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A Quality Improvement Initiative for Intraoperative Low Dose Ketamine Utilization in Thoracotomy

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ABSTRACT

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The challenge of postoperative pain control following a thoracotomy is well noted among anesthesia providers. The intraoperative utilization of low-dose ketamine in several patient populations, including those undergoing a thoracotomy, has been deemed a viable intervention in the multi-modal analgesia plan at not only reducing postoperative pain scores for patients, but also reducing opioid consumption. This quality improvement project sought to increase provider awareness of this intervention among anesthesia providers in a community hospital with a goal to influence a practice change. This was completed using a pre-post design centered around an educational in-service, with an additional 60-day follow-up survey to gather provider feedback on the success of the in-service. Baseline knowledge and utilization of this technique was determined prior to the educational offering. Statistically significant improvement in the knowledge of low-dose ketamine was noted and all providers indicated a willingness to implement this practice change. Despite low volumes of this patient population in this community hospital, those providers who did implement the use of low-dose ketamine felt both postoperative pain and opioid consumption were reduced.

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Postoperative pain control following a thoracotomy is a major challenge acknowledged by anesthesia providers. Opioid utilization has long been identified as the standard of care for postoperative pain relief. However, today's anesthetists are frequently challenged to adopt a multi-modal pain relief strategy that minimizes opioid consumption for patients. The intraoperative utilization of low-dose ketamine in several patient populations, including those undergoing a thoracotomy, has been deemed a viable intervention in the multi-modal analgesia plan at not only reducing postoperative pain scores for patients, but also reducing opioid consumption. This quality improvement project sought to increase provider awareness of this intervention among anesthesia providers in a community hospital with a goal to influence a practice change.

Background

A thoracotomy is an invasive, major surgical procedure fraught with challenges to patient recovery. Gerner (2008) describes the postoperative pain following thoracotomy as "very severe, probably the most severe pain experienced after surgery". Soto and Fu (2003) identified pain management as the "key component in the alteration of lung function after thoracic surgery". The use of opioids in the postoperative recovery, specifically via intravenous (IV) or epidural patient-controlled analgesia (PCA), has long been the gold standard of care after thoracotomy. However, the list of potential adverse effects of opioids is extensive, not the least of which is respiratory depression and sedation, which directly counter the ability to cough, deep breath, and ambulate. Health care providers must target interventions that decrease pain and limit opioid consumption. This quality improvement project promotes the benefits of utilizing intra-operative

low-dose ketamine in reducing postoperative pain and opioid consumption following thoracotomy procedures.

Problem Description

A thoracotomy is an invasive surgery, allowing a surgeon to access the thoracic cavity of the chest. Lazopoulos et al. (2015) note that the most common type of thoracotomy is the posterolateral approach, an approximately six-inch-long incision through all layers of tissue and rib displacement typically between the fifth and sixth ribs (American Lung Association, 2020), as this allows the best visualization of the thoracic cavity. A patient may require a thoracotomy for a variety of conditions or disease processes, the most common of which is lung cancer. Surgery is a viable treatment in lung cancer, specifically non-small cell lung cancer (American Cancer Society, 2019). If the cancer is identified in early stages while still confined to the lung, a thoracotomy can be performed to remove the cancerous portion of the lung and can be a curative intervention. However, this approach creates many challenges to patient recovery, including significant postoperative pain.

Acute pain is perhaps the most well-known and common barrier to patient recovery following a thoracotomy procedure. Acute pain creates both physical and mental stress for the patient, as well as hindering critical interventions required to prevent postoperative complications. In this patient population, the ability to cough, deep breath, and ambulate are critical components to recovery. Coughing and deep breathing increases lung expansion, mobilizes secretions, and prevents the development of atelectasis and pneumonia. Ambulation also increases lung expansion, as well as deceasing the risk of deep vein thrombosis and deconditioning. Splinting from severe pain can hinder these essential interventions and directly contribute to postoperative respiratory complications. Pehlivan et al. (2019) assert the

management of pain in this population is difficult and complex, as the source of the pain is multi-factorial, emanating from both the chest wall and lungs themselves, with the presence of chest tubes in the postoperative recovery period contributing to the persistent existence of pain.

Opioids are a standard inclusion in the multi-modal pain management of thoracotomies; however, the potential adverse effects of opioids can create new complications and barriers to patient recovery. The list of potential adverse effects of opioids is extensive, not the least of which is respiratory depression and sedation, which directly counter the ability to cough, deep breath, and ambulate. As opioid consumption increases, so does the risk of adverse effects. The use of continuous infusion of opioids, via IV or epidural PCA administration, has traditionally been the gold standard in the acute recovery period (Batchelor et al, 2019). This continuous infusion helps to maintain a more consistent pain level, but also may lead to opioid tolerance, thus requiring increasing doses. Additionally, 1 in 7 opioid naïve patients are at risk for opioid dependency following lung surgery (Harrington, 2018). In order to enhance recovery from thoracotomy procedures, health care providers must target interventions to decrease pain, and ideally, limit opioid consumption.

Ketamine is a N-methyl-D-aspartate receptor antagonist with both analgesic and anesthetic properties. It produces a “profound analgesia and amnesia yet retains most protective reflexes” (Nagelhout & Elisha, 2018). Subramaniam et al. (2019) note that “ketamine has been used successfully as an adjunct analgesic to decrease postoperative opioid requirements in many clinical trials.” In addition to standard analgesia, it can be protective from opioid-induced hyperalgesia, a phenomenon of increased pain after large doses of opioids have been used and abruptly discontinued, as is common after general anesthesia for major surgeries. Pharmacodynamically, ketamine has several very useful properties. In the cardiovascular system,

ketamine acts as a stimulant, increasing heart rate, blood pressure, and cardiac output. In the respiratory system, ketamine decreases pulmonary resistance, allows for normal respiration to be maintained, and "is the only bronchodilating induction agent and the agent of choice in any patient with active asthma who requires surgery" (Nagelhout & Elisha, 2018). Studies have shown that the intraoperative use of IV ketamine in major surgeries, including thoracotomies, can reduce acute postoperative pain, reduce opioid consumption, and improve patient outcomes.

Malignant neoplasms have the second highest mortality rate in both the state of Maryland and Allegany County (Maryland Department of Health, 2020). Despite an annual decline in incidence levels since 2003, lung cancer remains the deadliest malignant neoplasm in the state of Maryland. As of 2017, Maryland has a lung cancer incidence of 54.6 per 100,000, and a mortality rate of 36.1 per 100,000, figures that are slightly better than the national average (U.S. Cancer Statistics, 2017). However, lung cancer remains a far greater torment in Allegany County, Maryland. As of 2017, Allegany County has a lung cancer incidence rate of 78.5 per 100,000, and a mortality rate of 47.3 per 100,000, appreciably exceeding the state in both measures. In fact, lung cancer accounted for approximately 28% of all cancer deaths in Allegany County from 2013-2017, significantly exceeding all other cancer types.

Problem Statement

The recovery from a thoracotomy is a considerable challenge, for both patient and provider, witnessed first-hand by the co-lead investigator over the last seven years in the Cardiovascular Intensive Care Unit (CVICU) in a large community hospital located in Allegany County, Maryland. Providers have thus far been unable to implement successful interventions to best decrease pain and limit opioid consumption in this patient population.

Available Knowledge

A problem, intervention, control, outcome, time (PICOT) question was developed to guide the literature search for this project. The PICOT utilized was: In thoracotomy patients, how does intraoperative IV administration of low-dose ketamine compared to no administration of ketamine impact IV opioid consumption within the first hour in the post-anesthesia care unit (PACU)? A search for studies regarding the intraoperative use of ketamine in thoracotomy procedures was performed using an advanced search in the EBSCOhost Research Databases interface accessed through the West Virginia University Health Sciences Library. Specific databases utilized in this interface were: Academic Search Complete, CINAHL with Full Text, Health Source: Nursing /Academic Edition, and MEDLINE. Using the individual elements of the PICOT ultimately yielded 24 possible articles for review. The element of the PICOT proving most difficult to evaluate was the population. Studies are limited in availability in the utilization of intraoperative ketamine in thoracotomies; therefore, similarly invasive surgical procedures were included. After reviewing all articles produced in the systematic search, it was determined that five articles providing appropriate evidence were sufficient to answer the PICOT. An evaluation table, located in Appendix A, was prepared to delineate the various details of each study chosen for review.

Literature Review

Kaur, Saroa, & Aggarwal. Kaur et al. (2015) hypothesized that utilizing intraoperative low-dose ketamine may have an opioid sparing effect in an open cholecystectomy. Despite including a different patient population, this study brings a wealth of insight into the efficacy of intraoperative ketamine. The statistical difference in pain scores between the control and intervention groups lasted for only the first six hours postoperatively, shorter than other studies.

However, a decrease in reported pain during this six-hour window may account for the significant reduction in total opioid consumption. A key statistic in this study involved the requirement of a rescue analgesic. IV Morphine was administered as a weight-based rescue analgesic in the post anesthesia care unit (PACU) if the patient reported a visual analog score (VAS) score > 3. Only 5/40 ketamine patients required a rescue analgesic dose of IV morphine, compared to 40/40 in the control group. Based on this result alone, the use of ketamine could be recommended to decrease postoperative pain and ultimately, limit the need for a rescue analgesic. To control for confounding factors, the authors note that intraoperative opioids were not used, so as to not mask the effectiveness of ketamine.

Choi et al. Choi et al. (2015) established opioid-induced hyperalgesia (OIH) can be induced by high-dose remifentanil, and that OIH and opioid consumption can be diminished with intraoperative ketamine use. OIH is a phenomenon of increased pain after high-dose opioid use and abrupt discontinuation, as can be seen under general anesthesia during procedures. This study, conducted during laparoscopic gynecology surgery, included three groups: group RL received low-dose remifentanil, group RH high-dose remifentanil, and group KRH a combination of high-dose remifentanil and ketamine, as well as a ketamine bolus at induction. In the PACU, ketorolac 30 milligrams (mg) IV was administered when the patient reported numeric pain score (NRS) exceeding 4 on a 0-10 scale. Additional 15 mg doses were administered for each successive NRS score > 4 in the PACU. While not reaching statistical significance, group RH received the first analgesic earliest. Group RH required significantly more total analgesic compared to group RL in the PACU. Compared to both groups, group RH reported significantly higher pain scores at 6 and 24 hours and required higher cumulative fentanyl dosing in the first

48 hours. These statistics demonstrate that OIH can be induced by high doses of remifentanil and this phenomenon may be offset with the addition of ketamine.

Ozyalcin et al. Ozyalcin et al. (2004) evaluated the efficacy of preemptive ketamine via intramuscular (IM) and epidural routes in thoracotomy to control acute and chronic postoperative pain in a placebo-controlled trial. The greatest limitation of this study is likely its publication date, as it was in 2004. Despite this date, this study was not without merit. The patient population, intervention, comparison group, and outcomes measured are all an ideal match for this project. Of note, ketamine was administered as an intraoperative bolus only and yet still received positive results in significantly decreasing pain and opioid consumption. This suggests that a continuous infusion of ketamine is not necessary to still be effective.

Subramaniam et al. Subramaniam et al. (2011) sought to "demonstrate the analgesic efficacy and opioid-sparing effect of low dose ketamine in patients undergoing lumbar laminectomy and fusion procedures". The study extended a ketamine infusion for 24 hours after surgery. The most notable difference, as illustrated in the synthesis table in Appendix B, is this is the only study to include the chronic preoperative use of opioids as an inclusion criterion, whereas each other study explicitly lists this as an exclusion criterion. Subramaniam and his partners theorized that ketamine would have an opioid-sparing effect for those who have a history of chronic opioid use, as is common for those with chronic back pain. The authors note in their discussion that chronic use was defined as a minimum of two weeks of use prior to surgery; however, the drug, dose, and total duration of use were not controlled or analyzed, and this could have potentially influenced the results of the trial.

A sample size of 26 patients per group was needed to reach 90% statistical power. Ultimately a sample size of only 15 for each group was obtained; therefore, this study did not

reach the predetermined number for an appropriate evaluation of significance. After collaboration between providers and the research team, clinical judgement was used to halt the study. Two specific reasons were given for halting the study. First, it was felt that neither group had an obvious reduction in pain or opioid use. The second reason given for stopping the trial was a concern over the number of patients exhibiting CNS side effects; however, most of the patients exhibiting CNS side effects were in the saline control group, including four of the six suffering hallucinations or confusion.

Pehlivan et al. Pehlivan et al. (2019) hypothesized that low-dose ketamine will reduce acute and chronic pain after thoracotomy surgeries. This study, the most recently published, had many encouraging outcomes. This study was performed with thoracotomy patients and, like Subramaniam, continued the ketamine infusion for 24 hours after surgery completion. Unlike Subramaniam, this study saw a significant reduction in VAS both at rest and with coughing for the first 24 hours postoperatively. Total morphine consumption was also significantly reduced.

Literature Synthesis

A synthesis table, found in Appendix B, illustrates the notable similarities and differences among the studies. Each study utilizes intraoperative IV ketamine (intervention) and evaluates its effect on postoperative pain and opioid consumption (outcome). In addition, each study is a randomized control trial, testing ketamine against a control group. As previously stated, the limited availability of studies including in the utilization of intraoperative ketamine in thoracotomies required the search be expanded to similarly invasive surgical procedures. These studies across a variety of surgical populations have shown that intraoperative use of low-dose ketamine can enhance patient recovery by decreasing both postoperative pain and cumulative opioid consumption.

Recommendations for Practice

Based on this review, low-dose ketamine would be an appropriate intraoperative medication to add to the multi-modal pain management of thoracotomy patients. Careful review and contemplation of the above studies should be applied to guide this practice. Rosenbaum, Gupta, and Palacios (2020) define a critical dose for ketamine administration as 1 to 1.5 mg/kg IV. They state that doses below this threshold achieve both analgesia and sedation; however, when exceeded, the patient may enter a dissociative state. The range of doses used in these five studies is 0.1-0.3 mg/kg IV, well below this established threshold. The potential for CNS effects of ketamine are well-known; however, very few of the studies report such adverse reactions. This can likely be attributed to the low-dose regimen. Based on the evidence provided in these five studies, low-dose ketamine can be safely infused within the intraoperative period as a bolus and/or continuous infusion. Also, of particular importance to the repeated bolus method, Daily Med (2019) provides recommendations that subsequent dosing of ketamine does not produce significant cumulative effects. Finally, opioid use in postoperative management of pain in thoracotomy patients is still valuable and is generally a necessary intervention for patient comfort and recovery. In each study reviewed, ketamine is an adjunct in pain management, not the sole treatment. Despite the potential pitfalls of opioid use, severe acute pain after thoracotomy procedures cannot be managed by ketamine alone. In each study, opioids, primarily administered using a PCA, were employed for pain management.

Theoretical Framework

The Stetler Model of evidence-based practice (Stetler, 2001) is the theoretical framework applied to guide this project. This is a five-step, or phase, process that aims to translate evidence into practice. The first phase is “Preparation”, in which the problem is identified. This phase has

been completed, as the project leader identified the problem of severe pain following thoracotomy through personal experience while working in the community hospital CVICU. The possible solution to this problem was obtained in consultation with the faculty of record, Dr. Mike Frame, as well as the community hospital's co-chief Certified Registered Nurse Anesthetist (CRNA). Phase two of the model is termed "Validation", and this phase involves evaluating a wide range of available evidence and determining its appropriateness for the problem. This phase was completed in conjunction with the literature search of the PICOT. Phase three is "Comparative Evaluation/Decision Making". This phase is best described as a literature synthesis and discussion and has also been completed for this project. Phase four is the "Translation/Application" step. This step synthesizes the findings of the evidence into an actionable plan for dissemination and represents the purpose of this project. The final phase is "Evaluation". This was completed by using a pre-post design centered around the educational in-service, with an additional 60-day follow-up survey to gather provider feedback on the success of the in-service.

Specific Aims

The first aim was to increase knowledge of low-dose ketamine and the benefits it may bestow upon the patient's recovery through an educational delivery of available evidence. The goal of increased awareness was to influence a practice change for utilization of low-dose ketamine resulting in reduced consumption of opioids and postoperative pain. The second aim was to develop guidelines for the use of intraoperative low-dose ketamine utilization in thoracotomy procedures, with an overall goal of the delivery of safe and effective anesthesia. The final aim was to evaluate if increased awareness has influenced a practice change and if providers feel the change has been beneficial on the postoperative recovery period for patients.

Purpose Statement

The purpose of this project was to promote awareness within the Anesthesia Department of a large community hospital, via an educational in-service, regarding the benefits of utilizing intraoperative low-dose ketamine in reducing postoperative pain and opioid consumption following thoracotomy procedures.

Methods

Context

This DNP project was implemented at a large community hospital in Cumberland, MD. The audience for this project is CRNAs and Anesthesiologists of the Anesthesia Department at this institution. The specific patient population discussed were patients undergoing a thoracotomy procedure, a surgery performed at this hospital.

Intervention

To achieve the primary objective of the project, an educational in-service was developed detailing the benefits of intraoperative low-dose ketamine utilization on postoperative pain and opioid consumption among thoracotomy patients. An outline of this educational offering is located in Appendix D. This presentation was developed using PowerPoint software to aid in the content delivery. The actual delivery method of this information was via live presentation. The in-service began with a brief outline of the background and significance of pain and opioid consumption after thoracotomy as previously described in this proposal. Next, a summation of the literature was given to establish the benefits of low-dose ketamine. At this point, the dose range that represents “low-dose” for ketamine was defined. Guidelines for ketamine utilization were established and offered for consideration by the anesthesia providers. The DNP project team determined a recommended dose for ketamine bolus at induction. Two options were

provided for anesthesia maintenance: continuous infusion and bolus method. The guidelines for use also include contraindications to use, precautions, and special considerations. A summation of the recommendations for utilization can be reviewed in Appendix E and was also provided to the audience in a separate digital document as a reference if implementation was chosen.

Feasibility Analysis

There were very few barriers to the dissemination of this evidence showing that intraoperative low-dose ketamine can reduce postoperative pain and opioid consumption. There were no privacy concerns or technical limitations. The content of the presentation was synthesized by the project team from published evidence and protocols already in use at other facilities. The only requirement was educating the anesthesia department through an in-person forum. No cost burden was associated with disseminating the synthesis of evidence, and only a small amount of time was required by the staff to acquire this new knowledge. The staff was asked to take the time to participate in a pre-survey to determine any knowledge deficit and an end-of-session questionnaire to measure success as evidenced by correct awareness of such things as low-dose ranges. Success was also measured in provider willingness to try low-dose ketamine during thoracotomy surgery which was measured in a follow-up survey 60-days after evidence dissemination.

Very few barriers existed to the actual implementation of this practice change. The proposed practice change does not place any extra demands on currently available resources. Utilizing low-dose ketamine, especially using a bolus method verses an infusion, does not alter the current workflow or effort of anesthesia providers during a thoracotomy, and using this medication is certainly within the skillset of the anesthesia team. In addition, the cost of ketamine is low, with 50 mg/ml vials costing only $5.17 per 10ml vial. Reduced opioid

consumption may also be of financial benefit. Minimal adverse effects of low-dose ketamine are present in current evidence.

Needs Assessment

The goal of this DNP project was to increase anesthesia provider awareness of low-dose ketamine, encouraging a practice change by increasing knowledge of the benefits in thoracotomy as well as alleviating possible concerns of adverse reactions. In order to meet this goal, the primary requirement was a forum in which to disseminate the evidence and proposed practice change. The primary stakeholder for this audience was the anesthesia care team. In an attempt to influence this practice change, the DNP project team developed well-rounded guidelines and recommendations for the utilization of this medication and technique. If the value of the evidence was accepted, and individual practitioners chose to incorporate low-dose IV ketamine into their practice, then PACU staff and the cardiothoracic surgery team responsible for postoperative care were informed about the ketamine utilization. As with any anesthetic, the anesthesia provider should have made the patient aware of the planned medications they are to receive while under anesthesia including the intended benefits and possible risks.

SWOT Analysis

As with any project, both pros and cons exist and must be analyzed and considered. The main strength of this project was the support it received within the community hospital. The co-chief CRNA expressed support of this practice change and offered a letter of support for this project (see Appendix F). A facility anesthesiologist was very encouraging as well and felt that ketamine was underutilized at the institution. Also, the cardiothoracic surgeon also offered to support this practice change in the anesthesia care of thoracotomies. Finally, the Vice President and Chief Nursing Officer also offered his support for this project. The financial cost of

dissemination was nil, and only a small amount of time was asked of the anesthesia department to listen and participate in surveys to measure the project's success and offer feedback on the presented information based on their clinical experience. The low cost of ketamine and an anticipated decreased in opioid consumption, while not specifically examined, could potentially lead to a cost savings in addition to improving patient outcomes. One significant weakness appreciated was that, as a community hospital, the institution handles a lower volume of thoracotomies compared to larger facilities.

One significant opportunity for this project was this hospital site in Cumberland, Maryland was recently acquired by a large academic institution, increasing the resources and exposures to new evidence-based practices such low-dose ketamine utilization. A threat identified to this project arises from the nature of the pharmaceutical industry. Newer medicines are being developed every day, and a new and improved medication may become available that prove superior to ketamine in the pain management of this population. While a cutting-edge medication that could improve pain control and management would be welcomed, the usefulness of ketamine, and the value of this in-service, could be eclipsed a new medication emerge.

Sustainability

This project stemmed from a conversation with one of the co-chief CRNAs, who expressed a desire to implement elements of the Extended Recovery After Surgery (ERAS) guidelines in practice as this facility. Ketamine is a medication frequently included in multiple ERAS surgical population recommendations and protocols. The evidence reviewed for this project demonstrates the efficacy of low-dose ketamine in other major surgeries, and thus could be used by anesthesia providers at this facility in other surgical populations. Additionally, long-term impacts from this project could result in the stimulus needed to introduce broader ERAS

recommendations for not only lung surgery but other surgical populations as well. In the short-term, team member Jared Lamp, CRNA offered his support of ensuring the continued success of this project.

Project Team.

This project was led by co-chief investigator Jason Wampler, SRNA. Dr. Mike Frame, CRNA served as the faculty of record and chief investigator and provided guidance through each phase of the project. Jared Lamp, CRNA served as a content expert and, as a staff nurse anesthetist at the community hospital, a facilitator and resource to the anesthesia team after the evidence was presented.

Congruence with Organization

The mission statement at the hospital is: "We are dedicated to providing patient-centered care and improving the health and well-being of people in the communities we serve" (UPMC Western Maryland, 2020). Six core values serve as pillars for all programs at the institution: integrity, innovation, compassion, accountability, respect, and excellence. The use of low-dose ketamine to reduce postoperative pain and opioid consumption is a patient-centered approach, aligning with the institution's desire to be innovative, seeking improvement through new practices; compassionate, showing care and kindness to patients; and excellence, striving for superior performance.

Timeline

The goal was to present this project proposal for IRB review no later than October 31, 2020. December 31, 2020, was the target date for final IRB approval and complete development of the educational in-service and surveys. The intervention was implemented on Tuesday, March 2, 2021, to the Anesthesia Department. Sixty days was provided to allow for implementation of

this evidence into their practice. Within this time, initial data from the pre-post design was analyzed. After these sixty days, the final follow-up survey was administered to gather provider feedback. The Fall of 2021 was devoted to completing data analysis and composing the final DNP project poster. Summer 2022 was the target for the final DNP project presentation. Please refer to the SMART Work Plan is Appendix C for a more detailed description of this timeline.

Evaluation Plan

A pre-post design was utilized to evaluate the purpose of this project. Prior to the presentation, anesthesia providers were asked to take a short survey evaluating current knowledge of low-dose ketamine and determining prior utilization of this technique. This established a baseline of current knowledge and practice. The end-of-session questionnaire compared newly gained knowledge to the baseline to establish if learning occurred. The providers were also asked to rate on a Likert scale the likelihood of adopting this evidence into practice which indicated that the evidence had influenced a practice change. A second survey, occurring sixty-days following the in-service, determined if any providers had implemented the evidence of this in-service, as well as gathering any feedback based on their clinical experience with this practice change. Providers were also granted a forum to explain why they may have been hesitant to adopt this practice change, giving the DNP team a chance to understand why the evidence may not have influenced a practice change.

Measures

Project Objectives

The Centers for Disease Control and Prevention (CDC) evaluation brief "Writing SMART Objectives" (2018) was used to develop clearly stated, feasible, and measurable objectives for this project. The SMART acronym stands for specific, measurable, achievable,

realistic, and time phased. The main objective was the purpose of this project, to promote awareness within the Anesthesia Department, via an educational in-service, regarding the benefits of utilizing intraoperative low-dose ketamine in reducing postoperative pain and opioid consumption following thoracotomy procedures. The secondary objective was to influence a practice change, utilizing low-dose ketamine in anesthesia care during thoracotomy procedures, using the same in-service. The overall goal was to improve anesthesia care.

Objective Evaluation

To evaluate the first objective, increased awareness, a pre-post design was utilized. Prior to the presentation, anesthesia providers were asked to take a short survey evaluating current knowledge of low-dose ketamine and determining prior utilization of this technique. This established a baseline of current knowledge and practice. Following the presentation, anesthesia providers were asked to take an end-of-session questionnaire to evaluate comprehension of the presentation's content and to survey their willingness to utilize intraoperative low-dose ketamine among thoracotomy patients in their practice. The questionnaire (1) established if the educational in-service was successful in promoting anesthesia provider awareness regarding the benefits of low-dose ketamine, (2) determined whether greater awareness was likely to translate into a practice change among these providers, and (3) allowed those who were resistant to this practice change an opportunity to express their concerns. In this pre-post design, the in-service represented the starting event, and each survey consisted of a combination of closed and open-ended questions. Likert scale questions were added to the end-of-session questionnaire to measure willingness to adopt this practice change.

To evaluate the second objective, if a practice change has been influenced, a 60-day evaluation period was provided to allow providers the opportunity to institute the evidence

presented into their practice. As this project was an educational in-service to increase awareness of low-dose ketamine, the participants were informed that this change was not mandated; however, they were encouraged to trial this technique. After this time, an additional survey was administered to (1) determine if any anesthesia providers had made a practice change, (2) gather feedback on the effectiveness of this practice change based on the provider's clinical judgement, (3) allow providers to offer recommendations with respect to the presented guidelines based on their recent clinical experience using ketamine, and (4) allow those who were resistant to this practice change an opportunity to express their concerns. As with the end-of-session questionnaire, this survey consisted of closed, open-ended, and Likert scale questions. Data was compared from the baseline survey (has there been any prior utilization of low-dose ketamine) to the end-of-session questionnaire (would any providers be willing to utilize this technique) to this final evaluation (has the evidence been implemented) to determine if the in-service influenced a favorable practice change. Survey questions may be reviewed in Appendix G.

The anesthesia care plan is individualized for each patient and developed based on patient preference, history, and the clinical experience of individual providers. No patient data was collected. The surveys collected subjective data concerning the provider's recent clinical experiences utilizing low-dose ketamine.

Approach for Ongoing Assessment

The 60-day follow-up survey functioned as the ongoing assessment of this project. As previously stated, in addition to determining if providers implemented the evidence presented, this survey gathered feedback from the providers based on their individual clinical experience. This feedback will be used to make any necessary updates to the recommended guidelines as previously presented; what has worked, what has not. It also served to inform the DNP team

what information was most useful and if any potentially valuable information was omitted. This feedback can only be obtained through clinical experience and evaluation; therefore, it is vital to collect.

Analysis

No survey instrument was found that compliments this intervention. Therefore, questions for the project surveys were developed by the project investigator. Once developed, the surveys were entered into Qualtrics XM software and distributed to the Anesthesia Department members electronically in accordance with the established timeline. This system allowed for anonymous feedback and additional time for provider response. Nine CRNAs responded to each survey, although only three were afforded the opportunity to perform a thoracotomy during the allotted timeframe of this project.

All data was analyzed via IBM SPSS software. A one-sample T-test was used to evaluate effectiveness of teaching, if the CRNA felt ketamine was effective in reducing pain and opioid consumption, and if a practice change had been influenced. Dr. Laurie Theeke, former West Virginia University School of Nursing professor and PhD Program Director, assisted in data analysis.

Ethical Considerations

The intervention of this project was an educational in-service regarding the benefits of low-dose ketamine in the postoperative recovery of thoracotomy patients. As this was an in-service, there was no mandate that providers implement this intervention, only that they consider the merits of the evidence presented from the systematic review of this subject. Anesthesia provider feedback was anonymous using Qualtrics XM software. The use of ketamine in general

anesthesia is a federally approved indication for this drug. This was not an experimental intervention or clinical trial; therefore, no patient information was collected.

The proposal was submitted for IRB review at the West Virginia University to obtain approval for the research. The intervention of this project was reviewed the Director of Medical Staff Services at the community hospital who confirmed that no additional formal review was required at the institution prior to implementation.

Results

Prior to the educational offering, baseline knowledge and utilization of low-dose ketamine was established. Approximately, 78% of respondents had heard about and correctly identified the correct low-dose ketamine range (see Figure 1), but only 44% stated they were aware that low-dose ketamine limited CNS side effects (see Figure 2). Some 78% of respondents also stated they had utilized low-dose ketamine in any surgical population, but only 44% had utilized it in thoracotomy.

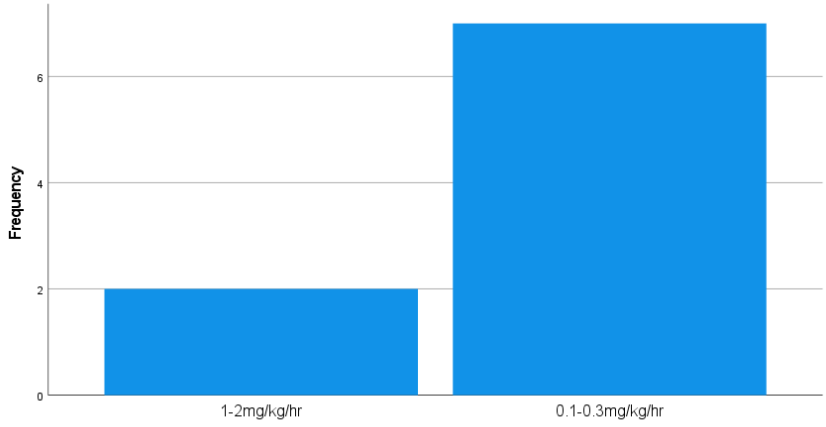

Figure 1: Baseline Low-Dose Ketamine Dose

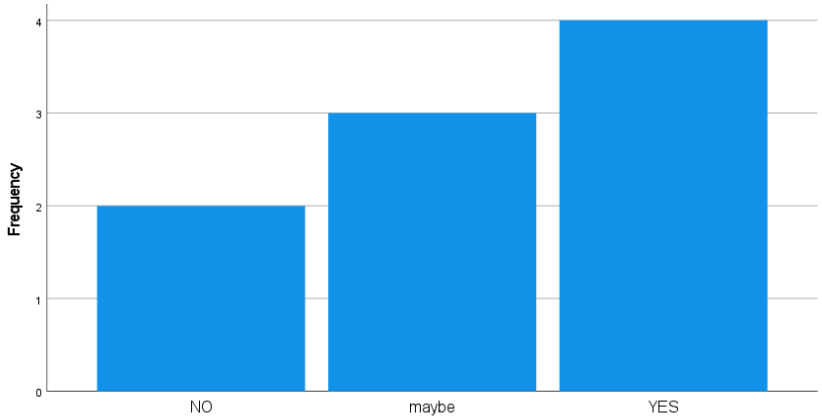

Figure 2: Baseline CNS Side Effects

After the in-service, identification of the correct range for low-dose ketamine increased to 100% and limited CNS side-effects to 89%, both clinically significant improvements. Additionally, all CRNAs responded affirmatively when asked if they were willing to consider a practice change, utilizing low-dose ketamine in thoracotomies, with 89% indicating they were either moderately or extremely likely to consider this change. No concerns over this practice change or the material presented were raised by the CRNAs present.

After 60 days, the follow-up questionnaires were distributed. Only three of the nine CRNAs who responded had the opportunity to provide anesthesia during a thoracotomy since the educational offering. Of those, two utilized low-dose ketamine. The remaining CRNA who did not expressed concern related to the patient's advanced age. Both CRNA's who utilized low-dose ketamine reported that in their clinical judgement, both pain and opioid consumption were reduced. The remaining six CRNAs who did not have the opportunity to utilize low-dose ketamine showed a slight decrease in their willingness to change their practice in this patient population. No concerns were raised with the guidelines for utilization that were provided. One CRNA requested an accompanying protocol for in-patient ketamine utilization so that the option to continue the infusion in the postoperative period was available.

Discussion

Summary

Low-dose IV ketamine, when administered intraoperatively during thoracotomy procedures, can reduce postoperative pain and opioid consumption. Increasing anesthesia provider awareness of this technique through education encouraged a practice change, allowing patients to realize these benefits and ease the burden of recovery from this difficult procedure. This project exemplified a DNP project by aligning with the DNP Essentials I, II, III, VI, and VIII (American Association of Colleges of Nursing, 2006). Essential I, Scientific Underpinnings for Practice, was embodied by using a theoretical framework to guide this DNP project. Essential II, Organizational and Systems Leadership for Quality Improvement and Systems Thinking, was fulfilled as this quality improvement project utilized scientific findings to guide patient care. Essential III, Clinical Scholarship and Analytical Methods for Evidence-Based Practice, was the essence of this DNP project as existing evidence was appraised and synthesized into practice. Essential VI, Interprofessional Collaboration for Improving Patient and Population Health Outcomes, was addressed as the primary audience for this project was both CRNAs and anesthesiologists. Finally, Essential VIII, Advanced Nursing Practice, was represented by using advanced clinical judgement in the design, delivery, and evaluation of this evidence-based project.

Interpretation

The educational offering as a live in-service was effective in both teaching and persuasion. This was demonstrated by the clinically significant increase in both knowledge of low-dose ketamine and willingness for a practice change. This offers support that brief live

presentations can be valid teaching tools, which frequently occur during staff meetings and journal clubs.

Unfortunately, only nine CRNAs responded to the surveys. As a community hospital, a smaller number of anesthesia providers are employed there than larger university centers. Low numbers were anticipated for this site, but this small sample size did contribute to very little changes in data required to meet clinical significance. For instance, clinical significance of correctly identifying the correct range for low-dose ketamine was obtained, but the increase was only from seven to nine CRNAs.

The clinical judgement of the CRNAs who utilized low-dose ketamine that pain and opioid consumption was reduced correlates with the data discovered during literature review. The CRNA who chose not to use low-dose ketamine based on the patient's age was justified in his or her thinking. In most RCTs reviewed for this project, age less than 65 years old was a common exclusion criterion. Additionally, pre-procedure midazolam was suggested to further reduce CNS side effects of ketamine; however, midazolam given to patients over 65 can increase the likelihood of postoperative delirium.

Overall, all CRNAs expressed a willingness to adopt a practice change regarding low-dose ketamine utilization. However, a slight decrease in the degree of willingness was noted from the end-of-session to follow up survey. At the completion of the educational offering, 5 of 9 CRNAs chose "extremely likely" when asked if they would be willing for a practice change (see Figure 3). At the completion of the project, that total had been reduced to 3 of 9 (Figure 4). The lack of opportunity to quickly utilize this intervention shortly after information delivery may have been responsible for this. As time goes by, excitement and eagerness to implement new ideas and evidence into practice wanes if an opportunity to do so is not provided.

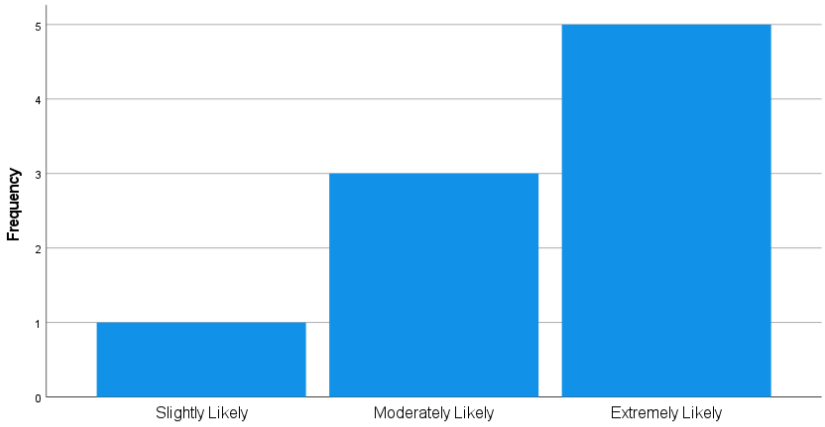

Figure 3: End-of-Session Willingness for Practice Change

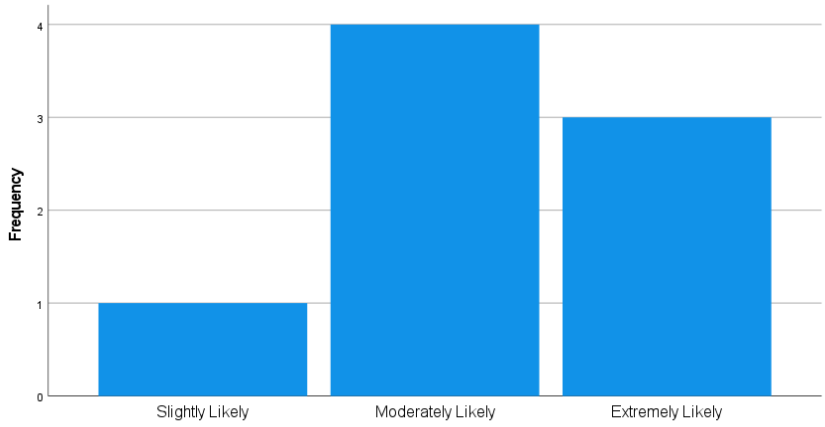

Figure 4: 60-Day Follow-Up Willingness for Practice Change

Finally, it should also be noted that there were several "inappropriate" responses to the final follow-up survey. Several respondents noted that ketamine was useful in reducing pain and opioid consumption despite not actually having the opportunity to implement the intervention. One reason for this faulty response could have been formatting issue with the survey that may have confused the CRNA. Another potential reason may be that the respondents were eager to please the surveyor, a common phenomenon among those completing surveys. At the time of the final survey, the co-lead investigator was enrolled in a clinical rotation at the hospital and had discussed the project with several of the staff CRNAs. The CRNAs may have felt that responding affirmatively to the survey would enhance the investigator's standing in the Nurse

Anesthetist Program or would generally please the investigator to know his intervention was successful.

Limitations

Both time and the relatively low volume of thoracotomy procedures performed at the community hospital proved to be limiting factors in providing most anesthesia providers with an opportunity to utilize this proposed practice change. The small sample size made clinical significance easy to obtain but limits the generalizability of the results. This small sample size was anticipated. Despite the small sample, the co-lead investigator, based on previous experience, felt compelled to introduce this evidence in this facility, as he felt strongly that the patients in this facility deserved the same high quality of care as those in larger teaching institutions.

Additional factors may have limited the internal validity of the results. As previously stated, several respondents rated the effectiveness of ketamine despite answering that they had not performed the intervention. This may have been related to poor survey formatting or a bias of the respondents to please the surveyor. The investigator also could have been more precise in distributing and tracking survey results. An improved design would have randomly assigned each CRNA an identification number. This number would have allowed surveys to remain anonymous, but the investigators could have then tracked individual improvement in knowledge and willingness to implement this practice change, rather than just the group as a whole.

Finally, the scope of this project as an academic DNP project limits the measurement of ketamine's effectiveness. The general focus of this project was based on a system change (increased knowledge and willingness to implement a practice change) rather than health outcomes. Based on this direction, it was determined that measuring ketamine's effectiveness

was best accomplished by surveying the CRNA's clinical judgement. A quantitative RCT similar to those found in the literature review measuring patient reported pain scores and documented opioid consumption would provide more definitive data on low-dose ketamine's effectiveness in thoracotomies at this facility.

Conclusions

This project met each objective delineated prior to implementation. The educational offering increased provider awareness of both the appropriate dose of low-dose ketamine as well as reduced CNS side effects associated with this lower dose. After the offering, both immediately and after time had passed, anesthesia providers reported a willingness to implement this practice change. Finally, regarding the ultimate goal to improve anesthesia care at this site, pain and opioid consumption was reduced in the eyes of the nurse anesthetists afforded the opportunity to implement low-dose ketamine in thoracotomies.

Given the success of this project, this intervention should be sustained at this site. This quality improvement project met the mission of the hospital in providing patient-centered care, as well as the values of innovation and excellence. The anesthetists who were able to implement this intervention are in position to be the best facilitators of the effectiveness of low-dose ketamine, as they can recount first-hand knowledge of its utility to their fellow nurse anesthetists. Few barriers exist to continuing this intervention. First, as with many things post-COVID, a continuous available supply of ketamine is far from guaranteed. Additionally, as previously stated, more effective techniques or medications could be discovered. Finally, anesthesia providers must understand the goal is to reduce opioid consumption, not eliminate it. Low-dose ketamine is intended to be an adjunct in multi-modal analgesia in thoracotomies. For example, a

patient can be offered both a thoracic epidural and ketamine as a multi-modal approach to their postoperative pain management.

Several recommendations are appropriate for this site following the success of this intervention. Low thoracotomy volumes may make it difficult to sustain in this population alone, but as the literature reveals, this intervention can be useful to other patient populations where severe postoperative pain may be anticipated, such as open abdominal or populations. Additionally, the genesis of this project was in the co-chief CRNA's desire to implement ERAS in this facility. Therefore, another avenue for expansion would be to implement additional ERAS elements in thoracotomies or other patient populations. Finally, as requested by a staff CRNA, a protocol allowing for in-patient use of ketamine infusions would likely increase intraoperative utilization.

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Appendix A: Evaluation Table

Year	Citation: Author, Title, Country	Purpose of the Study	Sample Description	Design / Independent Variables	Measures / Dependent Variables	Findings (statistically significant)	Appraisal/Comments
2019	Pehlivan, S., The Effect of Low Dose Ketamine Infusion on Postoperative Acute and Chronic Pain After Thoracotomy. Turkey	Hypothesis: low dose ketamine will reduce acute and chronic pain after thoracic surgery	N = 40 Pop: thoracotomy No significant difference in demographics EC: uncontrolled hypertension, diabetes mellitus, drug use due to chronic pain, psych hx, opioid addiction, severe liver and/or renal failure - Estimated need for significance: 20/group	Double-blind RCT IdV1: Ketamine (K) IdV2: Control Each group of 20 had their assigned med started pre-incision and continued for the first 24 hours postop -No Attrition	DV1: Pain rating at rest and moving using VAS at 2, 6, 12, and 24 hr postop DV2: total morphine consumption DV3: pulmonary function DV4: chronic pain at 1- and 3-months postop	<u>Group K has</u>: - lower pain scores at rest and movement at all time markers - Less morphine consumption - Less chronic pain at 3 months (but not 1 month) *no difference in pulmonary performance	- The effect of decreased acute and chronic pain appears to be r/t to low-dose IV ketamine use in this study. - The authors do state that measuring chronic long-term effects would be more effective in a larger sample size. - Ketamine continued for first 24-hours postop - Group K does not add up to 20. If a surgery type was not performed, they used an (-) to mark this. My assumption is that the 0 for lung resection and pneumonectomy under group K is a typo and should be 7. This plus does decrease the clarity of the article and brings up a certain level of doubt regarding the peer review.

2015	Choi E. Effect of intraoperative infusion of ketamine on remifentanil-induced hyperalgesia. India	To show high-dose remifentanil can induce OIH, and to confirm that OIH and opioid consumption can be diminished with intraoperative IV ketamine use	N = 75 Pop = Laparoscopic gynecological surgery No significant difference in demographics EC: PMH opioid use, alcohol abuse, psych dx - Estimated need for significance: 24/group	RCT IdV1: RL IdV2: RH IdV3: KRH 3 groups of (25) patients. In the OR, the first group was given low-dose remifentanil, the second group high-dose remifentanil, and the third group high-dose remifentanil + ketamine starting at induction and ending at final suture. - No attrition	DV1: Time to first postop analgesic and total analgesic consumption DV2: Pain rating post up using NRS at 0, 1, 6, and 24 hr postop DV3: Tactile sensitivity postop via Touch-Test to evaluate hyperalgesia	<u>RH Group:</u> - Greater PACU analgesic use than RL - Greater cumulative fentanyl dose 48 hr postop than other 2 groups - higher NRS at 6- and 24-hour postop than other 2 groups - Lower touch test value, greater pre/post op difference in touch-test for at 48-hour postop than other 2 groups	- Demonstrates OIH and Ketamine can reduce this phenomenon. - Intra-op only. - RL required higher concentrations of desflurane intra-op but does not discuss any possible ramifications. - Study does not state that was double-blind - Study does not give all p-values, only notes when RH $p < 0.05$ compared to other groups. Reader can't determine if significance exists between RL and KRH, or if there are values that may be clinically significant. - The authors never mention a direct comparison between the RL and KRH groups. There is appears to be little difference in postop pain, opioid consumption, and hyperalgesia. If this is true, then why not simply use RL and avoid OIH in the first place?

2015	Kaur, S. Effect of intraoperative infusion of low-dose ketamine on management of postoperative analgesia. India	Hypothesis: intraoperative low-dose ketamine may have opioid sparing effect	N = 80 Pop: Open Choley No significant difference in demographics EC: Chronic analgesic use, PMH cardiac, hepatic, renal, pulmonary, neuro, psych, endocrine, myopathy, or pregnant women. - Estimated need for significance: 30/group	Double-blind RCT IdV1: Ketamine (K) IdV2: Control Each group of (40) received pre-incision bolus and intra-op infusion of assigned med. Infusion stopped at skin closure. - No attrition	DV1: Pain rating post up using VAS at 2, 4, 6, 12, and 24 hr postop DV2: total morphine used in 24hr postop DV3: use of rescue analgesia (morphine) DV4: patient satisfaction at 24 hr postop	<u>Group K has</u>: - Lower pain scores 0-6 hr postop, but difference was not significant for 12 and 24hr. - Reduction in morphine use - Reduction in rescue morphine requirement - No difference in patient satisfaction scores	- Decreased pain and opioid use is related to intraoperative IV ketamine use. - The ketamine appears to "wear off" after the 6-hour mark in this population. The decreased pain in this 6-hour window likely accounts for the decreased opioid consumption. - Only *5/40* ketamine patients required a rescue analgesic dose of IV morphine, compared to *40/40* of the control group. - Low-dose ketamine was used, proved effective in reduced opioid consumption, and no patients showed severe postoperative side effects (table 4). - The author's state that intra-op opioid infusion was not used to avoid masking the analgesic measurement of ketamine.

2011	Subramaniam, K. Intra- and Postoperative Very Low Dose Intravenous Ketamine Infusion Does Not Increase Pain Relief after Major Spine Surgery in Patients with Preoperative Narcotic Analgesic Intake. U.S.	To demonstrate the analgesic efficacy and opioid-sparing effect of low dose ketamine in patients with preop narcotic intake	*N = 38 Pop: Lumbar laminectomy and fusion for back pain with preop narcotic analgesic intake No significant difference in demographics EC: PMH severe cardio-pulmonary disease, severe uncontrolled hypertension, raised intracranial pressure, glaucoma, hepato-renal dysfunction, pregnancy, and psychosis. *Estimated need for significance: 26/group	Double-blind RCT IdV1: Ketamine (K) - Attrition: 5 mid-study -15 total evaluated IdV2: Control - Attrition: 3 mid-study -15 total evaluated Each group had their assigned med started at induction and continued for the first 24 hours postop	DV1: Pain rating post up using VAS at 0, 1, 2, 4, 8, 12, 18, 24, 36, and 48 hr postop DV2: narcotic requirement first 48 hr postop DV3: side effects	There was no significant difference in postop pain, narcotic requirement, or side effects in the two groups *Interim analysis was performed, and the study halted as the study was showing no change in analgesia and concern for increased CNS effects	- 8/38 (21%) Attrition: Only 2 for CNS side effects, 1 from each group. The others were for reasons not r/t IdV. - Preop opioid use is often an EC for other studies. - The author's note that preop opioid use is a minimum of two weeks. The type, dose, and duration of this use were not controlled or factored into their analysis, this could have influenced the results of the trial. - Clinical judgement was used to halt the study, interim stats validate. - Based on this study alone, IV ketamine would not be an appropriate medication in patients with preop opioid use. - A trial with these same parameters in a non-orthopedic population may be considered. If the results are similar, then opioid use for chronic pain may dissuade ketamine use across all surgical populations.

2004	Ozyalcin, N.S. Effect of pre-emptive ketamine on sensory changes and postoperative pain after thoracotomy: comparison of epidural and intramuscular routes. Country not stated in study	To evaluate the efficacy of pre-emptive ketamine via IM and epidural routes to control acute and chronic postop pain	N = 60 Pop: Thoracotomy No significant difference in demographics EC: drug and alcohol abuse, ischemic heart disease, psych hx, chronic low back pain. - Estimated need for significance: Not stated	Double-blind RCT IdV1: IM IdV2: EPI IdV3: Control Each group of (20) patients were administered their assigned med via bolus only 15 minutes before anesthesia induction. - No attrition	DV1: Pain rating post up using VAS at 2, 4, 6, 8, 10, 12, 24, and 48 hr postop DV2: analgesia consumption in same time frame as above DV3: pin-prick hyperalgesia 2, 15, and 30 days postop	<u>Group EPI has:</u> -Less intra-op fentanyl use than control -Less postop use of analgesia than both other groups -Reduced pin-prick hyperalgesia vs both groups at day 2 and 15 postop	- This study is older, and I have not noted much discussion of IM ketamine use in recent articles. - That said, this is a very good comparison of ketamine vs no ketamine in a double-blind study showing significant reduction in opioid consumption. - Dose is bolus only, no continuous infusion.

DV: Dependent Variable
EC: Exclusion Criteria
EPI: Epidural
IdV: Independent Variable
IM: Intramuscular
IV: Intravenous
KRH: high-dose remifentanil + Ketamine
N: Sample Number
NRS: Numeric Rating Scale for pain
NS: Normal Saline
OIH: Opioid-Induced Hyperalgesia
PMH: Past Medical History
Pop: Patient Population
RCT: Randomized Control Trial
RH: High-Dose Remifentanil
RL: Low-Dose Remifentanil
VAS: Visual Analog Scale

Appendix B: Synthesis Table

	Studies				
	A	B	C	D	E
Population: Thoracotomy	X				X
Interventions					
1. Postoperative pain	X	X	X	X	X
2. Postoperative opioid consumption.	X	X	X	X	X
Additional Considerations					
1. RCT	X	X	X	X	X
2. Ketamine use beyond OR	X			X	
3. Hyperalgesia measured		X			X
4. Chronic opioid use as exclusion criterion	X	X	X		X
5. Postoperative CNS side effects reported				X	
6. Postoperative PCA for pain control	X	X		X	X

Legend: A = Pehlivan, 2019; B = Choi, 2015; C = Kaur, 2015; D = Subramaniam, 2011; E = Ozyalcin, 2004.
X indicates presence of the intervention/consideration.

Appendix C: SMART Work Plan

Project Goals: Complete and submit project proposal to IRB

***SMART Objective**	**Activities**	**Projected Completion Date**	**Projected Number of People Reached**	**Organization(s)/ Partner(s) collaborating with to conduct activity**	**Evaluation Plan** (Describe measures used to assess satisfaction, project outcomes, benefits of activities, etc.)
Develop a faculty approved DNP project	1. Identify a problem 2. Perform systematic review related to the problem	Completed Spring 2020		Dr. Frame	Approval to proceed to proposal phase of project received.
Develop first draft of project proposal	1. Research and synthesize background 2. Update literature 3. Perform Needs Assessment & SWOT Analysis 4. Identify Theoretical Framework 5. Develop project goals and plan 6. Develop evaluation plan 7. Assemble and compose first draft	Completed Summer 2020		Dr. Frame Dr. Barker Peer Review	Draft completed and submitted on time for review.
Identify location for project implementation.	1. Meet with stakeholders at hospital 2. Obtain verbal approval 3. Obtain written approval	Completed Summer 2020		Co-chief CRNA	Written approval received.
Develop an educational presentation about low-dose ketamine utilization in thoracotomy.	1. Search literature 2. Synthesize literature 3. Develop recommendations for low-dose ketamine use	1. Complete 2. Complete 3. August 31, 2020 4. August 31, 2020 5. September 2020		DNP Team	Educational presentation developed.

	4. Develop pre- and post-surveys 5. Synthesize presentation				
Finalize and present project proposal to IRB for approval	1. Revise first draft of project proposal. 2. Submit for review by Dr. Frame 3. Revise and submit for review by Dr. Frame 4. Submit to IRB	1. September 2020 2. September 2020 3. October 2020 4. November 2020		Dr. Frame	Proposal submitted to IRB for approval by November 2020

Project Goals: Implement and evaluate DNP project at large community hospital

***SMART Objective**	**Activities**	**Projected Completion Date**	**Projected Number of People Reached**	**Organization(s)/ Partner(s) collaborating with to conduct activity**	**Evaluation Plan** (Describe measures used to assess satisfaction, project outcomes, benefits of activities, etc.)
Complete development of the educational presentation about low-dose ketamine utilization in thoracotomy	1. Update literature review 2. Ascertain appropriate delivery method of presentation 3. Review and update presentation 4. Submit for final review by Dr. Frame	December 31, 2020		DNP Team	Presentation and associated combination test and surveys completed.
Implement the educational presentation to the anesthesia dept at community hospital by January 2021	1. Establish appropriate time for presentation 2. Conduct pre-test/survey 3. Present evidence to anesthesia department 4. Posttest/survey	January 2021	27	Anesthesia Dept.	Pre-test/survey Immediate post-test/survey

Evaluate anesthesia department feedback regarding low-dose ketamine utilization 60 days after in-service	1. Analyze results of initial surveys. 2. Conduct final survey 3. Analyze and evaluate results of DNP Project.	Spring 2021	27	Anesthesia Dept. DNP Team	Data evaluated.

Project Goals: Present Findings of DNP Project

***SMART Objective**	**Activities**	**Projected Completion Date**	**Projected Number of People Reached**	**Organization(s)/ Partner(s) collaborating with to conduct activity**	**Evaluation Plan** (Describe measures used to assess satisfaction, project outcomes, benefits of activities, etc.)
Synthesize written manuscript of DNP project	1. Write, write, write 2. Review	Summer/Fall 2021		Dr Frame	Manuscript reviewed and approved by FOR
Present DNP Project	1. Develop presentation 2. Present	Spring 2022		Dr Frame	Presented

***SMART** is a simple acronym used to set objectives. It stands for: 1. **Specific** – Objectives should specify what they want to achieve; 2. **Measurable** – You should be able to measure if you are meeting the objectives or not; 3. **Achievable** - Are the objectives you set, achievable and attainable; 4. **Realistic** – Can you realistically achieve the objectives with the resources you have; and 5. **Time** – When do you want to achieve the set objectives.

Appendix D: Educational In-service Outline

- Background and significance of pain and opioid consumption after thoracotomy.
- Literature summary establishing the benefits of low-dose ketamine.
- Define “low-dose” range for ketamine.
- Define inclusion criteria
- Define contraindications
- Define precautions
- Provide recommendations for intraoperative ketamine utilization.
    - Preop medications
    - Induction dosing
    - Maintenance dosing
    - Special considerations

Appendix E: Recommendations for Utilization

- Inclusion criteria
    - Population: Patients undergoing thoracotomy
    - ASA I-III
- Contraindications: Hypersensitivity to ketamine and severe hypertension
- Precautions: Hypertension, cardiomyopathy, arrhythmia, elevated intracranial pressure, glaucoma, hepatic or renal failure, obstetrics, non-schizophrenia related hallucinations or psychosis, chronic alcoholism, and schizophrenia
- Recommendations for ketamine utilization.
    - Preop: Versed is suggested as to further limit the risk for emergence delirium
    - Induction
        - Ketamine Bolus: 0.5 mg/kg over 60 seconds
        - Additional induction medications per provider preference
    - Maintenance dosing of ketamine: 0.1-0.3 mg/kg/hr.
        - May be continuous infusion or repeated bolus per provider preference.
        - If continuous infusion used, stop at closure.
    - Special considerations.
        - Geriatric use: consider using half-recommended dose for age > 65
        - VATS: Consider utilizing repeated bolus method as VATS may progress to thoracotomy
        - Avoid concurrent use of Precedex as this may prolong emergence.

Appendix F: Letter of Support

I, Nicholas Oscanyan, co-chief CRNA at UPMC Western Maryland, support the proposed practice change of including low-dose ketamine in the anesthesia care of thoracotomy patients at this facility. I would like to formally offer my support of Mr. Wampler's quality improvement DNP project that should encourage this proposed practice change at our facility.

Nicholas Oscanyan, DMNAP

Appendix G: Surveys

Pre-survey

- **Goals**
    - Establishing baseline knowledge
    - Evaluating utilization prior to in-service
- **Possible Sample Questions**
    - Have you ever read about or listened to a discussion about the usefulness of low-dose ketamine?
    - What dose do you consider "low-dose" regarding ketamine?
    - Are you aware that the evidence reports limited CNS side effects with the utilization of low-dose ketamine?
    - Have you ever included low-dose ketamine in your anesthesia practice?
        - If yes, for what surgical population?
        - In your clinical judgement, how effective was low-dose ketamine in:
            - Reducing post-operative pain?
            - Reducing post-operative opioid consumption?

End-of-session questionnaire

- **Goals:**
    - Evaluate teaching
    - Determine willingness for practice change
    - Allow those resistant an opportunity to express concerns.
- **Questions**
    - What dose is considered "low-dose" for ketamine?
    - Are CNS side effects a significant concern with low-dose ketamine?
    - What is the benefit(s) of utilizing low-dose ketamine in the delivery of anesthesia?

- How likely are you to consider a change in practice by including low-dose ketamine usage for the care of thoracotomy patients? (Likert scale to be provided)
    - If not at all, please explain why you are unwilling to consider this practice change.
- Do you have any feedback or suggestions to offer concerning the in-service delivery or content presented?

60-day Follow-up

- **Goals**
    - Determine if practice change has been made
    - Gather feedback on effectiveness
    - Gather feedback on guidelines
    - Allow those resistant an opportunity to express concerns.
- **Questions**
    - Have you provided anesthesia to a thoracotomy patient since participating in the low-dose ketamine in-service?
        - If no, how likely are you to consider a change in practice by including low-dose ketamine usage for the care of thoracotomy patients?
        - If yes, did you use low-dose ketamine in the anesthesia care of this patient(s)?
            - If no, please explain why you chose not to administer low-dose ketamine to this patient(s).
            - If yes, in your clinical judgement, how effective was low-dose ketamine in:
                - Reducing post-operative pain? (Likert scale to be provided)
                - Reducing post-operative opioid consumption? (Likert scale to be provided)

- How likely are you to consider using low-dose ketamine in the anesthesia care of other major surgeries with similar post-operative pain and opioid consumption? (Likert scale to be provided)
- Do you have any feedback or suggestions to offer concerning the guidelines for utilization?