

Perioperative Use of Magnesium to Decrease Postoperative Pain in Adults

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Abstract

Magnesium has been used to treat different illnesses, from preeclamptic patients, and as an adjunct to manage pheochromocytoma during surgery. Due to its easy accessibility and cost-effectiveness, magnesium has recently emerged as a pain management supplement. While narcotics continue to be the primary treatment for postoperative pain, the concept of multimodal analgesia is evolving, and there has been a definite decrease in the adult patient's need for narcotics after surgery. Although widely used in anesthesia, magnesium is not yet an integral component in a standardized protocol within multimodal analgesia. Students and other anesthesia providers are not given the opportunity to learn how to integrate and manage magnesium in their anesthetic properly, due to its infrequent use in the operating room. Through a literature review it was shown that the use of magnesium was efficacious and had a wide safety margin in the adult population. Anesthesia providers strive to be proactive in our nations fight against the opioid crisis and consistently seek out evidence-based research for new safe alternatives. A face to face educational session was conducted to the 2018 and 2019 Student Registered Nurse Anesthetist (SRNA) cohorts at Adventist University of Health Sciences (ADU). They were educated on the use of magnesium as a pain management adjunct to reduce postoperative narcotic use. A pre-and post-test was administered; results were collected and with the help of statistical software a correlation between pre and post scores determined an increase in knowledge amongst the SRNA's was achieved. An understanding of magnesium's usefulness as a pain management adjunct can help providers achieve a tight control of postoperative pain in the adult population.

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Introduction

The use of perioperative opiates is associated with undesirable physical and psychological side effects and slower turnovers in the operating room (OR). Multimodal analgesia is a technique that leverages opiate and non-opiate pathways to decrease pain perception and avoid undesirable side effects. Magnesium is an electrolyte with a broad therapeutic index that has many physiological effects including blocking the actions of the N-methyl-D-aspartate (NMDA) receptor site (Do, 2013; James, 2009). Blocking of the NMDA receptor with magnesium is suggested to decrease pain perception. Over half of the surgeries currently performed in the United States (U.S.) are being conducted in an outpatient setting. Subsequently, there is a need for further research into effective ways to decrease the post-operative use of opiates. (Da Oliveira, Castro-Alves, Kahn, & McCarthy, 2013). High use of opioids not only leads to undesirable side effects but it also hinders the discharge process, slowing down recovery after minor procedures (Misal, Joshi, & Shaikh, 2016).

Postoperative pain control is an essential consideration for any individual undergoing an operation, thus bringing this issue to a more global stage (Castro & Cooney, 2017). Untreated pain eventually leads to both physical and psychological complications. Regulatory agencies have found pain relief to be an indication of quality within a health organization, bringing to light the importance of this issue. In the OR, unresolved pain that continues in the post-anesthesia care unit (PACU) delays discharges; which significantly impacts the continuity of the daily flow. Furthermore, this can lead to a decrease in patient satisfaction and early readmissions; these circumstances warrant unwanted implications for any healthcare organization.

The concept of a multi-modal approach has found its way in the local OR's and with good reason. The idea of a multimodal approach is to target different pain pathways to reduce the

amount of post-operative analgesics needed in recovery. This awareness has demonstrated the justification to research other non-opioid options such as magnesium.

After identifying that there is a lack of knowledge with the use of magnesium among anesthesia providers as a pain adjunct, a problem statement was formulated. Using the PICO format, the questions were formulated and served as the guide for the literature review. In patients undergoing surgery, there is a need for decreased opiate use postoperatively (P), how does the use of magnesium as an intraoperative pain adjunct (I) compare to traditional pain management (C) to diminish the need for opiates, and improve patient outcomes throughout the perioperative period (O)? That question raises interest to be answered in a setting where patient satisfaction and pain-free experience is a significant component of the anesthesia providers. Also, In the Adventist University SRNA's 2018 and 2019 cohort (P), did a 30-minute (T) power point presentation regarding the use of magnesium as a pain adjunct (I) result in an increase of knowledge(O)?

Possible innovations would be creating standardized protocols for the use of magnesium in perioperative pain control based on evidence-based research. Although, it is part of our anesthetic toolbox, magnesium is not yet a standard for pain management in the OR. If standardized as a pain management supplement, anesthesia providers could use magnesium in their practice moving forward, with the pursuit to reduce the number of postoperative opiates needed for recovery from anesthesia.

Literature Review

A review of the literature showed that unresolved postoperative pain is associated with an increase of catecholamine release in the body, and anxiety that can interrupt recovery and discharge (Castro & Cooney, 2017; Guo et al., 2015; Serra et al., 2016). Unmanaged pain can

lead to several delayed complications post-operatively, such as the timing of discharge, delay in patient's recovery, impaired wound healing, greater use of opioids, and the development of chronic pain (Guo et al., 2015). The effective treatment of pain has been shown to reduce perioperative morbidity, and the most effective approach is the use of multimodal analgesia (Shah & Dhengle, 2016). The multimodal approach involves targeting different pain receptors to reduce the amount of opioid intake, minimizing side effects from opiates, and improving the management of pain. Goals for a multimodal approach to pain should include minimal adverse effects, patient safety, drug efficacy, and the use of medications outside the hospital without hindering the patient's activities of daily living (Zukowski & Kotifis, 2012).

The use of magnesium in anesthesia has many known clinical applications today, such as an adjunct to attenuate the sympathetic response of endotracheal intubation (Do, 2013).

Intrathecal magnesium can also be added to Fentanyl to prolong labor analgesia without known adverse side effects (Do, 2013). Magnesium can aid in extending the effects of neuromuscular blockers making it helpful during certain anesthetics where this effect is desired (Sousa et al., 2016; James, 1991). This effect can be useful in patients that exhibit a resistance to neuromuscular blockers such as those taking certain seizure medications. Moreover, using magnesium during a rapid sequence intubation that requires the use of succinylcholine may attenuate hyperkalemia produced by the depolarizing muscle relaxant (Do, 2013).

With all the useful applications for anesthesia providers, it is no surprise that research continues to study ways in which magnesium can contribute to improving the outcome of surgical patients. Despite results showing the favorable use of magnesium to reduce postoperative opioid usage, it is not yet standardized for the operating room (Da Oliveira et al.,

2013; James, 2009; Richebe, et al., 2015; Sousa et al., 2015; Yousef & Al-deeb, 2012; Zukowski & Kotfis, 2012).

Pain originates after a noxious stimulus triggers a widespread release of neurotransmitters that bind to their corresponding receptors (Shah & Dhengle, 2016). One of those is the NMDA receptor; magnesium antagonizes this receptor which is believed to alter perception and duration of pain (Da Oliveira et al., 2013; James, 2009; Richebe, et al., 2015; Sousa et al., 2015; Yousef & Al-deeb, 2012; Zukowski & Kotfis, 2012). Magnesium is thought to work by blocking the extracellular calcium ions on the NMDA receptor, inhibiting calcium influx, thus reducing an increase in activity (Yousef & Al-deeb, 2012). As far back as 1963, the beneficial effects of magnesium chelates on painful pulmonary scars was documented (Anstett, 1963). Due to magnesium's availability, low cost, and high therapeutic index, research for its use as a pain management adjunct continue to be published (Do, 2013).

Several studies have monitored the side effects of magnesium when used as a pain adjunct. The use of magnesium does not come without the possibility of adverse effects, and its use should be based on evidence (Albrecht, Kirkham, Liu, & Brull, 2013; Guo, et al., 2015; Serra, et al., 2016; Yousef & Al-deeb, 2012; Zukowski & Kotfis, 2012). Studies have shown that nausea and vomiting have been reported amongst patients to be one of the most upsetting side effects postoperatively, when taking opiates (Do, 2013). A review of the literature revealed that magnesium does not eliminate the unwanted side effects of opiates, however, using magnesium does reduce the incidence of postoperative nausea and vomiting (PONV) due to the consequent reduction of opioid use (Do, 2013; Da Oliveira et al., 2013; Castro & Cooney, 2017). An increased use of opioids can cause PONV and other upsetting complications of surgery. Other side effects of opioids range from postoperative ileus, constipation, hypercarbia, and even

respiratory arrest (Castro & Cooney, 2017). The national attention brought to substance abuse has led providers to find new ways to control pain without the overuse of opioids.

Elective surgeries are mostly done in an out-patient setting such as ambulatory centers, private clinics, and same day surgery centers. Postoperative pain control is essential for this kind of configuration and yet can be a difficult task to accomplish. In the United States (U.S.) and Canada, the surgical procedures performed in major ambulatory surgery centers were approximately 70%, 30% of these patients were improperly medicated with narcotics, and complained of moderate to severe pain within the first 24-hours (Serra et al., 2015). Outpatient surgery centers are met with rapid turnovers, and the need to drive down the use of potent opiates. Magnesium has been shown to be efficacious in its ability to reduce the opioid consumption in the PACU, leading to reduced recovery time (Albrecht et al., 2013; Castro & Cooney, 2017; Da Oliveira et al., 2013; Do, 2013). Magnesium's use as a pain management adjunct promotes not only patient satisfaction but also improves quality, leading to increased hospital reimbursement (Castro & Cooney, 2017).

A recent study conducted in the U.S. surveyed 3,000 patients regarding postoperative pain, and results indicated that approximately 86% reported post-operative pain after a surgical procedure (Gan, Habib, Miller, White, & Apfelbaum, 2013). Furthermore, 76% reported moderate/extreme pain immediately following surgery, and a surprising 74% still experienced this level of pain even after discharge. This data reflects why an increase in evidence-based research is needed to manage pain postoperatively. Pain guidelines, published by the American Society of Anesthesiologists (ASA) in 1999 and last updated in 2012, were implemented as a standard. Unfortunately, these guidelines have not managed to control postoperative discomfort (Gan et al., 2013). It is widely accepted that the approach to pain management needs to be

discussed before the day of surgery if feasible to achieve best patient outcomes on the day of surgery (Serra et al., 2015). A survey was administered to a random sample of patients who underwent surgery in the last five years. Of the patients studied, only 24% reported pain counseling from an anesthesiologist, and only 3% listed receiving pain counseling from an anesthesiologist postoperatively. When patients were asked if given the option, would they prefer opioids vs. non-opioid pain management, 57% favored the use of non-opiates (Gan et al., 2013). Pain management is shifting to a stronger dependence on a multimodal approach as opposed to an opioid-based management (Albrecht, Kirkham, Liu, & Brull, 2013; Castro & Cooney, 2017; Guo, et al., 2015; Serra, et al., 2016; Yousef & Al-deeb, 2012; Zukowski & Kotfis, 2012). It is important to educate anesthesia providers that magnesium does work, why trade a proven opiate that has been proven to work for something that may be unsafe or not even be efficacious?

A review of the literature has demonstrated that the use of magnesium intraoperatively can delay and reduce the use of opioids postoperatively (Albrecht, Kirkham, Liu, & Brull, 2013; Castro & Cooney, 2017; Guo, et al., 2015; Serra, et al., 2016; Yousef & Al-deeb, 2012; Zukowski & Kotfis, 2012). Pain levels were remarkably lower postoperatively when magnesium was used as an analgesic adjunct, compared to nonsteroidal anti-inflammatory drugs (Sousa, Rosado, Neto, Guimaraes, & Ashmawi, 2016). Postoperative shivering was linked to less opiate analgesia when magnesium was administered (Castro & Cooney, 2017).

There has been substantial evidence on the efficacy of the use of magnesium regarding post-operative pain management, ultimately improving the overall quality of surgery. The effectiveness can range from 24-48 hours' post operation contingent on the type of surgery performed (Guo et al., 2015). Magnesium has been shown to reduce early postoperative pain at rest as well as late pain with movement (Da Oliveira et al., 2013). The use of magnesium

intraoperatively is not limited to general anesthesia. Its use intrathecally has been studied and was shown to block hyperalgesia, and acute pain postoperatively (Richebe et al., 2015). NMDA receptors are thought to be in the spinal cord. Therefore, the use of magnesium allows for a prolonged anesthetic and better analgesia, with fewer side effects. Magnesium has led to less opioid needs after spinal and general anesthesia, and is viewed suitable and safe (Soave et al., 2009). These findings illustrate why magnesium can be a valuable pain adjunct in surgery and secondarily, reduce the quantity of opioid needed in PACU.

The use of magnesium has not shown to alter patients' blood pressure, but flushing, bradycardia, and sedation has been reported (Albrecht et al., 2013; Castro & Cooney, 2017; Da Oliveira et al., 2013; Do, 2013; Shah & Dhengle, 2016). With the use of magnesium intraoperatively, bradycardia was not observed as frequently as seen with the use of opioids. When bradycardia was witnessed, first-line treatment was sufficient to correct the bradycardia. If magnesium is used in combination with neuromuscular blockers the provider should anticipate prolonged muscle paralysis, and a delayed response in obtaining a complete train of four (Albrecht et al., 2013). There is no correlation with magnesium administration and magnesium toxicity intraoperatively (Albrecht et al., 2013; Da Oliveira et al., 2013; Do, 2013; Castro & Cooney, 2017). Perioperatively, patients lack therapeutic levels of magnesium due to irregular O.R schedules, bowel preparations, and a delay in consumption postoperatively. Although postoperative magnesium levels are not routinely tested, hypomagnesemia may aid in keeping toxicity at bay (Da Oliveira et al., 2013). Although not stated, correcting perioperative hypomagnesemia may not be enough to affect perioperative pain.

Magnesium has been used in many aspects of anesthesia including pre-eclamptic management, convulsions, cardiac anesthesia, lethal arrhythmias, and pheochromocytoma.

Magnesium levels within the acceptable range deliver a margin of safety for patients undergoing surgery unless they have renal impairment since magnesium is eliminated through the kidneys (Zukowski, M., & Kotifis, K. (2012). Hypermagnesemia is rarely seen in clinical practice, but caution should be taken with renal patients (Do, 2013). Therapeutic ranges for Magnesium are 0.7-1.1 mmol/L, and once levels >5 mmol/L are reached adverse effects begin to appear. The symptoms of magnesium toxicity range from dizziness, loss of deep tendon reflexes, and both cardiac and respiratory effects (Do, 2013; Soave, et al., 2009). Dosages and routes have proven to be inconsistent in the literature review, demonstrating that more research is needed. The research shows a positive correlation with controlled postoperative pain and a lesser need for opiates. Educating anesthesia providers can provide the knowledge necessary to safely and efficiently manage the use of magnesium intraoperatively.

Contribution and Justification

Currently, there are no standards for the use of magnesium as a pain adjunct in the O.R., however, providing education on its use can promote awareness of its benefit in a multimodal pain management approach. Educating anesthesia providers on the effects of magnesium would prepare the providers to use the drug with a fundamental knowledge base to use it safely to provide pain management. Serum magnesium levels should be monitored to prevent an increase in serum magnesium levels. The anesthesia provider should be educated to maintain good communication with the perioperative team to monitor for adverse effects of magnesium toxicity. Ultimately, the goal is to give the patient the safest experience in the perioperative period and control their pain in combination with opiates and non-opiate analgesics. Through an educational module and poster presentation, the anesthesia providers were educated on how to include and exclude patients for the use of magnesium intraoperatively. Although the use of

magnesium can limit the total opioid consumption, the provider needs to be cautious with other medications to avoid the synergistic effects they can potentiate.

Aim

The objective of the scholarly project was to educate two cohorts of SRNAs from ADU's Nurse anesthesia program about the proven effects of the use of magnesium as an intraoperative pain adjunct in the form of a 60-minute power point presentation. The goal was for the SRNA's to become aware of how magnesium can benefit patients in perioperative pain management and lastly, its ability to decrease the use of postoperative opioids. Finally, a pretest was administered that illustrated a knowledge deficit of the material presented; the goal was that the SRNA's would demonstrate an increase in knowledge of the use of magnesium as an analgesic adjunct in their posttest with statistical significance.

Objectives included:

1. Identify the efficacy of magnesium to provide pain relief.
2. Identify magnesium's role in reducing postoperative opioid use.
3. Identify magnesium's safety margin and adverse effects

Project Methods

A literature review was performed to obtain evidence-based research for the presentation educating anesthesia providers regarding the use of magnesium intraoperatively. The information gathered was disseminated in the form of an educational presentation. The studies utilized for this scholarly project included a review of all quantitative and qualitative research, including all meta-analysis of randomized clinical trials, and literature reviews from 2012-2017. Formulating objectives was composed after identifying the lack of magnesium used as a multimodal adjunct. During a 60-minute educational module, the collected research was

presented to two SRNA cohorts on October 26, 2017. The project employed the use of a pretest/posttest to collect quantitative data to determine if the increase in knowledge was statistically significant. The pre-test was administered to establish a baseline knowledge. After the educational module was presented, the posttest evaluated if the educational dissemination was successful. The participants had a short period to ask questions following the presentation. The target audience was initially 52 nurse anesthesia graduate students attending ADU, but only 46 took part in the scholarly project. The educational intervention was conducted in a classroom on campus at ADU in the nursing building, at a convenient time for the two classes of students to be able to attend during clinical conference after a clinical day. The investigators met with the Project Mentor, Committee Chair, and other qualified committee members to discuss the power point presentation in detail.

The information presented to the anesthesia providers addressed the following:

The overall benefits for magnesium use versus narcotics postoperatively, the total opioid consumption when magnesium is being used, the assessment of pain post-operatively utilizing pain scales, and the safety and efficacy of magnesium use during anesthesia. Inclusion criteria was limited to SRNAs present on October 26, 2017 at the start of class, from the 2018 and 2019 NAP cohort.

Before the presentation, all participants provided written consent to participate in this study, the number of participants were 46 graduate nurse anesthesia students. Any personal, professional, academic, or demographic information collected was inserted into a Microsoft Spreadsheet in Excel, to help organize and prepare for data results once the presentation was completed. The participants in this study were anonymous, and the data collected was de-identified and stored on the investigators' personal laptop for the use of the scholarly project. The

collected data was sent to Dr. Roy Lukman, chair of the scientific review committee, for quantitative statistical analysis. A comparison was made between the pretest score and the post test scores to determine if an increase in knowledge was achieved. Once the educational project was complete, the investigators deleted the Microsoft Excel Spreadsheet from the laptop computer. The participant's privacy remained, and the data was confidential and treated responsibly.

Timeline

The first step was developing an aim and hypothesis for the project. Literature review for this project was initiated in the Summer of 2017. A proposal was outlined with guidance from the syllabus and was submitted for institutional review board approval. The scholarly project was developed continuously by the current syllabus. After the educational module was constructed, a pre/post exam was prepared for the implementation phase. The application and data collection phase took place on October 26, 2017 in the nursing building on the ADU campus after clinical. The post-implementation data was gathered on the same day of the presentation. The convenience sample was expected to be 25 SRNAs from the 2018 NAP cohort and 27 SRNA's from the 2019 cohort. A more detailed timeline is provided in Table-1.

Table-1

Timeline

Completion	Planning	Pre-Implementation	Implementation	Evaluation
5-12-2017	Identify an area of interest and a partner			
5-24-2017	Research question/Mentor identification			
5-31-2017		Citi Module Completion		

6-30-2017		Submit Final Scholarly Proposal		
7-17-17		Submit to IRB		
10-26-17			Conduct educational session/Data collection	Pretest and post-test/quantitative statistical analysis
4-9-2018			Poster Presentation	

Data Collection

Data was collected from the convenience sample of the SRNA's from the 2018 and 2019 NAP cohorts, who were present on October 26, 2017. Informed consent was defined and attained before the implementation of data collection. A pretest containing an assigned number was administered. The pretest consisted of ten questions; multiple choice, and true or false; influenced by the evidence-based researched gathered by the investigators in a comprehensive literature review. Enclosed in a sealed envelope the posttest, which consisted of the same ten questions from the pretest, had the identical number from the pretest for identification of data purposes only. The participants had no knowledge of the contents of the sealed envelope. After the pre-test was collected, the researchers presented a 60-minute power point presentation, allowing time for questions and answers post presentation. The participants were then directed to unseal their envelope and complete an identical posttest to the pretest. Data was collected using the anonymous pretest and posttest results, that included no demographic information, except for the number matching the pretest to evaluate results and ensure anonymity. Once all the data was collected, the pre-and post-test was graded, and the results were sent to Dr. Lukman, to perform a data analysis. Only the SRNA's that completed an informed consent were included in the analysis.

Evaluation and Plan

Quantitative data was used to measure the goal of achieving retention amongst the convenience sample, after an educational presentation regarding the benefits and safety of magnesium as a pain adjunct intraoperatively. Providing evidence-based research on magnesium may raise awareness on its use as a pain adjunct, influencing an improvement in postoperative pain control and patient satisfaction. A paired-sample t-test was utilized, and a significance level was determined with the help of Dr. Roy Lukman. The analysis was conducted using IBM SPSS computer software. The paired-samples t- test was conducted to analyze the data. The obtained t (-11.136) is associated with $p < .0001$ which indicates statistical significance (Appendix D). Therefore, it can be concluded that the average percentages increased significantly.

Results and Findings

In total, 46 (n=46) SRNAS participated in the pre and posttests following the educational presentation. All participants were bachelors prepared registered nurses with unknown years of experience. The inclusion criteria were to be an SRNA and to be present at the start of the presentation. One participant was excluded due to arriving late from clinical rotation. To analyze the differences in knowledge gained from the educational intervention, a pre- and post-analysis was conducted using the paired-samples t-test for the 46 participants. An alpha level of 0.05 or 95% confidence interval (CI) was chosen for the sample size (n= 46). The Pre-test mean value was 30.9 with a standard deviation of 16.3. The Posttest mean value was 74.5 with a standard deviation of 18.2. With a 95% CI of -51.6 to -35.8. In other words, among all pre and post results 95 out of 100 times the mean score will lie between the upper and lower interval of the CI. The obtained t (-11.136) is associated with $p < .0001$ which indicates statistical significance (see Appendix D). Therefore, it can be concluded that the average percentages increased

significantly. From these values, it can be determined that there was a significant difference between the pre-test and post-test mean percentage scores. The negative sign of the t value shows that sample mean is smaller than the hypothesized.

Limitations

Limitations could have included the lack of power owed to the small sample size (n=46). The original target audience was 52, however only 46 were present and consented at the time of the presentation. Given the limited size, replication may not be possible and can potentially threaten the external validity of the results. The sample size was limited to the two NAP cohorts, underrepresenting the entire SRNA population. This inherent bias was not a representation of all SRNAs, and this was a limitation in the ability to generalize the results in this population. Given the small size of the sample the results are less conclusive and may warrant a larger sample to decrease the margin of error. The SRNAs participating were not attending on their own free will and were there after a scheduled clinical rotation, together, both likely decreased the attention span of some of the SRNAs. The two cohorts also presented with two different levels of knowledge and it could have affected the way the information was interpreted. The preconceived culture in the local anesthesia group could be a limitation, deterring the use of magnesium by the SRNAs in their clinical practice. SRNAs may continue to use more opioids versus non-opioids due to preceptor guidance or solely a lack of knowledge; if preservation of the information is not achieved. Another limitation is the lack of standardization for the use of magnesium as a pain adjunct. There are no absolute recommended dosages or routes of administration, which may hinder its use at this point. The last limitation was that a post-test was administered immediately after the power point presentation. This poses a limitation because it does not allow for data

collection over time, considering the fluctuations in learning and a better reflection of retention (Dellwo, 2010).

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Appendix A

ADU NAP CAPSTONE PROJECT – INFORMED CONSENT

Title of the Project: Perioperative Use of Magnesium to Decrease Postoperative Pain in Adults

Principal Investigators: Isaac Gonzalez, RN BSN, Adventist University of Health Sciences & Jessica Milnor, RN BSN, Adventist University of Health Sciences

Faculty Advisor: Dr. Manuel E. Tolosa, DNAP, CRNA

We invite you to be part of a research study about the use of Magnesium Intraoperatively within the adult population, to reduce the amount of opioids used for post-operative pain management.

WHAT IS THE PROJECT ABOUT?

The purpose of this project is to educate Student Nurse Anesthetists at ADU on the use of Magnesium Intraoperatively within the adult population; to reduce the amount of opioids used for post-operative pain. The goal is that the post test will reflect an increase in knowledge from the pre-test results.

WHAT DOES PARTICIPATION IN THIS PROJECT INVOLVE?

Participants will be asked to complete an anonymous pre-assessment, sit through a classroom presentation, and then complete an anonymous post-assessment. The assessment will address students' current understanding of magnesium's efficacy for the use of pain relief, the role of magnesium as an approach for post-operative pain management, safety margins, and the adverse effects of magnesium used intra-operatively. The presentation and completion of the questionnaire is anticipated to take approximately 60 minutes.

WHY ARE YOU BEING ASKED TO PARTICIPATE?

Participation in this project is voluntary. Given the convenience sample being utilized, the participants include the current ADU NAP students in 2018 and 2019 cohorts.

WHAT ARE THE RISKS INVOLVED IN THIS PROJECT?

Although no project is completely risk-free, we don't anticipate any major risks from participation in this project. Minor risks include: lack of interest, mental fatigue, poor test-taking performance, and frustration.

ARE THERE ANY BENEFITS TO PARTICIPATION?

There are no direct benefits from participation in this project. Indirect benefits of participation in the project include the opportunity to gain additional knowledge about the use of magnesium intraoperatively, as a possible adjunct for pain management post operatively.

HOW WILL THE INVESTIGATORS PROTECT PARTICIPANTS' CONFIDENTIALITY?

The results of the project will be published, anonymity will be maintained. To maintain confidentiality of assessments, the investigators will conduct this project in a way to ensure that

information is submitted without participants' identification. No identifying factors will appear on the paper and each paper will be numbered for evaluation. Thus, the investigators will not have access to any participants' identities.

WILL IT COST ANYTHING OR WILL I GET PAID TO PARTICIPATE IN THE PROJECT?

Participation will cost approximately 60 minutes of personal time, but will require no monetary cost. There will be no compensation or incentives for participation in this study.

VOLUNTARY CONSENT

By signing this form, the participant is acknowledging that he/she have read this form, understand the risks and benefits of this project, and understand what participants are being asked to do. The investigators will be happy to answer any questions participants may have about the project. For any questions, contact Isaac Gonzalez (Isaac.gonzalez@my.adu.edu) and Jessica Milnor (Jessica.milnor@my.adu.edu). For concerns regarding the project process or the investigators, please contact the Nurse Anesthesia Program at (407) 303-9331.

Participant Signature

Date

Participant Name (PRINTED LEGIBLY)

Appendix B**Pre-Test and Post-Test Questionnaire**

1. Located primarily in the intracellular space, Magnesium acts on what receptor?
 - A. Glycine
 - B. Glutamate
 - C. NMDA
 - D. Gaba
2. What two catecholamine receptor sites does magnesium effect?
 - A. Adrenergic and adrenal glands
 - B. Adrenergic and Dopamine receptor sites
 - C. Adrenal and thyroid glands
 - D. Cortisol and DHEA receptor sites
3. All the following are signs and symptoms of Hypomagnesemia except?
 - A. Weakness and lethargy
 - B. Muscle spasms
 - C. Seizures
 - D. Hyperkalemia
4. How does magnesium prolong the effect of rocuronium?
 - A. Inhibiting calcium influx
 - B. Inhibiting potassium influx
 - C. Enhancing calcium efflux
 - D. Enhancing potassium efflux
5. Magnesium can be used for all the following except
 - A. attenuate the sympathetic response of endotracheal intubation
 - B. Intrathecal magnesium can also be added to Fentanyl to prolong labor analgesia without known adverse side effects.
 - C. Using magnesium during a rapid sequence intubation that requires the use of succinylcholine may attenuate hyperkalemia produced by the depolarizing muscle relaxant
 - D. The treatment of hypocalcemia
6. All the following are true about the use of magnesium except?
 - A. Is not readily available, and expensive
 - B. Inexpensive with a high therapeutic index
 - C. Can potentially prolong muscle paralysis
 - D. Is not associated with magnesium toxicity
7. The adverse effects seen with the use of magnesium intraoperatively include all the following except?
 - A. Flushing
 - B. Hypermagnesemia
 - C. Sedation
 - D. Hypotension

E. Prolong muscle weakness with NDMB's

8. Uses of magnesium currently include all the following except?

- A. Anti-vasospasm after SAB
- B. Pheochromocytoma
- C. Neuraxial anesthesia
- D. Endogenous calcium agonist

9. What population is more at risk for Magnesium Toxicity?

- A. A patient that suffers from Hyperthyroidism
- B. A patient that has end stage renal failure
- C. A patient that suffers from Diabetes Mellitus
- D. A patient with Crohns disease

10. Surgical patients are predisposed to hypomagnesemia due to, select all that apply

- A. patients undergoing cardiothoracic or major abdominal surgery or thyroidectomies
- B. Preoperative bowel preparation
- C. chelation of magnesium by transfusion of citrate-rich blood products
- D. perioperative volume expansion of the extravascular fluid
- E. All the following are true
- F. None of the following are true

Appendix C

Pre-Test and Post-Answer Key

1. C
2. A
3. H
4. A
5. D
6. A
7. B
8. D
9. A
10. E

Appendix D Data Collection

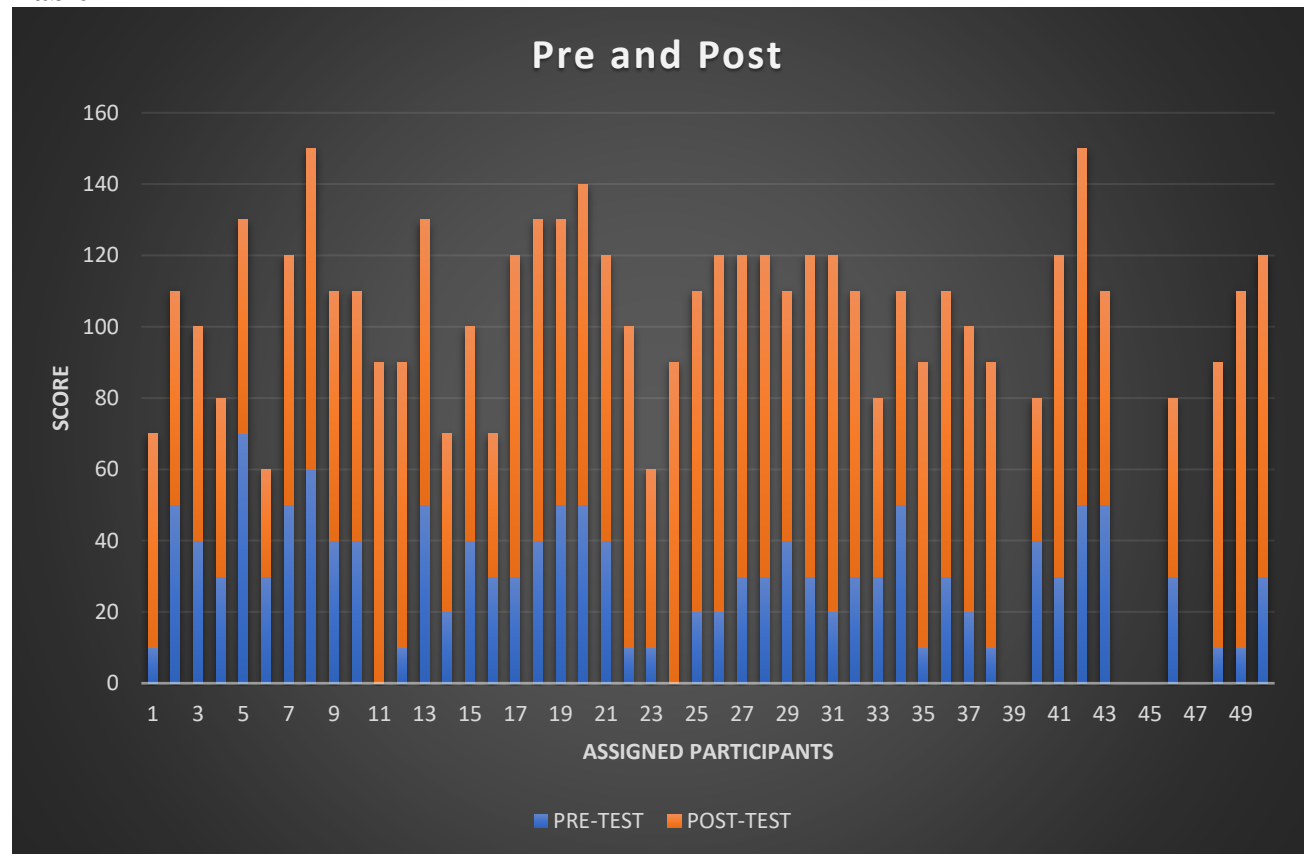
Table 2

Table 3
Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	30.8696	46	16.30625	2.40423
	Post-Test	74.5652	46	18.22166	2.68664

Table 4
Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair Pre-Test - 1 Post-Test	-43.69565	26.61317	3.92390	-51.59879	-35.79252	-11.136	45	.000

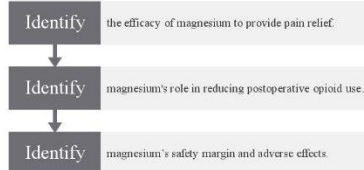
Appendix E

2/18/2018

Perioperative Use of Magnesium to Decrease Postoperative Pain in Adults

Isaac Gonzalez RN, BSN, RN
 Jessica Milnor RN, BSN, RN
 Project Mentor: Mathew Newbern, MD United States Anesthesia Partners (USAP)
 Project Chair: Mammel E. Tolosa, DNAP, CRNA
 Nurse Anesthesia Program, Adventist University of Health Sciences

OBJECTIVES



PROBLEM

- The use of perioperative opiates is associated with undesirable physical and psychological side effects, slower turnovers in the operating room and an extended discharge process
- Multimodal analgesia (MMA) is a technique that leverages opiate and non-opiate pathways to decrease pain perception and avoid undesirable side effects



BACKGROUND

- Over half of the surgeries currently performed in the United States are being conducted in an outpatient setting. Subsequently, there is a need for further research into effective ways to decrease the post-operative use of opiates
- Postoperative pain control is an essential consideration for any individual undergoing an operation
- The high use of opioids can lead to undesirable side effects that may delay the discharge process

THE EXPECTATION

- According to the available literature, 75-85% of patients find the postoperative pain therapy unsatisfactory (Zukowski & Kotfis, 2013)
- Patients expect effective pain relief after surgery, without side effects, and this may not always be possible when complicated procedures are performed in ambulatory settings
- The protocols based on intravenous opioids or regional blocks are no longer appropriate, when a short postoperative course is anticipated



PAIN

- Unrelieved postoperative pain is associated with both physical and psychological consequences including increased sympathetic nervous system activity, fear, and anxiety, which may complicate and delay recovery
- Inadequate analgesia negatively impacts patient satisfaction and may contribute to hospital readmissions with associated negative implications for hospital reimbursement
- Regulatory agencies such as the Joint Commission have identified pain relief as a main indicator of quality within a health care system
- The effective treatment of pain has been shown to reduce perioperative morbidity, and the most effective approach is the use of multimodal analgesia

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CHANGES TO STANDARDS



- In 2000, as part of a national effort to address the widespread problem of underassessment and undertreatment of pain, The Joint Commission introduced standards for organizations to improve care for patients with pain
- Today, the United States is in the midst of a prescription opioid epidemic and in 2016 the Joint Commission began a project to revise its pain standards and address the problem

Baker, D. W. (2017)

CHANGES TO STANDARDS

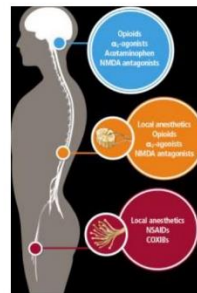


- **The New Standards**
 - Recommend that pain assessment include identification of psychosocial risk factors that may affect self-report of pain
 - Involve patients to develop their treatment plan and set realistic expectations and measurable goals
 - Focus reassessment on how pain impairs physical function
 - Monitor opioid prescribing patterns
 - Promote access to nonpharmacologic pain treatment modalities

Baker, D. W. (2017)

CURRENT GUIDELINES

- Chou et al (2016) reviewed the clinical practice guidelines that the American Pain Society, with input from the American Society of Anesthesiologists published as recommendations. They commissioned an interdisciplinary expert panel to develop a clinical practice guideline to promote evidence-based, effective, and safer postoperative pain management in children and adults
- The expert panel formulated recommendations that addressed various aspects of postoperative pain management, including preoperative education, perioperative pain management planning, use of different pharmacological and nonpharmacological modalities, organizational policies, and transition to outpatient care
- The recommendations are based on the underlying premise that optimal management begins in the preoperative period with an assessment of the patient and development of a plan of care tailored to the individual and the surgical procedure involved



RECOMMENDATION 6

- The panel recommends that clinicians offer multimodal analgesia, or the use of a variety of analgesic medications and techniques combined with nonpharmacological interventions, for the treatment of postoperative pain
- For example, clinicians might offer local anesthetic-based regional (peripheral and neuraxial) analgesic techniques in combination with systemic opioids and other analgesics as part of a multimodal approach to perioperative pain

INTRODUCTION

- The idea of a multimodal approach is to target different pain pathways to reduce the amount of post-operative analgesics needed in recovery. This awareness has demonstrated the justification to research other non-opioid options such as magnesium
- Due to its easy accessibility and cost-effectiveness, magnesium has recently emerged as a pain management supplement
- Although widely used in anesthesia, magnesium is not yet an integral component in a standardized protocol within multimodal analgesia. Students and other anesthesia providers are not given the opportunity to learn how to integrate and manage magnesium in their anesthetic properly, due to its infrequent use in the operating room

GOAL



- Our goal of the literature review was to justify the use of magnesium for its efficacy and safety margin in the adult population
- It was identified that there is a lack of knowledge with the use of magnesium among anesthesia providers including students, as a pain adjunct
- Magnesium is already part of our anesthetic toolbox, but not yet a standard for pain management in the OR. The end goal is for anesthesia providers to attain the knowledge needed to use magnesium in their practice moving forward, with the pursuit to reduce the number of postoperative opiates needed for recovery from anesthesia

OPIOID MONOTHERAPY

- A 2012 report of the International Anesthesia Research Society found that a single opioid-related adverse event increased costs per patient by \$1,000
 - Opioid-only treatment also compounds potential complications for already at-risk patients. Factors such as obesity, smoking, and sleep apnea
 - Opioid monotherapy can increase long-term costs like hospital readmissions, a cost often clouded in the background in the discussion of pain management because it occurs after the initial intervention
- Barriers:**
- The volume of opioids ordered during surgery are due to their availability, inclusion in many hospital formularies and relatively low cost, particularly those available in generic form. In contrast, a multi-modal approach uses multiple drugs, some of which may be available only in costlier, brand-name versions

Soto (2016)

Table 2. Multimodal Techniques for Pain Management^a

Techniques	Common Medications	Guideline Recommendations
	Systemic Analgesics	
Nonopioid analgesics	Acetaminophen, selective COX2s, nonselective NSAIDs, calcium channel blockers, alpha ₂ -adrenergic agonists	Implementing around-the-clock NSAIDs, if opioids are recommended, using acetaminophen for breakthrough pain, and oral administration of opioids postoperative pain management
Opioid analgesics	Morphine, hydromorphone, fentanyl, hydromorphone, sufentanil	Implementing around-the-clock opioids in patients who can tolerate oral medications
	Central Regional Analgesics	
Intrathecal or epidural opioids	Morphine, fentanyl, or sufentanil	Epidural opioids combined with local anesthetics have been found to be more effective when compared with either epidural opioids or local anesthetics alone. Tailoring the dose to the patient's needs is important
Epidural opioids ± local anesthetics	Morphine, fentanyl, or sufentanil ± bupivacaine or ropivacaine	When used in combination with local anesthetics, associated benefits, such as effective pain management, decreased opioid consumption, and decreased risk of hospital stay. IVPCs recommend the use of local anesthetic epidural analgesia for postoperative pain management
IVPCs	Morphine, fentanyl, or sufentanil	
IVPCs	Doxorubicin	of the extremities, anesthesia, and thorax

* Guidelines recommend the use of combinations of systemic opioid and nonopioid analgesics, in addition to central regional analgesia. AFS: American Pain Society; COXIB: cyclooxygenase-2 inhibitor; NSAID: nonsteroidal anti-inflammatory drug. Source: References 7, 9.

Retrieved from: <https://www.nursingtimes.net/article/treatment-options-in-managing-acute-perioperative-pain>

Retrieved from: <https://www.uqhealthsystem.com.au/article/treatment-options-in-managing-acute-pericarditis-pain>

Table. Medical Organizations Recommending Minimizing Use of Opioid Monotherapy and Endorsing Multimodal Analgesia as a Best Practice for Postsurgical Pain Management

Agency for Healthcare Research and Quality	Wells R, Brennan TA, McCarroll M. Improving the quality of care through patient and family engagement: a review of the literature. <i>Health Affairs (Millwood)</i> . 2011;30(12):3283-3292. doi:10.1371/journal.pone.0018822
American Geriatrics Society	Shul S, Greenberg F, Cassell C, et al. The American Geriatrics Society. <i>Principles of the Management of Older Patients with Common Problems</i> . 2009. http://www.ags.org/AGS/PracticeGuidelines/PrinciplesoftheManagementofOlderPatientswithCommonProblems
American Pediatric Society, American Society of Anesthesiologists, American Society of Health-System Pharmacists	Shul S, Gordon D, Lin-Ena-Cassell O, et al. Management of post-operative pain: a clinical practice guideline from the American Pain Society, American Society of Anesthesiologists, American Society of Health-System Pharmacists, Esophageal Cancer Research, and Administrative Council. <i>J Pain</i> . 2009;10(12):1163-1174. doi:10.1016/j.pain.2009.08.005
American Society for Pain Management Nursing	Jarvis D, Jurgens CP, Pains C, et al. American Society for Pain Management Nursing. <i>Pain Management: A Clinical Practice Guideline and Resource Manual</i> . Pain Management. 2011;1:138-145.
American Society of Perianesthesia Nurses	American Society of Perianesthesia Nurses. http://www.aspan.org/ASPN/Pages/ASPN-2012-2013.aspx
Enhanced Recovery After Surgery	Guastafello LO, Scott M, Schwann W, et al. Guidelines for perioperative care in elective colonic surgery: a clinical practice guideline from the American Society of Anesthesiologists. <i>Anesth Analg</i> . 2011;112(5):209-224. doi:10.1097/00000541-201105000-00007
The Joint Commission on Accreditation of Healthcare Organizations	Joint Commission on Accreditation of Healthcare Organizations. <i>Standards and Practices for Patient Safety</i> . 2012. doi:10.1093/ajph/102.4.615

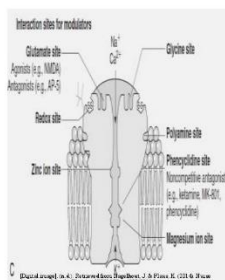
Retrieved from <http://www.painmedicine.com/PRN/Article/OT7/Multimodal-Analgesia-for-Post-surgical-Acute-Pain-Management-The-Role-of-the-Behavior-Practitioner/4158/abstract#true>

- There are many pharmacological and nonpharmacological options for pain relief that may be used intraoperatively. Opioids have been the mainstay of acute postoperative pain management. Although highly effective analgesics, opioids are associated with a number of side effects that carry significant risks.
- The overprescribing of opioids has reached a critical level worldwide, and surgery may be the trigger for long-term opioid use in many patients.
- A multimodal approach involves the use of two or more pharmacological agents or techniques that target different receptors within the pain pathway. An anesthesiologist may encounter the use of intravenous magnesium sulfate in the operating room for a variety of reasons, such as acting as a multimodal opioid. Magnesium sulfate may be a beneficial adjunct in the management of acute postoperative pain.

- Magnesium sulfate is the fourth most common cation in the human body. It functions as a calcium channel blocker and is known to regulate calcium influx within the cell. Magnesium has a broad therapeutic index and is cost effective

- The physiologic importance of magnesium lies in its role as a cofactor in more than 300 enzymatic reactions, including those involving energy metabolism and the function of the Na-K-ATPase pump
- The analgesic mechanisms of magnesium are not well understood, but it is thought that calcium regulation and N-methyl-D-aspartate (NMDA) receptor blockade play a role

- Acts as mediator for Na^+/K^+ ATPase system, therefore essential in maintaining trans membrane potential, by maintaining Na^+/K^+ gradient across the membrane
- Generation of cAMP via adenylylase is dependent on Mg^{2+}
- Mg^{2+} controls the release and action of Parathyroid hormone, and regulates Calcium metabolism
- Mg^{2+} helps in Oxidative Phosphorylation, Glucose utilization and Protein synthesis
- Involved in several other processes:
 - Muscle contraction
 - Neuronal & cardiac activity
 - Vasomotor tone/Anti-vasospasm
 - Acts as a CNS depressant
 - Decreases the amount of acetylcholine released from the motor nerve terminal, prolonging REM
 - Decreases catecholamine release from the adrenal medulla and adrenergic nerve endings



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HOMEOSTASIS

- Magnesium homeostasis is maintained and regulated by hormonal and metabolic effect on GI absorption and renal excretion. The normal range of magnesium in plasma is 0.7-1.31 mmol/L ($1.5-2.5 \text{ mg/dL}$)
- Mainly excreted by the kidneys. It is reabsorbed in the ascending limb of loop of Henle, Aldosterone increases renal excretion while Parathormone increases gut absorption, and reduces renal excretion
- **Hypomagnesaemia** Surgical patients are predisposed to hypomagnesaemia due to bowel preparations, administration of osmotic peroperative volume and patients undergoing cardiothoracic and abdominal surgeries
- **Hypomagnesaemia** occurs rarely in clinical medicine unless the renal function of the patient is compromised. If the plasma concentration of magnesium reaches $< 0.5 \text{ mmol/L}$, toxic symptoms such as loss of deep tendon reflex and dizziness can occur

TABLE 14-23. MANIFESTATIONS OF ALTERED SERUM MAGNESIUM CONCENTRATIONS

Magnesium Level			Manifestation
mg/dL	mEq/L	mmol/L	
<1.2	<1	<0.5	Tetany Seizures Arrhythmias
1.2-1.8	1-1.5	0.5-0.75	Neuromuscular irritability Hypocalcemia Hypokalemia
1.8-2.5	1.5-2.1	0.75-1.05	Normal magnesium level
2.5-5	2.1-4.2	1.05-2.1	Typically asymptomatic
5-7	4.2-5.8	2.1-2.9	Drowsiness Flushing Nausea and vomiting Diminished deep tendon reflex Somnolence Loss of deep tendon reflexes Hypotension ECG changes Complete heart block Cardiac arrest Apeix Paralysis
>12	>10	>5	

Escobar P, G. Cullen R, F. Snelting R, E. Calvo M, K. Stool M, C. Ortega R, A. ... Holt H F. (2015) *Chemical medicine* Philadelphia PA: Wolters Kluwer

CLINICAL USE

- Effective in blunting sympathetic, autonomic and endocrine reflexes provoked by noxious stimuli. i.e. Tracheal intubation. Magnesium may prevent hyperkalemia during massive transfusion.
- Treatment of arrhythmia (e.g. a torsades) slows the rate of impulse formation at the SA node, prolongs SA conduction, the PR interval and the AV node refractory period
- Aids to help manage patients with pheochromocytoma during surgery
- Intrathecally, magnesium added to Fentanyl will prolong labor analgesia without known adverse side effects
- Magnesium acts as a calcium channel blocker at presynaptic nerve terminals and decreases acetylcholine release at the motor endplate, resulting in the potentiation of a neuromuscular block by nondepolarizing neuromuscular blocker
- Decreases the incidence of shivering by up to 70-90%
- Magnesium is an effective bronchodilator but does not affect respiratory drive

WHY MAGNESIUM?

- Unmanaged pain can lead to several delayed complication post-operatively
 - Timing of discharge, delay in patient's recovery, impair wound healing, greater use of opioids, and the development of chronic pain
- Magnesium has been efficacious in reducing the opioid consumption in the PACU
 - Reduces recovery time
- Pain management is shifting to a multimodal approach as opposed to an opioid-based management
- Use of magnesium intraoperatively can delay & reduce the use of opioids postoperatively



ADVERSE EFFECTS

- Common side effects:
 - Bradycardia
 - Flushing of skin
 - Sedative effect
 - Prolong muscle paralysis, especially when NMB's are used
 - Hypotension
 - Arrhythmias
- Magnesium is contraindicated among pregnant females, except when used to prevent seizures associated with eclampsia. Magnesium is a pregnancy class D drug and crosses the placenta delivering equal amounts to the neonate. In higher doses, magnesium can cause hypocalcemia in the neonate which can result in fractures and bone abnormalities
- Renal impairment will prolong the magnesium levels in these type of patients and need be cautious

EARLY LITERATURE

- Ever since the study of magnesium sulfate in clinical anesthesia beginning in 1996, magnesium has drawn attention in the field of anesthesia and pain medicine
- Peri-operative magnesium did not yield any significant analgesic benefit according to 2 previous reviews. This conclusion however was based on a small number of trials and these previous reviews provided qualitative instead of quantitative data reporting
- More recent quantitative meta-analysis suggested a positive relationship between magnesium and post-operative pain independent of the mode of administration (e.g., bolus or continuous infusion)

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LITERATURE REVIEW

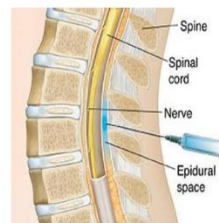
- Pain management is shifting to a stronger dependence on a multimodal approach as opposed to an opioid-based management
- According to Do (2013), studies have shown that nausea and vomiting have been reported amongst patients to be one of the most upsetting side effects postoperatively, when taking opiates. A review of the literature revealed that magnesium does not eliminate the unwanted side effects of opiates, however, using magnesium does reduce the incidence of postoperative nausea and vomiting (PONV) due to the consequent reduction of opioid use
- Serra et al (2015) reported that 30% of outpatient surgical patients were improperly medicated with narcotics, and complained of moderate to severe pain within the first 24-hours

LITERATURE REVIEW

- In a double blind randomized control trial of 60 women who underwent laparoscopic gynecologic oncology type surgeries, Souza et al. (2016) found that pain levels were remarkably lower postoperatively when magnesium was used as an analgesic adjunct, compared to nonsteroidal anti-inflammatory drugs
- In a review of 27 RCT's involving 1504 patients, Guo et al. found that systemic magnesium use during general anesthesia significantly reduced post-op pain scores without adverse effects
- Albrecht et al (2013) through a meta analysis found that Magnesium has been shown to be efficacious in its ability to reduce the opioid consumption in the PACU, leading to reduced recovery time
- FASTER TURNOVER!

LITERATURE REVIEW

- Ryn et al. (DO, 2013) compared magnesium sulfate and remifentanyl during middle ear surgery. In this study, either drug when combined with sevoflurane provided adequate level of hypotensive anesthesia, however, the magnesium group had more favorable postoperative courses showing better analgesia and less shivering and nausea/vomiting after surgery
- In addition, sevoflurane was required less to maintain surgical anesthesia in patients receiving magnesium sulfate than those receiving remifentanyl
- Seyhan et al. (Do, 2013) reported that magnesium sulfate reduced propofol, atracurium and postoperative morphine consumption in gynecologic surgical patients



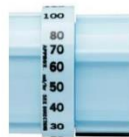
NEURAXIAL ANESTHESIA

- The use of magnesium intraoperatively is not limited to general anesthesia. Its use intrathecally has been studied and was shown to block hyperalgesia, and acute pain postoperatively
- NMDA receptors are thought to be in the spinal cord. Therefore, the use of magnesium allows for a prolonged anesthetic and better analgesia, with fewer side effects. Magnesium has led to less opioid needs after spinal and general anesthesia, and is viewed suitable and safe
- Magnesium can prevent the induction of central sensitization from peripheral nociceptive stimuli

ANESTHETIC CONSIDERATIONS

- When using IV magnesium in the postoperative setting, it is necessary to assure that other analgesics are available, as there is no evidence to support that magnesium alone could effectively control postoperative pain
- In pts with A-V block, avoid Magnesium as it may cause asystole or worsen arrhythmias
- Renal function should be measured to identify patients who should be excluded from analgesic magnesium because of the increased risk for toxicity
- During the postoperative period, electrolytes should be closely monitored. Although higher magnesium levels were found to be associated with improved analgesia, monitoring is needed as hypermagnesemia can cause adverse effects
- There is strong evidence for the usefulness of magnesium in reducing extubation time among cardiovascular surgery patients

DOSING



- No optimal dose has been identified. The greatest analgesic effect was noted when systemic magnesium was administered both intraoperatively and postoperatively
- No correlation was found between the total dose of magnesium that was administered and the cumulative intravenous morphine consumption (Castro, 2017)
- Most studies in the literature review used a bolus dose ranging from 30 to 50 mg/kg (given over 10 minutes), with a continuous infusion of 8 to 15 mg/kg per hour intraoperatively
- In the De Oliveira et al (2013) and Albrecht et al (2013) meta-analyses, there was no significant difference in opioid consumption when IV magnesium was administered by bolus only, continuous infusion only, or by both methods

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LIMITATIONS

- Recently conducted meta-analyses were published without recently completed relevant investigations
- Some studies only focused on one specific kind of surgery or a certain age group, limiting the ability to generalize for other anesthetics
- Few studies reported on magnesium levels, it was difficult to evaluate the relationship between magnesium levels and the reported outcomes
- No set dosing has been identified, more studies are needed correlating the opioid sparing effects with an optimum magnesium level



FUTURE RESEARCH

- Studies suggest that there might be significant age- or gender-related differences in magnesium-mediated analgesia. Future high-quality RCTs are needed to clarify the roles of age and gender on magnesium-mediated post-operative analgesia.
- MMA is steadily being embraced as a pain management best practice in the hospital setting.
- Perioperative magnesium administration should be considered as a strategy to reduce postoperative pain outcomes in patients undergoing surgical procedures.

QUESTIONS?

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