA regulations no protected health information should be disclosed outside of the covered entity, Ascension Borgess Hospital, for this project.

This determination applies only to the activities described in the documents submitted to the WMed IRB.

If you should have questions regarding the status of your project, please contact the Office of the IRB at 269-337-4345 or e-mail irb@med.wmich.edu.

Sincerely,

[redacted]

Parker Crutchfield, PhD
IRB Chair
Western Michigan University Homer Stryker M.D. School of Medicine
1000 Oakland Drive
Kalamazoo, MI 49008-8012

cc: Robert Hilliard
Joshua Ayers
Barbara Mulder

Appendix C

Data Collection Tool

Patient Identification Information (Gender, Age, ASA score)	Protocol Used (Y/N)	Length of Surgery (Minutes)	Time to Rescue Analgesic in PACU (Minutes)	Length of PACU Stay (Minutes)	Pain Score on Arrival to PACU (0-10)	Pain Score When Leaving PACU (0-10)	Intraoperative Opioid Administration (MME)	PACU Opioid Administration (MME)	Total Perioperative Opioid Administration (MME)	Lidocaine Infusion Utilized (Y/N)	Ketamine Utilized (Y/N)

Appendix D

Intraoperative Dexmedetomidine Infusion Protocol Guidelines

Intraoperative Dexmedetomidine Infusion in Spine Surgery

QI Project: Implementation of an evidence-based protocol utilizing dexmedetomidine infusions during spine surgery

Rational: Dexmedetomidine has been shown to decrease perioperative opioid use, decrease time to emergence, decrease pain scores, and increase time to rescue analgesic in PACU.

Inclusion Criteria:

- Patients > 18 years old
- Spine surgery scheduled for > 1h at Ascension Borgess Hospital
- Receiving a general anesthetic

Exclusion Criteria:

- Patients < 18 years old
- Spine surgery scheduled for < 1h
- Kyphoplasties
- Baseline heart rate ≤ 50 beats per minute

Instructions:

- Dosing of Dexmedetomidine will be based upon ideal body weight (IBW)
  - Ideal Body Weight Calculation:
    - Males: Height (cm) – 100
    - Females: Height (cm) – 105
- Patients will receive a 1 mcg/kg (IBW) bolus dose of dexmedetomidine over a 10-minute period immediately following induction and intubation
- A continuous infusion will be initiated at a set rate of 0.2 mcg/kg/h (IBW)
- Termination of infusion will be based on context sensitive half-time and length of surgery
  - If surgery > 2h in duration, infusion will be terminated between 45-75 minutes prior to emergence
  - If surgery < 2h in duration, infusion will be terminated between 15-45 minutes prior to emergence
- All other aspects of care will be managed at the discretion of anesthesia provider

If you have any questions, please contact us either by email, text message, or TigerText.

Sincerely,

Josh Ayres
jayres@oakland.edu
(269) 808-1283

Peter Galea
pgalea@oakland.edu
(734) 233- 5145