Marian University

Leighton School of Nursing

Doctor of Nursing Practice

Final Project Report for Students Graduating in May 2022

Utilization of ERAS Protocols to Reduce Postoperative Opioid Consumption

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Abstract

The use of perioperative opioids for pain management can come with great consequences as the opioid crisis is more prevalent than ever. In the US, nearly 70% of all opioid tablets prescribed after surgery become problematic as they are diverted and not used for medical benefit (Soffin et al., 2019). Enhanced Recovery After Surgery (ERAS) guidelines were developed over two decades ago with over 17 tools to improve postoperative recovery as well as reduce the economic burdens of healthcare; including the burden of the opioid crisis (Beloeil et al., 2019). By retrospective chart review, analysis of potential benefits in reducing postoperative opioid consumption as well as pain scores led to developing suggestions for implementation of ERAS items into practice at the project site. With no current practice guidelines in effect, the study found that implementation of multimodal anesthesia through combinations of ERAS items can reduce overall fentanyl consumption ($p<.001$) as well as reduce pain for up to 4 hours after surgery ($p=.022$). By evaluating current practice at the project site, recommendations should be made to explore the benefits of implementing combinations of ERAS items to promote better postoperative recovery as well as reduce the burden of the prescription opioid crisis.

Utilization of ERAS Protocols to Reduce Postoperative Opioid Consumption

In the United States, it is estimated that over 2 million people struggle with the abuse of opioids with an estimation that an opioid overdose leads to one death every fifteen seconds (Soffin et al., 2019). Opioids are used in many areas of healthcare to treat moderate to severe pain, but a major contributor to opioid consumption is during the perioperative and postoperative period of anesthesia. Although opioids are known to effectively treat all types of pain, there is potential for serious adverse outcomes contributing to an annual healthcare cost of nearly $80 million (Soffin et al., 2019). To combat the opioid crisis, the implementation of new practice guidelines has and can continue to reduce the consumption of opioids during the postoperative period.

Background

Pain is a perception of sensory input received as result of a noxious or unpleasant stimulus (Brown et al., 2018). This unpleasant sensation results from a stimulus activating opioid receptors in sensory pathways throughout the spinal cord and brain (Tedesco et al., 2017). Opioids such as morphine, fentanyl, and hydromorphone are commonly used in anesthesia to block the transmission of pain signals at the opioid receptors caused by surgical stimulation, thus reducing the perception of pain (Brown et al., 2018).

Since opioids are known to work on several sensory pathways, adverse effects can result from dose-dependent opioid administration such as respiratory depression, hyperalgesia, sedation, hemodynamic instability, nausea, and vomiting (Oseka & Pecka, 2018). These adverse effects have shown to increase hospital length of stay, morbidity and mortality, and healthcare cost (Wainwright et al., 2020). Over the last decade, implementation of ERAS protocols has helped reduce overall hospital stays for surgical patients from lengths of stay of 5-10 days to 1-3

days (Wainwright et al., 2020. To reduce the adverse effects of opioids, new protocols have been implemented to treat pain while reducing the overall consumption of opioids.

To reduce the magnitude of the opioid crisis, anesthesia providers have developed Enhanced Recovery After Surgery (ERAS) protocols utilizing multimodal therapies to reduce postoperative pain, shorten hospital stays, and reduce opioid consumption (Oseka & Pecka, 2018). ERAS focuses on 17-20 areas that are centered around optimizing the patient preoperatively as well as choosing the best intraoperative plan to enhance recovery and promote patient satisfaction (Wainwright et al., 2020). Multimodal analgesia consists of many combinations of techniques ranging from neuraxial anesthesia and peripheral nerve blocks to non-steroidal anti-inflammatory drugs (NSAIDS) and gabapentinoids to alter pain perception resulting in less pain after surgery (Wainwright et al., 2020).

Though the ERAS is not a universal practice guideline, it is a multifaceted tool that can be used to tailor the anesthetic plan to the specific situation or patient. For example, using alternative analgesics such as gabapentin can significantly reduce postoperative opioid consumption ($p < .001$) in patients undergoing surgical intervention for up to 48 hours (Clarke et al., 2014). By using alternative techniques outlined in ERAS guidelines, overall opioid consumption can be reduced by tailoring the plan to the individual patient.

Problem Statement

In many facilities, opioids continue to be a first-line treatment for pain, which adversely can increase the chance for lengthened hospital stays and adverse outcomes such as nausea, vomiting, delayed awakening, hypotension, bradycardia, or respiratory depression which can all delay recovery times and early transfer (Soffin et al., 2019). By evaluating and comparing the

use of ERAS guided anesthesia, using a multimodal approach to reduce postoperative opioid consumption can provide major benefits during the first 24 hours of recovery after surgery.

Gap Analysis

Current practice implementation for the project site focuses heavily on the administration of opioid analgesics to reduce postoperative pain following surgery. As an acute care hospital, focus is on early recovery after surgery and quick discharge from the post-anesthesia care unit (PACU). Utilization of opioids can provide excellent analgesia but can also prolong recovery due to the adverse effects associated with administration. By implementing ERAS protocols with a multimodal approach, overall reduction of opioids can adequately lead to effective pain management as well as earlier recovery and less unwanted effects after surgery.

The major barriers to implementation of this project include alteration of current practice as well as the development of a specific facility practice guideline designating ERAS items as a treatment protocol. In anesthesia, there is a vast variety of methods and techniques that can be used to delivery safe and effect anesthesia as if everyone has a certain “recipe” that they frequently use. Change and alteration of current practice will require strong evidence, administrative and partner support, and adequate data to support the need for change. This can be evaluated by beginning investigation into the potential improvements in recovery and pain management.

Development of new protocols and guidelines is a multifaceted process involving a collection of specialties to ensure proper implementation. Not only will anesthesia providers require education and alteration in care delivery, auxiliary staff such as operating room nurses, recovery room nurses, physicians, and other healthcare personnel will need to be educated on ERAS recommendations as and the treatment guidelines that would change practice. Approval

from administration to implement a new practice guideline could require ample time and resources to investigate its benefits through pilot studies and trials within the facility. With these barriers, the purpose of this study is to evaluate the potential benefits that could propose recommendations to improve clinical outcomes for surgical patients.

Review of Literature

Methods

The search for evaluation of ERAS protocols and opioid consumption began through major database searching including PubMed, CINAHL, Google Scholar, and MEDLINE. The keywords and phrases that yielded the most significant results included "*ERAS protocols*," "*reduced opioid consumption*," "*ERAS* AND *multimodal analgesia*" and "*multimodal analgesia*." The search was limited to peer-reviewed articles, systematic reviews, meta-analyses, and randomized control trials (RCTs) that have been published in the last 5 years. Even after narrowing the search with the above criteria, a collection of 1014 articles were discovered. In the current phase of research, seventeen articles currently have been discovered as relevant to the proposed topic of how ERAS protocols can reduce postoperative pain and opioid consumption.

Enhanced Recovery After Surgery

To improve overall patient outcomes for individuals undergoing surgery and anesthesia, collaborating healthcare professionals were driven to develop a set of guidelines to improve the overall patient surgical experience. The ERAS guidelines were developed to provide evidence-based recommendations that improve surgical outcomes (Oseka & Pecka, 2018). Such evidence has been proven to reduce postoperative complications, decrease length of stay, accelerate discharge, reduce opioid consumption, and reduce postoperative pain (American Association of Nurse Anesthetists, 2017). In a prospective control study evaluating the ERAS guidelines for

patients undergoing TKA, 247 patients were evaluated for postoperative complications (Zhu et al., 2017). The results indicated that patients who received anesthesia guided by ERAS guidelines experienced 15% less complications than the control group as well as reduction in postoperative pain in the first 24 hours after surgery (Jiang et al., 2019). This information is further reiterated during a meta-analysis of 9936 orthopedic cases involving TKAs and total hip arthroplasties where significantly lower length of stays as well as postoperative complication rates were discovered in the 4205 cases receiving ERAS guidelines ($p<.01$) in comparison to those receiving control group modalities (Zhu et al., 2017).

Postoperative Pain Management

Though ERAS protocols are designed to deliver enhanced recovery over the entire continuum of care for an individual, the various strategies are best evaluated over the first 24 hours after surgery. Postoperative pain is one of the most common complications experienced after surgical intervention and often requires management to reduce nociception or sensory transmission (Brown et al., 2018). Nociception can occur without pain as pain is the conscious response to nociceptive stimulation (Kaye et al., 2020). This entails that physiological stress from nociception and pain can occur intraoperatively even with sedation, thus, requiring early intervention to reduce pain throughout the entire surgical continuum (Oseka & Pecka, 2018).

Administration of powerful opioids is not the only way to manage pain after surgery. Wainwright et al. (2020), collectively produced 17 recommended guidelines driven by ERAS to manage patients undergoing surgery. Of these guidelines, they included alternative treatments to pain management that include choosing to provide neuraxial anesthesia and peripheral nerve blocks to reduce the overall general anesthesia requirements to enhance and quicken recovery as well as reduce opioid consumption (Oseka & Pecka, 2018). The American Association of Nurse

Anesthetists published its own ERAS guidelines which include therapies like the use of steroids, NSAIDs, gabapentinoids, ketamine, local anesthetics, acetaminophen, dexmedetomidine, or different combinations of similarly classified medications to reduce the complications associated with excessive opioid consumption (American Association of Nurse Anesthetists, 2017).

Reduction in Opioid Consumption

The shocking statistics involving the consumption of opioids in the United States drives the need for alternative therapies. Opioid-related substance abuse disorder affects over 2 million Americans alone and results in an annual healthcare bill of $80 billion dollars to treat, contain, and control the damage it accrues (Soffin et al., 2019). To counter the opioid crisis, one major focus of ERAS protocols is to reduce opioid consumption during surgery by balancing anesthesia through the opioid-sparing effects of multiple therapies to provide better surgical outcomes with less complications (Wainwright et al., 2020). A double-blind RCT known as the OCTOPUS study utilized eight subject groups that received non-opioid analgesic treatments in comparison to a morphine control group (Beloeil et al., 2019). This study discovered that non-opioid analgesic treatments consumed significantly less morphine postoperatively ($p<0.05$) as well as had lower overall visual analog scores ($p<0.01$) for rating pain (Beloeil et al., 2019).

Multimodal Therapies

Though recommendations for ERAS guidelines include the use of opioids, alternative medications should be considered when individualizing pain management. By exploring all modalities, one can equip themselves with the necessary tools to individualize patient care. One heavily emerging therapy recommendation is the use of dexmedetomidine (Precedex), a potent alpha-2 agonist that greatly benefits anesthesia by providing hypnotic/sedation, anxiolytic, sympatholytic, and analgesic effects (Kaye et al., 2020). Few medications can provide all these

benefits when used correctly, meaning less medications are used with less risk for adverse effects or synergistic outcomes. In a meta-analysis discussing the benefits of dexmedetomidine, over 1792 patients were evaluated after administration of dexmedetomidine and found that VAS ratings were lower than the control group and the dexmedetomidine group consumed 30% less opioids in the postoperative period ($p<0.05$) (Kaye et al., 2020).

Another modality to combat opioid consumption as well as the negative side effects of various medication therapies is to use nonpharmacological treatment to reduce postoperative pain and opioid consumption. Patients can be very sensitive to medications or have previous histories of opioid dependence, therefore, exploring nonpharmacological methods can be beneficial to such patient populations. Alternative therapies such as continuous passive motion, preoperative exercise, cryotherapy, electrotherapy, and acupuncture have all been studied as effective therapies to counter postoperative pain (Tedesco et al., 2017). In a large systematic review, 3 large RCTs discovered electrotherapy to effectively reduce postoperative pain in the first 48 hours postoperative by stimulating with non-painful electrical stimulus to block pain transmission at pain fibers (Brown et al., 2018). Acupuncture has been studied and is shown to be beneficial in reducing postoperative pain by an average of 2 points on the VAS in the first 24 hours after operation (Tedesco et al., 2017). Alternatives may not be successful for all patients experiencing moderate to severe pain but can help reduce opioid consumption and related consequences if balanced with a multimodal approach.

Theoretical Framework

Some of the most important concepts of ERAS guidelines are promoting a quick recovery without adverse outcomes and adequate pain relief following surgery. The middle range theory known as a balance between analgesia and side effects was created by Marion Good in 1998, to

promote recovery and reduce pain through multimodal therapy (Good, 1998). This coincides with the same goals as ERAS guidelines which align to reduce recovery room length of stay, minimize postoperative pain, and advocate for early ambulation (Oseka & Pecka, 2018). This theoretical framework is centered on a continuum of three propositions: 1) Multimodal Therapy; 2) Attentive Care; and, 3) Patient Participation (Good, 1998) (see Figure 1, Appendix B – Framework). The framework connects the three propositions to the nursing process and how it could be utilized with ERAS guidelines.

Proposition 1: Multimodal Therapy

Postoperative pain management often starts with the use of opioids. One way to reduce opioid consumption is to incorporate the use of both pharmacological and non-pharmacological adjuvants in the treatment plan (Peterson & Bredow, 2013). The ERAS guidelines focus heavily on substituting non-steroidal anti-inflammatory drugs (NSAIDs), gabapentin, acetaminophen, and peripheral and regional nerve blocks for pain management (Oseka & Pecka, 2018).

Proposition 2: Attentive Care

Proper pain management requires frequent nursing assessment for analgesia as well as side effects. Using the nursing process to assess, diagnose, plan, implement, and evaluate in a cyclical pattern can be used to appropriately manage analgesia and side effects (Good, 1998). By utilizing assessment and evaluation of multimodal therapy, nurses can effectively balance analgesia and adverse outcomes while reducing opioid use in the postoperative period (Oseka & Pecka, 2018).

Proposition 3: Patient Participation

Educating the patient and setting realistic goals for pain can improve patient outcomes and reduce adverse events. Putting the patient at the center of his or her treatment plan can be the key to achieving postoperative goals and early recovery (Good, 1998).

Project Proposal Components

Goals, Objectives, and Expected Outcomes

The purpose of this project is to determine the effectiveness of ERAS guidelines in reducing postoperative opioid consumption. The objective is to compare evidence-based practice guidelines and compare them to the current anesthesia delivery methods used at this project site, it is expected that utilizing ERAS guidelines will provide adequate postoperative pain relief with potential decrease in opioid consumption. This will be an assessment for this site and surgical population to determine if alteration or full implementation of ERAS guidelines can provide better outcomes for patients in the first 24 hours following surgery.

Project Design

A retrospective chart review was completed comparing the project site's traditional practice to ERAS guided anesthesia methods. The data was collected utilizing a quantitative descriptive approach utilizing cases that have been completed over a 9-month period. Reviewed case data completed during this period through electronic health records was manually entered into a Microsoft Excel spreadsheet and categorized and organized for analysis. Statistical analysis was completed through JASP data analysis software to determine correlations and relationships of patient variables and outcomes to the study design.

Sample

The collected sample consisted of 58 patients undergoing general or gynecological procedures. The subjects ranged in age from 18-85 years old and were randomly selected to meet the criteria for each group. The control group consisted of 30 patients selected at random from electronic medical record (EMR) data that were compared to 28 patients who received ERAS interventions. Inclusion criteria consists of patients undergoing surgery at the project site and receiving opioid analgesics throughout the perioperative period or ERAS recommendations as specified in the preoperative anesthetic evaluation. Exclusion criteria was used to eliminate procedures that resulted in severe postoperative complications such as surgical site infections (SSI), bowel dehiscence, or conversion to open laparotomy after laparoscopic designation.

Methods

The implementation of ERAS recommended interventions was compared to a control group with ample opioid administration in patients undergoing gynecological/obstetrical and general surgery procedures. With collaboration of a project mentor, an agreement was established to access data through chart audits of human subjects with the exemption granted from Marian University's Institutional Review Board (IRB) as well as approval from the site's research administration.

A retrospective chart review was completed to evaluate the effects of implementation of ERAS guided anesthesia on reduction of opioid consumption and postoperative pain. Charts were reviewed investigating a 9-month period comparing opioid consumption and pain scores between an opioid control group and an ERAS guided anesthesia approach. Personal health information was avoided and de-identified from data collection. Demographic data such as age, gender, and ASA status was collected as well as anesthesia delivery techniques, medication

reconciliation, pain scores, and opioid consumption. Data analysis was used to determine if ERAS recommendations can reduce opioid consumption and/or postoperative pain scores.

Measurement Instruments

Multiple variables were used during this project to determine the effectiveness of the ERAs interventions. The independent variables utilized include implemented ERAS recommendations as individual or combination techniques during the delivery of anesthesia. Such variables include perioperative use of acetaminophen, dexamethasone, ketorolac, dexmedetomidine, ketamine, magnesium, lidocaine, and regional or local anesthetic techniques. Combinations of the above were also evaluated per recommendation by ERAS guidelines. Dependent variables evaluated during this study include interval postoperative pain scores, total opioid consumption, and postoperative length of stay (LOS). Due to the format of EPIC electronic health records, a VAS score was unobtainable and replaced with a numerical pain scale ranging from 0-10 for time interval assessments.

Data Collection

Data was collected from July 2021 to October 2021 through retrospective chart review of surgical cases completed from January 2021 to September 2021. The data was compiled into Microsoft Excel as de-identified case numbers. The tool was self-created and organized based on the data collected from electronic health records (EHR) at the project site. The data selected for each case included demographics, perioperative interventions, postoperative outcomes, serial pain scores, and opioid consumption totals. “Yes” or “no” responses were used to detail if the patients received a specific perioperative intervention or a combination of ERAS interventions. Pain scores were recorded in time intervals of 30 minutes and 2, 4, 8, and 24 hours after surgery

with a numerical scale ranging from 0-10. Opioid consumption was labeled and collected in terms of value by total amount consumed in milligrams and micrograms.

Nominal variables including surgery type, gender, and ASA status were analyzed to distinguish relationships among variables. Age in years was entered as an integer variable. Other nominal variables include the proposed ERAS interventions and administrations of preoperative carbohydrates, acetaminophen, ketorolac, ketamine, dexmedetomidine, lidocaine, magnesium, and pregabalin as the data is entered in the form of a "yes" or "no" the patient did or did not receive the ERAS intervention. Pain scores were recorded as interval variables utilizing a numerical pain scale ranging from scores of 0-10, with 10 being the highest level of pain. Total opioid consumption values were provided as continuous data as dosing of each fentanyl, hydromorphone, and morphine are of different units and dosages.

Data Analysis

The focus of this project was to evaluate the benefit in implementing ERAS guidelines to reduce perioperative opioid consumption and evaluate postoperative pain management**.** By comparing an opioid control group to an ERAS group, descriptive statistics and independent T-tests were performed to evaluate if significant differences existed between the study groups and performed interventions. An alpha level of 5% was accepted for the data analysis and a p-value less than .05 was considered statistically significant and support that the outcome provided was likely a result of chance.

Group descriptive statistics were analyzed to obtain mean values for age, gender, pain scores, and opioid consumption among comparison groups. Multiple independent sample t-tests were used to evaluate the difference in means between the opioid and ERAS groups. Student sample t-tests compared mean opioid consumption totals for both groups who received fentanyl,

hydromorphone, and/or morphine. Other t-tests were used to determine differences in pain scores at 30 minutes, 2-, 4-, 8-, and 24-hour intervals among groups as well as for each individual ERAS intervention analgesic effects. Descriptive statistics compared mean pain scores at each interval between case types, gynecological or general surgery cases. By evaluating potential differences between groups and specific interventions, the focus was to suggest the implementation of significant findings in relation to the effects of ERAS interventions for this study sample.

Results

According to analysis of pain scores for both the ERAS and control groups, the mean postoperative pain scores were lower at 30 minutes in comparison to 2, 4, 8, and 24 hours after surgery. When comparing the control opioid group and ERAS group pains scores at 30 minutes, there was a significant difference in the mean scores of 4.033 and 2.893 respectively. On average, mean pain scores at 2, 4, and 8 hours into the postoperative period remained relatively similar with slightly lower scores in the ERAS group, whereas the 24-hour pain scores exhibited no difference across groups. These differences were not significant in independent t-tests at 2, 4, 8, 24 hours after surgery.

Opioid consumption was compared between the two study groups. Independent T-tests were used to determine if there differences in the amount of opioid consumed in the postoperative period. Total values for fentanyl were recorded in micrograms (mcg) whereas hydromorphone and morphine were recorded in values of milligrams (mg). The ERAS group consumed significantly less fentanyl throughout the perioperative period in comparison to the opioid group (11.833, $p < .001$) with mean consumptions of 4.46 mcg and 117.5 mcg respectively. Similar results were found when evaluating the consumption of hydromorphone as

the ERAS group consumption was lower than the control group (3.786, $p < .001$). There was not a significant reduction in morphine consumption between study groups. When evaluating the benefits of regional and/or local anesthesia in reducing pain scores, lower scores were recorded 30 minutes after surgery ($p < .010$) but not in any other time interval.

ERAS protocols consist of a multimodal approach involving utilizing combination techniques to try to minimize pain. Individual interventions were evaluated as well to determine if each approach could yield better results. Dexmedetomidine was evaluated at each pain interval and found that there were not significantly different pain scores with this intervention alone. Similar results were found when evaluating individual interventions including ketamine, lidocaine, and magnesium infusions separately. When comparing pain scores of patients who received multimodal anesthesia involving infusions of magnesium, lidocaine, and dexmedetomidine, postoperative pain scores were lower in 14 patients who received this combination at 30 minutes, 2, and 4 hours after surgery ($p < .001$, $p < .001$, and $p < .022$ respectively). Average pain scores at these intervals for those who did not receive this combination of ERAS recommendations were 3.87, 4.12, and 3.957 compared to the multimodal groups scores of 1.82, 2.09, and 2.82 respectively. Aside from pain scores and opioid consumption, postoperative length of stay (LOS) was also included as a quality measurement but there were no differences in overall LOS for total hours between the two groups. When comparing case type to overall pain scores, there was no significant difference in pain scores between OB/GYN and general surgery cases.

Discussion

When compared to a traditional opioid-driven anesthetic, the ERAS protocols find their place as an alternative treatment plan that can yield many benefits to a faster and safer recovery

after surgery. Patients in the ERAS group consumed significantly less fentanyl and hydromorphone than the control opioid group. By discharge, comparisons of morphine consumption were similar across groups, detailing that the perioperative period of 24 hours utilizing ERAS items can reduce overall opioid consumption. As for pain scores, there were no differences in mean values for the two groups at 2, 4, 8, and 24 hours after surgery for individual interventions of ketamine, magnesium, lidocaine, and acetaminophen administration. However, a multimodal analgesic approach combining magnesium, lidocaine, and dexmedetomidine yielded significant reduction in postoperative pain scores at 30 minutes, 2 and 4 hours into the postoperative period. For this study, patients experienced similar LOS as well as no significantly different pain scores between types of surgery.

This study was designed to experiment various anesthetic plan opportunities that may or may not benefit the selected patient population. There is evidence that utilizing a combination of ERAS items can suggest improved outcomes for patients undergoing general and gynecological surgery. By utilizing a combination of ERAS items, opioid consumption was reduced as well as short-term postoperative pain goals. Though the 24-hour perioperative period did not see serial improvements in pain scores, the data shows that implementation of ERAS protocols can efficiently and comparably manage postoperative pain while erasing potential adverse effects of opioids. Anesthetic plans should be individualized to the patient and therefore the anesthesia provider should consider viable treatment options that better enhance the recovery of the surgical patient.

Future Implications

This study was an original investigation into ERAS recommendations for the project site. Though not all 17-20 recommendations were evaluated during this study, the goal was obtained

to see if focused intervention could provide potential benefits for the subject population. If future studies or trials involved a full implementation and educational program utilizing ERAS recommendations, improvements in the above study could be made. The data collected was evaluated on specific surgical populations whereas other specialty surgeries could be investigated for the benefits of ERAS implementation such as orthopedics and/or obstetrical procedures. In order to increase the sample size, greater participation among surgeons and anesthesia providers could provide substantial support in determining the efficacy of ERAS implementations as the population of patients undergoing surgical procedures with ERAS protocols would increase. By obtaining a larger sample size and focusing on a narrower case selection could provide more efficient and specific implementation recommendations.

Ethical Considerations/Protection of Human Subjects

This study complies with standards discussed with both IRB approvals from both Marian University as well as the project site. No intervention or direct communication occurred with human subjects throughout this study. Personal health information was protected and de-identified. Completion of this project went without conflict of interest among facilities and without compensation for access to data collection.

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Appendix A

Literature Review Matrix					
Reference in APA format	**Level of Evidence**	**Variables**	**Sample**	**Instruments**	**Results**
American Association of Nurse Anesthetists. (2017). Enhanced recovery after surgery considerations for pathway development and implementation. https://www.aana.com/docs/default-source/practice-aana-com-web-documents-(all)/enhanced-recovery-after-surgery.pdf?sfvrsn=6d184ab1_12	Level I	There are no defined independent vs. dependent variables. These are the ERAS practice guidelines designed and implemented by the AANA.	There is also no designated sample as the guidelines provide multiple options for the delivery of care. There are over 92 citations included in this study with many of them meta-analyses, RCTs, and systematic reviews.	ERAS guidelines, Apfel PONV risk scoring system, Recommendations for optimal blood glucose levels during surgery, considerations for pre-, intra-, and postoperative opioid management.	ERAS protocols have shown to significantly deliver positive patient outcomes, reduce postoperative length-of-stay, accelarate the recovery process, and lead to significantly early discharge times.
Brown, E. N., Pavone, K. J., & Naranjo, M. (2018). Multimodal general anesthesia: Theory and practice. *Anesthesia and Analgesia, 127*(5), 1246–1258. https://doi.org/10.1213/ANE.0000000000003668	Level II	The independent variable is the use of multimodal analgesics such as dexmedetomidine and lidocaine to prevent adverse effects of opioid consumption (dependent variable)	689 patients undergoing one of four surgeries: laminectomy, total knee replacement, cesarean delivery, or exploratory laparatomy.	ERAS guidelines for multimodal analgesia	Opioid-free and multimodal analgesia can effectively provide balanced general anesthesia with adequate amnesia and muscle relaxation without sympathetic or

					hemodynamic instability.
Oseka, L., & Pecka, S. (2018). Anesthetic management in early recovery after surgery protocols for total knee and total hip arthroplasty. *AANA Journal, 86*(1), 32–39.	Level I	IV: ERAS Protocols DV: postoperative pain, reduced opioid consumption	Systematic review compiling 732,570 total knee arthroplasties in the United States between 2000 and 2010.	ERAS guidelines, Apfel PONV risk scoring system, numeric pain scale 0-10	Integrating ERAS protocols for intraoperative and postoperative pain management can reduce overall pain and opioid consumption. Minimizing opioids and using ERAS guidelines can also contribute to earlier mobility and shorter hospital stays.

Soffin, E. M., Lee, B. H., Kumar, K. K., & Wu, C. L. (2019). The prescription opioid crisis: Role of the anaesthesiologist in reducing opioid use and misuse. *British Journal of Anaesthesia, 122*(6), e198–e208. https://doi.org/10.1016/j.bja.2018.11.019	Level I	IV: regional anesthetic techniques DV: decreased opioid use	This meta-analysis did not list particular sample sizes but described multiple other RCTs and systematic reviews with significant data.	Supply & Demand Opioid prescription algorithm for anesthesiologists.	Anesthetists can play an essential role in reducing the overall consumption of opioids by understanding both perioperative and post-discharge implications for opioids as well as alternative analgesic therapies. The importance of patient education on analgesia and opioids can also aid in improving patient outcomes during the recovery process.

Wainwright, T. W., Gill, M., McDonald, D. A., Middleton, R. G., Reed, M., Sahota, O., Yates, P., & Ljungqvist, O. (2020). Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Acta orthopaedica, 91*(1), 3–19. https://doi.org/10.1080/17453674.2019.168379	Level 1	IV: Implementation of ERAS protocol recommendations DV: reduction in opioid consumption	This consensus statement contains multiple RCTs and systematic reviews with no specific sample sizes and only results from the mentioned studies. It targets 17 different areas with Level 1 and Level 2 evidence supporting the 17 different guideline areas.	AANA ERAS Guidelines for TKA and THA	The use of non-opioid analgesics such as gabapentinoids, NSAIDs, and paracetamol are effective in reducing post-operative opioid consumption. Combined neuraxial anesthesia and/or peripheral nerve blocks provide effective analgesia and reduction of opioid use by 40% in the postoperative perioid.
Tedesco, D., Gori, D., Desai, K. R., Asch, S., Carroll, I. R., Curtin, C., McDonald, K. M., Fantini, M. P., & Hernandez-Boussard, T. (2017). Drug-free interventions to reduce pain or opioid consumption after total knee arthroplasty: A systematic review and meta-analysis. *JAMA surgery, 152*(10), e172872. https://doi.org/10.1001/jamasurg.2017.2872	Level 1	IV: Multimodal therapy for analgesia DV: reduced postoperative pain, reduced opioid consumption	Meta-analysis of 2391 patients from 39 RCTs undergoing total knee arthroplasties.	WOMAC - Western Ontario and McMaster University Arthritis Index, VAS - visual analog scale for pain	Electrotherapy and acupuncture were found to effectively reduce postoperative pain in the first 2 days of the postoperative period.

Beloeil, H., Albaladejo, P., Sion, A., Durand, M., Martinez, V., Lasocki, S., Futier, E., Verzili, D., Minville, V., Fessenmeyer, C., Belbachir, A., Aubrun, F., Renault, A., Bellissant, E., & OCTOPUS group (2019). Multicentre, prospective, double-blind, randomised controlled clinical trial comparing different non-opioid analgesic combinations with morphine for postoperative analgesia: The OCTOPUS study. *British Journal of Anaesthesia, 122*(6), e98–e106. https://doi.org/10.1016/j.bja.2018.10.058	Level 2	IV: Non-opioid analgesic combination DV: reduction in postoperative opioid consumption	Double-blind RCT from 10 hospitals with 237 patients.	visual analog scale (VAS)	In a RCT with 10 hospitals and 237 surgical patients, patients receiving combined non-opioid analgesics had significantly less postoperative opioid consumption at 24 hours and 48 hours postoperative.
Zhu, S., Qian, W., Jiang, C., Ye, C., & Chen, X. (2017). Enhanced recovery after surgery for hip and knee arthroplasty: A systematic review and meta-analysis. *Postgraduate Medical Journal, 93*(1106), 736–742. https://doi.org/10.1136/postgradmedj-2017-134991	Level 1	IV: ERAS Protocols DV: Length of stay (LOS) and postoperative complications	systematic review and meta-analysis of 9936 surgical cases with 4205 cases utilizing ERAS while 5731 cases used traditional treatments.	visual analog scale (VAS)	ERAS significantly reduces postperative pain, length of stay, readmission rates, and reoperation rates in comparison to traditional treatments without guided protocols.
Jiang, H. H., Jian, X. F., Shangguan, Y. F., Qing, J., & Chen, L. B. (2019). Effects of enhanced recovery after surgery in total knee arthroplasty for patients older than 65 years. *Orthopaedic Surgery, 11*(2), 229–235. https://doi.org/10.1111/os.12441	Level 2	IV: ERAS protocols DV: postoperation complications: pain, ROM, PONV	RCT with 247 patients of 65 years of age or older, undergoing total-knee or total hip replacement.	VAS (visual analog scale)	ERAS protocol patients had significantly lower VAS scores in the first day postoperative.

Kaye, A. D., Chernobylsky, D. J., Thakur, P., Siddaiah, H., Kaye, R. J., Eng, L. K., Harbell, M. W., Lajaunie, J., & Cornett, E. M. (2020). Dexmedetomidine in enhanced recovery after surgery (ERAS) protocols for postoperative pain. *Current Pain & Headache Reports, 24*(5), 1–13. https://doi.org/10.1007/s11916-020-00853-z	Level 2	IV: Use of dexmedetomidine DV: reduced postoperative pain	systematic review of 14 RCTs and meta-analyses containing a total of 6429 patients receiving dexmedetomidine vs. control opioids	VAS (visual analog scale) and WOMAC test	In comparison to other non-opioid analgesic methods, controlled studies revealed that VAS results were significantly lower at 24 hours, one month, and two months postoperatively in dexmedetomidine group compared to control.
Zhang, N., Wu, G., Zhou, Y., Liao, Z., Guo, J., Liu, Y., Huang, Q., & Li, X. (2020). Use of enhanced recovery after surgery (ERAS) in laparoscopic cholecystectomy (LC) combined with laparoscopic common bile duct exploration (LCBDE): A cohort study. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research, 26*, e924946. https://doi.org/10.12659/MSM.924946	Level 4	IV: ERAS protocols DV: postoperative analgesia, postoperative complications, hospital length of stay (LOS)	A cohort study of 445 patients undergoing laparoscopic cholecystectomy; 148 received ERAS-guided care compared to a control group of 297 patients.	Numerical pain scale (0-10)	Patients in the E-LC (ERAS lap chole group) saw decreased incidences of nausea, incisional pain, and vomiting. It was also discovered that the patients in the E-LC group had shorter hospital LOS and improved quality of life.

Naik, B. I., Tsang, S., Knisely, A., Yerra, S., & Durieux, M. E. (2017). Retrospective case-control non-inferiority analysis of intravenous lidocaine in a colorectal surgery enhanced recovery program. *BMC Anesthesiology, 17*(1),7-16. https://doi.org/10.1186/s12871-017-0306-6	Level 4	IV: ERAS with lidocaine infusion DV: patient-reported pain scores and opioid consumption	A retrospective review of 104 patiends split into a LIDO group and an ERAS group.	Mean morphine equivalents, numerical rating scale (0-10) for postoperative pain.	Patients in the Lidocaine infusion group consumed less opioids in POD 1 and equal or slightly less in POD 2. POD 1 and 2 found no differnce in pain scores.
Mitra, S., Carlyle, D., Kodumudi, G., Kodumudi, V., & Vadivelu, N. (2018). New advances in acute postoperative pain management. *Current Pain and Headache Reports, 22*(5), 1-11. https://doi.org/10.1007/s11916-018-0690-8	Level 1	IV: ERAS guided multimodal analgesia DV: postoperative pain management	Meta-analysis comparing level of evidence/support for multimodal analgesic techniques used in ERAS protocols	VAS and numerical pain scores, morphine equivalent dosing (MED).	ERAS pathways and guidelines are being implemented to set standards for reduced opioid consumption and improved postoperative pain management.
Pędziwiatr, M., Mavrikis, J., Witowski, J., Adamos, A., Major, P., Nowakowski, M., & Budzyński, A. (2018). Current status of enhanced recovery after surgery (ERAS) protocol in gastrointestinal surgery. *Medical oncology, 35*(6), 95-103. https://doi.org/10.1007/s12032-018-1153-0	Level 1	IV: ERAS protocols in gastrointestinal surgery DV: Pain, N/V, and mobility	A systematic review conducted compiling findings and suggested recommendations of RCTs and current published guidelines for ERAS in multiple surgical disciplines including GI	No dedicated instrument/tool defined in study.	ERAS guidelines in GI surgery not only decrease postoperative opioid consumption, pain scores, and hospital LOS, it also shows increasing 5-year survival rates after GI surgery.

			surgery, colorectal, and laparoscopy.		
Ren, Y., Sun, D., Pei, L., Liu, X., Liu, Y., & Liu, H. (2021). A full enhanced recovery after surgery program in gynecologic laparoscopic procedures: A randomized controlled trial. *Journal of Minimally Invasive Gynecology, 15*(21), 100-125. . https://doi.org/10.1016/j.jmig.2021.01.024	Level 2	IV: Full ERAS intervention, DV: postop LOS, hospital cost, postoperative pain	144 patients undergoing laparoscopic gynecologic procedures in a RCT split evenly into two groups: Full ERAS intervnetion vs control group of limited ERAS management.	numerical rating scale for pain (0-10), quality of life -15 (QoR-15) questionnaire	Postoperative LOS in the full ERAS intervention group was significantly shorter than the control group. Those assigned to the intervention group displayed decreased numerical pain scores after 2 hours postoperative up to 72 hours after surgery.

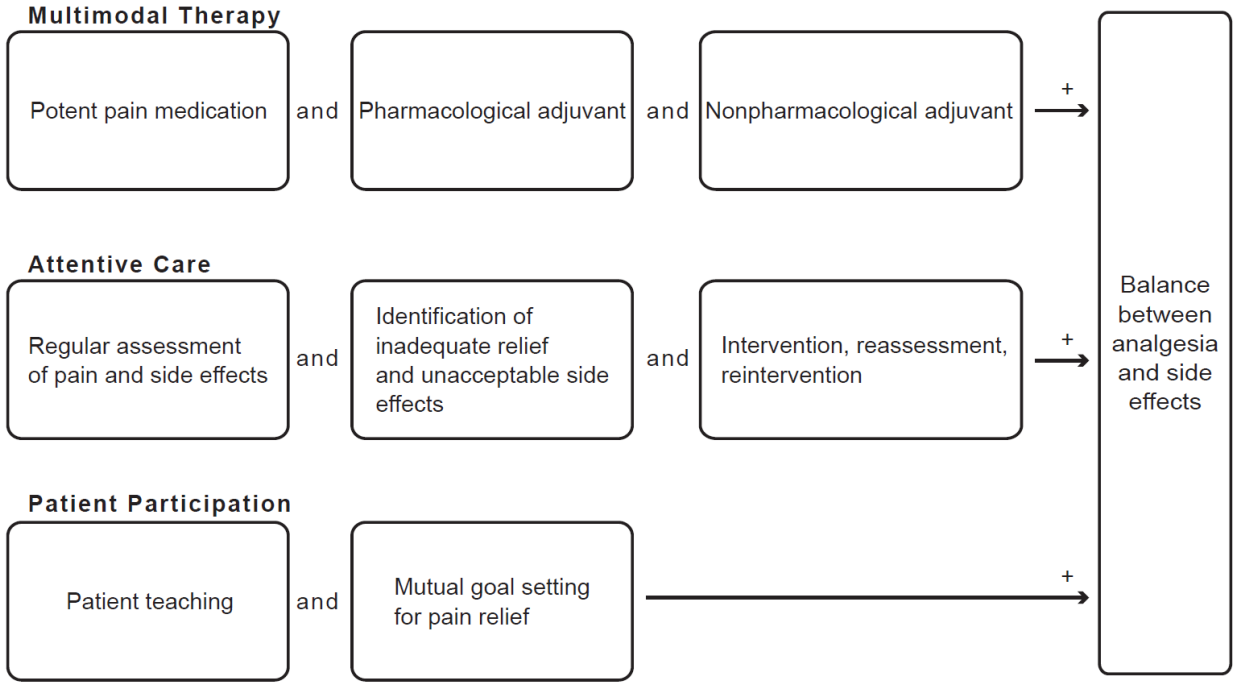
Wang, Y., Zhu, Z., Li, H., Sun, Y., Xie, G., Cheng, B., Ji, F., & Fang, X. (2019). Effects of preoperative oral carbohydrates on patients undergoing ESD surgery under general anesthesia: A randomized control study. *Medicine, 98*(20), 1-6. https://doi.org/10.1097/MD.0000000000015669	Level 2	IV: Oral carbohydrates 2 hours prior to surgery DV: 10 hours of fasting before surgery	73 patients undergoing endoscopic submucosal dissection (ESD) randomized into two groups; experimental carbohydrate drink group (36) and fasting control group (37).	Visual analog scale (VAS) for 6 criteria including: thirst, hunger, mouth dryness, nausea, vomiting, and weakness).	Carbohydrates prior to ESD surgery resulted in shorter LOS, less postop complications, and less thirst and hunger.
Simpson, J. C., Bao, X., & Agarwala, A. (2019). Pain Management in Enhanced Recovery after Surgery (ERAS) Protocols. *Clinics in Colon and Rectal Surgery, 32*(2), 121–128. https://doi.org/10.1055/s-0038-1676477	Level 1	Systematic review does not detail a specific Independent variable but explains various pain management techniques	N/A	N/A	Detailed descriptions for each pain management technique are found within study backed by data collected from systematic review.
Naik, B. I., Tsang, S., Knisely, A., Yerra, S., & Durieux, M. E. (2017). Retrospective case-control non-inferiority analysis of intravenous lidocaine in a colorectal surgery enhanced recovery program. BMC Anesthesiology, 17(1), 16. https://doi.org/10.1186/s12871-017-0306-6	Level 3	IV: administration of Lidocaine perioperative period DV: reduced postoperative opioid consumption	52 patients were given Lidocaine as an additive compared to an ERAS group	MED scores, numerical pain scale scores	The addition of a multi-component ERAS protocol to intravenous lidocaine incrementally reduces opioid consumption. This is most prominent in day one following

					surgery, but not as significant in day 2 or 3.
Paduraru, M., Ponchietti, L., Casas, I. M., Svenningsen, P., & Zago, M. (2017). Enhanced recovery after emergency surgery: A systematic review. Bulletin of Emergency and Trauma, 5(2), 70–78.	Level 1	IV: Utlization of ERAS items in emergency surgery DV: conventional emergency surgery protocols	311 emergency patients were evaluated in 3 studies that were compared to 294 traditional treatment plans	N/A	The implementation of 11-18 ERAS items resulted in fewer postoperative complications for patients undergoing emergency surgery.
Samimi, S., Taheri, A., & Davari Tanha, F. (2015). Comparison between intraperitoneal and intravenous lidocaine for postoperative analgesia after elective abdominal hysterectomy, a double-blind placebo-controlled study. Journal of Family & Reproductive Health, 9(4), 193–198.	Level 2	IV: administration of Lidocaine perioperative period DV: reduced postoperative VAS scores	109 patients undergoing elective abdominal hysterectomy controlled against a group receiving lidocaine infusion of 2mg/kg/hr	VAS scores	The pain intensity was significantly reduced in both IV and IP groups compared with control group until 12 hours postoperatively ($p = 0.001$) and there was no significant difference between IV and IP group in this regard ($p > 0.05$

Shariffuddin, I. I., Teoh, W. H., Wahab, S., & Wang, C. Y. (2018). Effect of single dose dexmedetomidine on postoperative recovery after ambulatory ureteroscopy and ureteric stenting: A double blind randomized controlled study. BMC Anesthesiology, 18(1), 3. https://doi.org/10.1186/s12871-017-0464-6	Level 2	IV: Administration of dexmedetomidine DV: postoperative pain, MAC (minimal alveolar concentration)	60 patients undergoing uteroscopy received either dexmedetomidine or saline to evaluate the benefits of pain relief and anesthesia agent requirements.	Visual analog scale (VAS)	Patients in the DEX group received less anesthestic agent, or decreased MAC, than the control group. They also saw decreased VAS scores after 1 hour during the postoperative period (p=.004)
Zhang, N., Wu, G., Zhou, Y., Liao, Z., Guo, J., Liu, Y., Huang, Q., & Li, X. (2020). Use of enhanced recovery after surgery (ERAS) in laparoscopic cholecystectomy (LC) combined with laparoscopic common bile duct exploration (LCBDE): A cohort study. Medical Science Monitor: International Medical Journal of Experimental and Clinical Research, 26, 924-946. https://doi.org/10.12659/MSM.924946	Level 3	IV: ERAS regimen defined by study DV: flatus time, postoperative pain, N/V, length of stay	445 patients undergoing laparoscopic cholecystectomy that were divided evenly into a control group and an ERAS group.	numerical pain scale scores	The incidence of nausea, incisional pain, and vomiting in the E-LC group were lower than in the LC group, and the differences were statistically significant ($p<0.05$)

Appendix B

Figure 1: Pain: A Balance Between Analgesia and Side Effects



Note. The middle range theory of a balance between analgesia and side effects. Adapted from Middle range theories: Application to nursing research (p. 55), by Good, M., 1998, Wolters Kluwer Health. Copyright 2013 by Lippincott Williams & Wilkins.