Does an educational intervention on BIS monitoring increase utilization of BIS monitoring and decrease post operative nausea and vomiting?

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Table of Contents

Dedication and Acknowledgments

The framework for my passion, curiosity, determination, and hard work was laid down by my parents who both possess master's degrees and are two of the most intelligent, dedicated, and supportive people I know. Thank you, mom, for your unwavering confidence in me to accomplish anything I set my mind to. I owe endless gratitude, love, and appreciation to my partner, Dustin, for being the calm to my storm; not just along this wild and winding journey, but among all of life's twists and turns.

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My biggest and most heartfelt thank you belongs to my father. You have been and always will be my biggest inspiration, greatest influence, and strongest motivation. I strive each day to make you proud of the person I have become, and I find comfort and peace in believing you are. There is not a day that does by that I do not think of you. I hope that wherever life takes us after we pass is beautiful and has welcomed you gracefully. Until we meet again – I love you.

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Abstract

Purpose: To evaluate if education about the benefits of BIS monitoring to a group of anesthesia providers would change practice and encourage increased use of BIS monitoring. **Background:** This project aimed to evaluate barriers to practice change, readiness for change, and support evidence-based practice aims surrounding the use of BIS monitoring. **Methods:** This project was a quantitative QI educational intervention with a post-survey. A retrospective chart review through EPIC healthcare software system was done to assess for increased use of BIS as well as BIS use's impact on post operative nausea and vomiting (PONV). **Results:** Findings revealed there was a decrease in BIS use after the educational intervention by 33%. PONV was also evaluated through chart reviews and the results demonstrated the incidence of PONV decreased by 33% in patients who had a BIS monitor applied vs. those who did not. A post-survey was completed by the study group that evaluated barriers to BIS application. This survey identified that anesthesia staff retained education on the benefits of BIS use, but more education is recommended for clearer understanding. **Recommendations**: Future practice recommendations include increased institutional access to BIS monitoring tools and evidence-based institutional guidelines for use of BIS monitoring. **Conclusion:** More research is needed on the effects of anesthetic medications on BIS monitoring reliability and how BIS can indirectly and directly decrease hospital costs.

Keywords: Bispectral Index Monitoring, BIS, PONV, general anesthesia, TIVA

Background

Bispectral Index (BIS) is a monitoring tool that collects, processes, and converts cerebral metabolic activity to a number from 0 to 100, with higher level suggesting the patient is more awake (Montreal-Carrillo et al., 2017). A BIS score for appropriate depth of anesthesia varies with surgery, but most surgeries have a BIS goal range from 40-60. The anesthesia provider can use this information to titrate their anesthetics to be within goal range on the BIS monitor. BIS monitoring has been shown to decrease anesthetic totals, decrease the risk of intraoperative awareness, decrease anesthetic costs, decrease incidence of PONV, and improve patient outcomes (Bocskai et al., 2018; Quesada et al., 2016).

Significance

Synthesis of research revealed a clear relationship between the application of BIS monitoring and lowering of anesthetic totals, decreased anesthetic costs, and decreased incidence of PONV (Bauer et al., 2004; Bocskai et al., 2018; Degrandi Oliveira et al., 2017; Quesada et al, 2016). A meta-analysis performed by Degrandi Oliveira, Bernardo, and Nunes in 2017 on 10,761 patients showed a PONV risk reduction of 12% in patients who underwent BIS monitoring (p. 72). BIS use can lead to improved patient outcomes by decreasing bradycardia, hypotension, and intraoperative desaturations (Park et. al., 2016; Quesada et al., 2016).

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In addition to decreased PONV risk with the application of a BIS monitor, decreased recovery times were a common theme among studies, and less time was spent in the operating room (Bocskai et al., 2018; Degrandi Oliveira et al., 2017; Quesada et al., 2016). This turnover relates back to decreased costs and better patient outcomes. With the cost of BIS approximately $15 per patient, the cost-to-benefit ratio is high (Quesada et al., 2016). BIS application can be a great tool to decrease anesthetic totals, decrease PONV, improve outcomes, and save money.

Purpose

BIS monitoring is a well-researched tool that is frequently used to assist in determining depth of anesthesia. BIS monitoring has many benefits including decreased post-operative nausea and vomiting (PONV), decreased PACU time, reduced ancillary costs, decreased anesthetic totals, and improved patient outcomes (Bauer et al., 2004; Bocskai et al., 2018; Degrandi Oliveira et al., 2017; Quesada et al, 2016). The purpose of this project was to provide an educational intervention on the benefits of BIS to increase use, decrease anesthetic totals, decrease PONV risk, and improve patient outcomes. This education was presented to a group of certified registered nurse anesthetists and anesthesia assistants at an urban tertiary care center. One month following the intervention a short post-survey assessed practice change, knowledge, and barriers to BIS use. A chart review was done to assess practice change, evaluate BIS implications on PONV, and evaluate a change in outcomes.

Review of Current Evidence

A review of the literature was conducted to evaluate the use of Bispectral Index Monitoring and its effect on drug totals, operating room costs, PONV, and patient outcomes. Databases searched included CINAHL, Google Scholar, and Pub Med using the keywords "BIS, Bispectral Index Monitoring, hemodynamics, cost, TIVA, general anesthesia, total intravenous anesthesia, PONV, propofol, operating room, nursing grand theories, education, and anesthesia". Boolean operators such as "and" and "or" were used to expand results. The literature was filtered to focus on systematic reviews, meta-analyses, and randomized control trials. Studies that were conducted on ICU patients were not included. Case reports and editorials were excluded. Results were limited to English language articles.

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Bispectral Index Monitoring

BIS monitors provide data that allows anesthesia providers to guide the titration of anesthetics. There is strong evidence that certain procedures, patient populations, and co-morbidities warrant strict use of BIS. This population includes patients who have suffered from or are at risk to suffer from intraoperative awareness. Intraoperative awareness is a consequence of an inadequate depth of anesthesia. Multiple studies suggest that the application of a BIS monitor can reduce the incidence of intraoperative recall in patients that are at high risk for intraoperative awareness (Bocskai et al., 2018; Gelfand et al., 2015; Park et al., 2016). Other cases where BIS use is highly recommended are emergency cases, craniotomies, sternotomy cases, cases utilizing long-acting paralytics, obstructive sleep apnea, and patients at risk for bradycardia (Bauer et al., 2004; Bocskai et al., 2018; Gelfand et al., 2015; Park et al., 2016; Quesada et al., 2016).

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Anesthetic Totals

Hemodynamics

Anesthetic medications alter the normal physiology of the human body. These alterations can result in unpredictable hemodynamic effects. Some of these after-effects include hypotension, bradycardia, and apnea. The best way to prevent adverse effects is by using the minimum amount of anesthesia necessary to produce the desired response. There is a clear relationship between the application of BIS and the lowering of anesthetic totals (Bauer et al., 2004; Bocskai et al., 2018; Degrandi Oliveira et al., 2017; Park et al., 2016; Quesada et al., 2016). These reductions in anesthetic totals range from negligible to upwards of 30% (Bauer et al., 2004; Gelfand et al., 2015). By lowering the total amount of anesthesia used, the provider can minimize the risk of negative physiologic consequences. The reduction of hemodynamic variations associated with BIS guided anesthesia contribute to the recommendations that BIS

monitoring should become a standard of care.

PONV

Post-operative nausea and vomiting (PONV) is a common complication of anesthesia that has been the focus of many treatments and guidelines over the years. The risk for experiencing PONV increases with higher totals of anesthetic drugs (Gelfand et al., 2015). Multiple studies have found evidence to support the finding that BIS monitoring decreases PONV (Bocskai et al., 2018; Degrandi Oliveira et al., 2017). A 2021 study demonstrated a 16% decrease in PONV in patients who underwent general anesthesia with BIS monitoring vs. general anesthesia without BIS monitoring (Adelin et al., p. 70). BIS monitoring decreases total anesthetic used, potentially decreasing PONV and improving patient outcomes and patient experience.

Delirium

Another undesired effect of anesthesia is the risk of delirium. This risk is increased in the geriatric population, which is a large subset of the individuals cared for by anesthesia providers. Degrandi Oliveira et al. (2017) found that patients who received lower doses of propofol due to BIS application regained orientation faster and had a 6% decrease in post-op delirium. Decreasing the risk of delirium improves patient outcomes and decreases the length of stay. Hypnotics and other medications used to treat delirium can be spared in this patient population, resulting in a better patient experience and decreased associated costs (Bocskai et al., 2018). According to the BIS Pocket Guide for Clinicians (2021), the American Geriatrics Society Expert Panel on Postoperative Delirium recommends monitoring the depth of anesthesia during intravenous sedation or general anesthesia using processed EEG monitors such as BIS.

Recovery Time and Associated Costs

Decreasing anesthetic totals by applying a BIS monitor can result in decreased costs for

the patient and hospital. As previously discussed, BIS monitor application results in less post-operative delirium. Patients who have delirium have longer recoveries and hospitals stays, leading to increased costs (Bocskai et al., 2018).

Time spent in the operating room (OR) is a large expenditure for hospitals. BIS monitoring can result in quicker times to extubation and swifter transitions from OR to the post-anesthesia care unit (PACU) (Degrandi Oliveira et al., 2017). Degrandi Oliveira et. al. found that patients exited the OR and transitioned to PACU an average of 3 minutes faster with the use of BIS monitoring (2017). With some operating rooms costing up to $115 per minute of operating room time, that 3 minutes could save over $300 per patient for the institution (Maskal et. al., 2020).

Patients are monitored in PACU until they are hemodynamically stable enough to return home or are admitted to a hospital bed; time spent in PACU can also contribute to increased hospital costs. BIS monitoring can lead to shorter post-operative recovery and expeditious discharge from PACU (Bocskai et al., 2018; Degrandi Oliveira et al., 2017; Quesada et al., 2016.). If the PACU is at capacity, patients are unable to leave the OR resulting in delays. Twenty hours of delayed OR time can cost a hospital upward of $44,000 (Fairley, et al., 2019). Research shows that a 5-to-8-minute reduction in PACU recovery time can reduce OR delays by more than 20% (Criddle & Holt, 2018, p. 410). Klopman and Sebel (2011) found that they were able to decrease PACU discharge time by 15 minutes in patients whose anesthetics were guided by BIS monitoring. With the cost of BIS being less than $15 per patient, the resultant cost-to-benefit ratio is high (Quesada et al., 2016).

Barriers to Use

Although there is evidence that BIS monitoring can improve patient outcomes and

decrease costs, it is not routinely used by all providers. BIS monitoring is perceived by some to be unreliable. Gelfand et al., found that almost 50% of anesthesia providers did not apply BIS monitoring in situations outside of high-risk populations (2015). They also reported that providers who are in training are more likely to use BIS monitors than experienced providers. The numbers associated with the BIS reading (1-100) are dimensionless numbers that can be potentially influenced by external sources and factors. It is possible that certain medications, forced air warming blankets, cauterization devices, and pacemakers may produce false readings (Luebbehusen, 2005). Some research shows that providers feel inadequately familiarized with BIS monitoring and many institutions do not have sufficient resources available to utilize BIS monitoring consistently, resulting in decreased use. These barriers suggest that an educational opportunity is warranted to discuss BIS monitoring and encourage practice change to support anesthesia trends.

Limitations

Most BIS studies specifically included patients recovering from propofol as the primary anesthetic agent, which is the standard anesthetic used in TIVA. In current practice, inhalational agents are more commonly used as maintenance anesthetics instead of propofol. There was only one study that evaluated BIS in relation to inhalational agents; this study supported the theory that BIS use also decreased inhalational agent drug totals (Bocskai et al., 2018), however, more research is needed on the effect of BIS on inhalational anesthesia totals. In recent years there has been an increase in anesthesia providers utilizing both intravenous agents and inhalational agents simultaneously, known as the “balanced technique”. This is an emerging technique that has not been studied in relation to BIS use.

Attitudes and Beliefs: Nola Pender's Health Promotion Model

Nola Pender's Health Promotion Model was first established in 1982 to assist nurses in identifying certain health care behaviors, beliefs, and barriers aimed towards improvement in health outcomes (2011, p. 2). Pender states that it is important to identify behavior specific cognitions such as benefits of action, barriers of action, and situational influences to determine how to best affect change (p. 4). When applying Pender's Model to CRNAs, it is imperative to analyze the behavior patterns and rationales for BIS use to identify a course of action for education. The goal is for CRNAs to change behavior patterns after an educational intervention on BIS use to improve patient outcomes. Pender's model incorporates the expectancy-value theory of achievement motivation model, which implies that individuals will be motivated to succeed if they perceive they will achieve a desired outcome (Wigfield & Eccles, 2000). Improved patient outcomes, decreased anesthetic totals, decreased incidence of PONV, and faster recovery times are desirable and achievable goals that will empower CRNAs to use BIS monitoring.

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In 2018, Nola Pender's model was utilized to study adolescent health; educational interventions were highlighted as an important tool for raising awareness of a given subject and eliminating misinterpretations (Da Silva Sandos et al., 2018, p. 586). The planned education intervention will provide new knowledge to CRNAs that aims to increase their willingness to utilize BIS monitoring. The educational session aims to clarify misconceptions related to BIS monitoring, leading to increased trust and comfortability in the use of BIS monitoring.

Methods

Design

This project was a quantitative QI educational intervention with a post-survey. This

project was conducted with a fifteen-minute education session on the various benefits of BIS monitoring. A retrospective chart review through EPIC healthcare software systems was done to assess for increased use of BIS post-education. EPIC charts were also reviewed to evaluate BIS monitoring's effect on incidence of PONV. A post-survey was given to the participants after the 30-day post-evaluation window to assess for barrier to BIS use. The PI of this project is a student registered nurse anesthetist (SRNA) and the author of this DNP project.

The Iowa Model

The Iowa Model was used as the framework for implementation and dissemination of this project. The Iowa Model is a nurse-developed model that incorporates evidence-based practice (EBP) to promote change and adoption of new practice guidelines. The first step is to identify a clinical problem, barrier, or knowledge gap where an EBP change may be warranted (Brown, 2014, p. 157). Increased BIS utilization was identified as the clinical priority for this project. The second step was to formulate a team of individuals such as stakeholders, management, QI personnel, DNP students, and staff who assisted in education, implementation, and facilitating the practice change (Brown, 2014, p. 157). This team gathered and critiqued research to determine feasibility, applicability, and sustainability. If research consistently supports positive change and improved outcomes, the studies have similar characteristics, and there is clinical relevance to the proposed topic then it is a good topic for implementation (Brown, 2014). A review of the literature on BIS use corroborates the opportunity for a practice change.

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Project Setting and Sample

The participants were a convenience sample of certified registered nurse anesthetists (CRNAs) and anesthesiologist assistants (AAs) at an urban tertiary care hospital that attended the monthly morning meeting on the morning of September 3rd, 2021 where the educational

intervention took place. All participation was voluntary. Inclusion criteria for participants included CRNAs and AAs who were currently licensed to be practicing anesthesia in the state of North Carolina. Exclusion criteria included SRNAs, anesthesiologists, and non-anesthesia personnel.

The electronic record review was a 60-day evaluation of anesthetized patients aged 18-80 years who underwent BIS monitoring for general anesthesia with endotracheal tube (ETT) use under the care of a CRNA or AA. The record review was split to evaluate 30 days prior to and 30 days post educational intervention. Monitored anesthesia care cases were excluded, as well as general anesthesia cases that did not utilize an ETT. The record review extended 30 days before and 30 days after the educational session. The charts were reviewed for an increase in BIS use and the incidence of PONV.

Intervention

The educational session took place at an urban hospital during a pre-shift monthly meeting. The educational session was a PowerPoint presentation that lasted 15 minutes and included evidence-based information on the positive implications of BIS monitoring including decreased PONV, decreased incidence of delirium, decreased anesthetic totals, and decreased costs (Appendix A). The presentation also discussed barriers to use of BIS monitoring. A quantitative Likert-style post-survey was distributed one-month post-education session to evaluate barriers to BIS use. The retrospective record review was done through EPIC and collected data on BIS use and PONV 30 days prior to, and 30 days post-educational intervention. The post-educational survey was available in the staff break room for a duration of 7 days. It was kept in a lock box that only the PI had access to, and staff members could anonymously drop survey results into the box at their leisure.

Data Collection Strategy and Instruments

IRB approval for this QI project was obtained prior to the education intervention or any chart reviews that took place. All chart reviews took place after approval from the UNCG IRB, and the tertiary care facility. The Ethics and Research Committee of the tertiary care facility examined the project aims prior to implementation and gave the PI approval to proceed.

Participants signed into the educational intervention on September 3rd; the sign in sheet was utilized to identify the sample size (22) and then shredded to protect privacy.

Anesthesia cases were reviewed through EPIC. An EPIC representative appointed by the facility assisted the PI in creating a report that combined ETT, general main OR cases, PONV, and BIS application data. The EPIC representative was given permission by the facility to run the reports and all PHI was removed. All correspondences involving EPIC data between the EPIC representative and PI were sent through encrypted emails and stored on a password-protected computer. This report was reviewed by the PI to exclude duplicates, verify the population, and ensure that the result population was limited to the main OR.

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The records were reviewed for 30 days before the educational intervention and for 30 days after. The pre-implementation and post-implementation electronic medical record (EMR) review assessed for the following key variables: use of BIS, patients between the ages of 18-80 undergoing general anesthesia, PONV score, and having an ETT in place. After the reports were generated, the EPIC representative and the PI utilized Tableau and Microsoft excel software to evaluate the data.

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The post-survey utilized a 5-point Likert scale to assess for barriers to BIS use and assess knowledge of the anesthetic implications associated with BIS use (Appendix B). The scale ranged from 1 to 5; a score of 1 meant the anesthesia provider strongly disagreed, and a score of

5 meant the provider strongly agreed. Likert-style surveys are historically trusted as self-reporting tools due to their ease of use and their ability to increase reliability by using multiple points (example: 5-point scale) vs. a traditional yes/no dichotomy scale (Taherdoost, 2019). The questions were developed by the PI, with input from anesthesia DNP faculty to establish validity. The post-survey was available in the anesthesia breakroom of the institution for 7 days. All CRNAs and AAs voluntarily attended the educational intervention and voluntarily took the post-survey. The staff members submitted their post-survey responses anonymously and placed their completed survey in a collection box that remained locked for all 7 days.

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Data Analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS), Tableau Reader, and Microsoft Excel. Prior to analysis, data was inspected by the PI and DNP faculty for quality control. Data analysis was guided by a quantitative methods expert on faculty at the UNCG School of Nursing. A statistics expert and mentor from the project facility assisted the PI in running data reports on PONV status and the use of BIS monitoring on all general anesthesia cases throughout the respective timeline. Descriptive statistics were used to evaluate percentages and means based on the PONV and BIS application data sets.

The post-survey was evaluated using central tendencies and descriptive statistics (Appendix D). The post-survey scores were filed on paper then transferred into an Excel sheet. The scores were stored in the PI's password protected personal laptop.

Human Rights Protection

This project was granted approval by the UNCG IRB and the research facility's Research Committee and Review Board prior to implementation. Before the educational intervention took place the participants were given information about the project and voluntary consent was

obtained. The participants were instructed that participation was voluntary, their names would be kept anonymous, and they would have no benefit from participating. This project presented no risk to minimal risk to participants and this, too, was explained prior to participation.

Paper surveys were kept in a secure locked cabinet. After 5 years of secure storage, the surveys will be shredded. No names will be attached to any of the Likert scores collected. The file will be uploaded to BOX.uncg.edu, which is password protected and requires multifactor authentication; data will not be stored on a hard drive. Only the PI, appointed EPIC representative, and the DNP faculty will have access to the anonymous data. All information obtained in this project is strictly confidential unless disclosure is required by law.

Results

A total of 22 CRNAs and AAs participated in the educational intervention but only 21 signed the research permission form, thus resulting in a total sample size of 21 anesthesia providers. All 21 participants met the inclusion criteria. Four participants filled out the post-evaluation survey. No demographic data or identifying characteristics (age, gender, years of service, etc.) were collected.

BIS Use

Epic was utilized to assess BIS use for 30 days before and for 30 days after the educational intervention. The aim of the education was to encourage increased BIS utilization and improve patient outcomes. A chart review was conducted assessing BIS use in anesthetized patients with endotracheal tubes from August 3rd to September 3rd, a month before the intervention, and from September 4th to October 3rd, following the intervention. In Table 1, The "N" category represents an ETT general anesthesia case that did not utilize a BIS monitor in that room for the 30-day duration, and the "Y" category represented ETT general anesthesia cases

that did utilize BIS monitoring. The operating room numbers are listed on the y-axis. A bar graph representing the total number of BIS monitors applied is shown in Table 2.

BIS use pre-intervention

There was a total of 854 ETT general anesthesia cases performed at the facility from August 3rd to September 3rd. Of those 854 cases, 234 had a BIS monitor applied, indicating approximately 27% of cases utilized a BIS monitor throughout the 30-day pre-intervention period.

BIS use post-intervention

There was a total of 648 ETT general anesthesia cases completed at the facility from September 4th to October 3rd. This 30-day period represents the post-intervention evaluation phase. Of 648 cases utilized for the post-intervention data, 118 had a BIS monitor applied (18%).

PONV

An EPIC chart review was done to evaluate the incidence of post-operative nausea and vomiting 30 days pre and post intervention. This chart review aimed to assess if the application of a BIS monitor had any effect on the incidence and/or severity of PONV. As shown in table 3, PONV severity was identified numerically from 0-2. A score of 0 identified severe PONV, a score of 1 identified moderate PONV, and score of 2 identified minimal PONV. If the patient experienced no PONV, they were recognized in the “null” column. This review was done 30 days pre and 30 days post-educational intervention, for a total of 60 days.

A total of 1150 patients had no BIS monitor applied over the 60-day period. Of those 1150 non-BIS patients: 0 had severe PONV (0%), 3 had moderate PONV (0.3%), and 379 had minimal PONV (33%) (Table 4).

A total of 352 patients over the 60-day period had a BIS monitor applied when they

underwent general anesthesia. Of those 352 patients with BIS monitor application: 0 had severe PONV (0%), 0 had moderate PONV (0%), and 79 had minimal PONV (22%) (Table 4).

Post Survey

A post-survey was placed in the break room on October 3rd, 30 days after the educational intervention took place and remained there for 7 days to give the CRNAs and AAs who participated in the educational intervention an opportunity to document the barriers to their use of BIS monitoring. Four CRNAs and AAs who attended the educational intervention filled out the survey, and the results can be found in Tables 5 and 6.

The anonymous survey was a Likert style, 5-question survey ranging from "strongly disagree" to "strongly agree". The survey results demonstrated that the anesthetists were limited to using BIS by the availability of electrodes and monitors. Results also indicated that the anesthetists agreed that BIS monitoring is useful in guiding anesthetic depth, decreases cost, and can decrease the amount of anesthetic used.

Discussion

BIS

The results of this project illustrate the reality of barriers and material availability in anesthetic practice. There was a decrease in BIS use after the educational intervention by 33%. This is assumed to be the result of BIS electrodes being placed on backorder throughout the duration of the project. Three days prior to the educational intervention, the CRNAs and AAs were instructed to apply BIS monitors only to total intravenous anesthesia cases and high-risk for intraoperative awareness patients. This restriction lasted throughout the duration of the evaluation phase. Given the unforeseen barrier of limited BIS electrodes and population restrictions, the 33% decrease is unsurprising. The post-survey results in Table 5 demonstrate the anesthetist's self-reporting BIS use was limited by the availability of the BIS electrodes and

monitors.

The assessment of anesthetic depth by an evidenced-based tool such as BIS monitoring can help eliminate the risks of over-dosing or under-dosing anesthesia. BIS use is one of the most studied non-invasive anesthetic monitors and has demonstrated a positive cost-to-benefit ratio and lower morbidity than more invasive methods of monitoring (Mathur et. al., 2019). Given the evidence-based benefits to BIS use, it's clinically relevant to improve BIS use numbers to higher than the 18%-27% documented over the 60-day period in this project.

Nola Pender's Health Promotion Model was used as an underpinning for this project. This health promotion model aims to encourage practice change through motivation and increase in awareness (Wigfield & Eccles, 2000). This project's design did not assess for willingness to change, so practice change is independent of motivation. Although motivation to change was not assessed, increased awareness of BIS and its benefits was achieved by the educational intervention as demonstrated by the post-survey results. When given BIS-related EBP guidelines that promote positive patient outcomes, AAs and CRNAs could be empowered to change their practice. The lack of available BIS electrodes introduced an unanticipated variable into the post-intervention analysis. Any future educational interventions aimed at BIS use will need to verify the available supply of electrodes and management's restrictions on use prior to implementation.

PONV

The PONV data-collection demonstrated that the use of a BIS monitors may have an impact on the degree of PONV experienced. In this project, 33% of patients that underwent general anesthesia with no BIS monitor applied from August 3rd, 2021, to October 3rd, 2021, experienced minimal amounts of PONV per a self-reporting tool. 22% of patients that underwent general anesthesia during the same time frame with the addition of a BIS monitor applied

experienced minimal amounts of anesthesia. Alternatively, zero patients with a BIS monitor applied experienced moderate PONV, whereas 3 patients who did not have a BIS monitor applied reported moderate PONV. There were no incidences of severe PONV in either group throughout the 60-day time frame.

The results of this project support current and previous research that BIS use can decrease the risk of PONV (Adelin et al., 2021; Bocskai et al., 2018; Degrandi Oliveira et al., 2017). These results demonstrate a 33% reduction in PONV with the application of a BIS monitor. A 2019 study examined the prevalence of PONV after anesthesia and found that PONV in post-anesthesia recovery could be as high as 32.3% within the first 24 hours after surgery (Abired, 2019, p.18). They concluded that there was a significant increase in the risk of PONV with general anesthesia patients when compared to those who received regional anesthesia (Abired, 2019, p.18). With PONV being so prevalent after general anesthesia cases, anesthesia providers can mitigate some of those risks with the application of a BIS monitor.

Post Survey

The post-survey also utilized Nola Pender's Health Promotion Model to assess the anesthetists' beliefs and behaviors around BIS use. The post-survey results demonstrated retention of education and an increase in knowledge on the benefits of BIS. All providers surveyed believed that BIS monitors were useful in guiding anesthetic depth. The survey results demonstrated the provider's believed that BIS use does decrease total anesthetic costs and totals. This was a topic heavily outlined in the PI's educational intervention and in the literature, showing knowledge retention on those topics. There was a clear consensus that the CRNAs and AAs did not think their supervising anesthesiologist's opinions and attitudes towards BIS monitoring changed their BIS use. This result demonstrates support from other anesthesia

personnel on the utilization of BIS.

The survey results showed that the number one barrier to the application of BIS monitors was the lack of monitor electrodes and the lack of available monitors in all rooms. The lack of equipment is an unfortunate but realistic barrier that is unrelated to the intrinsic motivation for change in the anesthetists. It is recommended that education on the benefits of BIS use should be presented to stakeholders and leaders in the material management and purchasing team to continue to keep an adequate supply of monitors and electrodes in stock for use. Although there was an increase in understanding, the anesthetists expressed mixed agreement to the usefulness of BIS in certain scenarios. Some providers believed if there was a different anesthetic monitoring tool, such as end tidal volatile agent monitoring, then BIS was not as necessary. Further research in BIS monitoring compared to ET agent monitoring to evaluate depth of anesthesia is recommended. The surveyed staff felt "neutral" about BIS monitoring's impact on PONV. A 33% decrease in PONV resulting from the use of BIS monitors in this project demonstrates a knowledge gap and opportunity for increased education of the PONV benefits of BIS use.

Strengths and Limitations

Strengths of this quality improvement project include examining current evidence-based literature on BIS monitoring and educating anesthesia personnel on new practice recommendations. The PI was able to identify a decrease in the incidence of PONV after general ETT anesthesia with the application of a BIS monitor. This project identified how a lack of materials can lead to a drastic change in practice, despite best evidence. This project examined realistic barriers to practice change and thus identified opportunities for improvement, such as implementing clear guidelines for use of BIS to increase utilization.

A major limitation of this project was the lack of BIS electrodes available for the participants to use during the post-evaluation phase. This negatively impacted the validity, reliability, and generalizability of the BIS application portion of the project. This is a realistic barrier in practice, and not unique to the research site. Repeating this project when there is an adequate supply of BIS electrodes is recommended.

Due to protecting privacy and preventing bias, the PI did not track the names of the 21 AA's and CRNA's who participated in the educational intervention when reviewing the EMR for post-intervention BIS application. Because of this, there is no statistical way to differentiate the educated group from the non-educated group of personnel when reviewing BIS application. This reduced the PIs ability to evaluate the effect of the educational intervention, which was one of the project's main aims.

The post-survey was filled out by only 4 of the original 21 participants, resulting in a 19% response rate. This makes the Likert means less reliable and will contain more outliers. This survey was a paper survey left in the break room to be filled out at their own leisure; electronic surveys may have yielded increased response and should be considered for future projects.

This project was completed with a relatively small sample size. Small sample sizes can prevent findings from being extrapolated and can lead to a question of clinical relevancy (Faber & Fonseca, 2014). This project was also done within a small timeframe of 60 days, which can hinder the validity of the data set. A longer evaluation timeframe and larger sample size are recommended for future studies for more representative data.

Recommendations for Future Study

The literature review targeted articles and studies that were conducted within the last 5 years to ensure accuracy. There were certain gaps in current research that required the PI to

utilize articles outside of that time frame. New practice recommendations and new research may be able to fill in some of those gaps. Some examples of new research recommendations include updated cost/benefit ratio of BIS monitoring and reliability of BIS with the use of anesthetic agents that effect EEG monitoring.

Although many studies supported the use of BIS monitoring to decrease incidence of PONV, few studies disclosed whether patients had a history of PONV, which could skew results. Research supports that being female, young, a non-smoker, and undergoing gynecologic procedures increase your risk of experiencing PONV (Abired, 2019, p.18). The studies the PI evaluated did not have any demographic data included. Evaluating these risk factors in relation to BIS and PONV in future studies would reduce alternative explanations for why the patient experienced PONV.

The AA's and CRNA's who were evaluated in the post-survey had doubts about BIS reliability when using medications that are known to interfere with EEG monitoring, such as Ketamine. Research was found by the PI to support that BIS readings rose anywhere from 10-15 points 5 minutes after administration of ketamine and remained elevated for 10-15 min before returning to baseline (Hans et al., 2005). This rise in the BIS score does not reflect the patient's level of consciousness but can lead providers to believe the patient isn't adequately anesthetized. Further research is warranted in this area.

Relevance and Recommendations for Clinical Practice

Some degree of PONV was experienced in 33% of the patients undergoing general anesthesia in this project, which is supported by numbers mentioned in the research. After the application of a BIS monitor, this number went down to 22%. This is a significant drop, and thus demonstrates the effectiveness of BIS in this patient population. Using a BIS monitor in

combination with antiemetics may be able to significantly impact PONV, which improves patient outcomes and the patient experience.

One of the barriers to BIS use identified in this project was a lack of clear institutional guidelines. The Iowa Model is a heavily researched tool used to promote excellence in health care and was used as a framework for sustainable change for this project. The model starts with identifying a change topic and reviewing literature to evaluate appropriateness (Buckwalter, 2017). This project has highlighted the change topic of BIS use and evaluated the implications associated with BIS use. This project has completed the first step of the Iowa Model. The second step is to formulate an implementation team that consists of leadership and stakeholders (Buckwalter, 2017). Once this project is disseminated, a team can be made to begin the process of developing institutional guidelines for BIS use to be utilized by the anesthesia team to improve patient outcomes.

Conclusion

The aim of this project was to educate a group of anesthesia providers on the benefits of BIS monitoring and evaluate subsequent changes in BIS use and patient outcomes. Due to a multitude of factors, the project was not able to conclusively evaluate the impact of an educational intervention on BIS use. This was due to a lack of BIS electrodes available and the PI lacking the capability of tracking only the 21 educated providers throughout the 60-day evaluation period. The post-survey revealed an increase in understanding ofthe benefits of BIS, but it wasn't a clear understanding. More education is recommended to decrease knowledge gaps related to BIS use. This project evaluated the effect of BIS use on PONV and resulted in clinically relevant positive patient outcomes. The application of a BIS monitor in patients undergoing general anesthesia showed a 33% decrease in PONV. Protocols should be developed

and adapted to encourage the use of BIS monitoring in at-risk groups, including those with a history of PONV. Education on current practice recommendations and evidence should continue to be provided to encourage safe and quality care.

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Table 1

Prevalence of BIS Use Among Patient's Undergoing General Anesthesia With the Use of an ETT

08/03/2021 - 09/03/2021

	Bis Monitor		
Room Name	N	Y	Grand Total
WRCOR01	37	18	55
WRCOR02	36	12	48
WRCOR03	29	14	43
WRCOR04	14	14	28
WRCOR05	28	13	41
WRCOR06	9	15	24
WRCOR07	31	18	49
WRCOR08	34	21	55
WRCOR09	30	22	52
WRCOR10	37	15	52
WRCOR11	50	15	65
WRCOR12	29	10	39
WRCOR14	35	6	41
WRCOR15	34	11	45
WRCOR16	44	10	54
WRCOR17	42	3	45
WRCOR18	35	2	37
WRCOR21	32	3	35
WRCOR22	34	12	46
Grand Total	620	234	854

09/04/2021 - 10/03/2021

	BIS MONITOR (Sheet11)		
ROOM NAME (..	N	Y	Grand T..
WRCOR01	28	2	30
WRCOR02	24	6	30
WRCOR03	28	6	34
WRCOR04	14	8	22
WRCOR05	19	8	27
WRCOR06	8	15	23
WRCOR07	17	14	31
WRCOR08	35	15	50
WRCOR09	27	7	34
WRCOR10	45	5	50
WRCOR11	37	13	50
WRCOR12	27	1	28
WRCOR14	25		25
WRCOR15	44	3	47
WRCOR16	55	2	57
WRCOR17	26	7	33
WRCOR18	33	2	35
WRCOR21	22	1	23
WRCOR22	16	3	19
Grand Total	530	118	648

Table 2

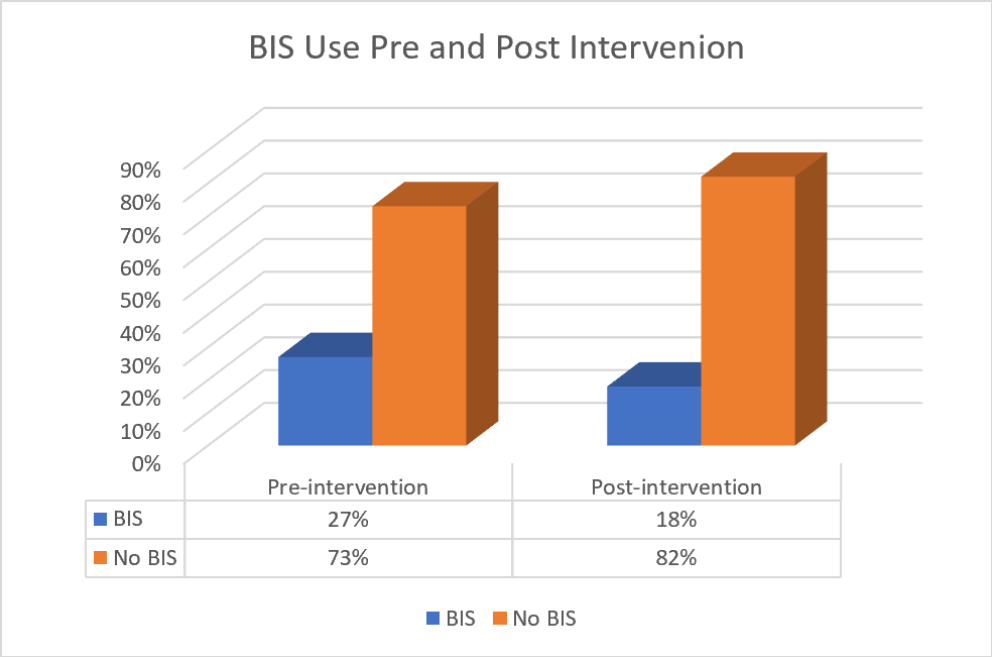

BIS Use Pre and Post Intervenion
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Pre-intervention
Post-intervention
BIS
27%
18%
No BIS
73%
82%
BIS
No BIS

Table 3

Correlation Between BIS Use and PONV in Patients Undergoing General Anesthesia with ETT

08/03/2021 - 09/03/2021

	Bis Monitor / PONV_SCORE					
	N			Y		Grand
Room Name	Null	1	2	Null	2	Total
WRCOR01	30		7	15	3	55
WRCOR02	25		11	8	4	48
WRCOR03	16		13	9	5	43
WRCOR04	12		2	14		28
WRCOR05	22		6	8	5	41
WRCOR06	7	1	1	15		24
WRCOR07	20		11	13	5	49
WRCOR08	22		12	15	6	55
WRCOR09	24		6	19	3	52
WRCOR10	24		13	13	2	52
WRCOR11	36		14	14	1	65
WRCOR12	22	1	6	3	7	39
WRCOR14	24	1	10	5	1	41
WRCOR15	30		4	10	1	45
WRCOR16	29		15	7	3	54
WRCOR17	15		27	1	2	45
WRCOR18	9		26	2		37
WRCOR21	20		12	3		35
WRCOR22	17		17	8	4	46
Grand Total	404	3	213	182	52	854

09/04/2021 - 10/03/2021

	Bis Monitor				(Sep) / P..
	N		Y		Grand
Room Name ..	Null	2	Null	2	Total
WRCOR01	21	7	2		30
WRCOR02	15	9	1	5	30
WRCOR03	18	10	3	3	34
WRCOR04	12	2	8		22
WRCOR05	15	4	8		27
WRCOR06	7	1	15		23
WRCOR07	12	5	10	4	31
WRCOR08	26	9	11	4	50
WRCOR09	18	9	6	1	34
WRCOR10	34	11	4	1	50
WRCOR11	28	9	10	3	50
WRCOR12	23	4	1		28
WRCOR14	18	7			25
WRCOR15	29	15	1	2	47
WRCOR16	45	10	1	1	57
WRCOR17	12	14	4	3	33
WRCOR18	15	18	2		35
WRCOR21	6	16	1		23
WRCOR22	10	6	3		19
Grand Total	364	166	91	27	648

PONV_SCORE
- ☑ Null
- ☑ 1
- ☑ 2

PONV SCORE:
2: Minimum
1: Moderate
0: Severe

PONV_SCORE (Sheet11)
- ☑ Null
- ☑ 2

Table 4

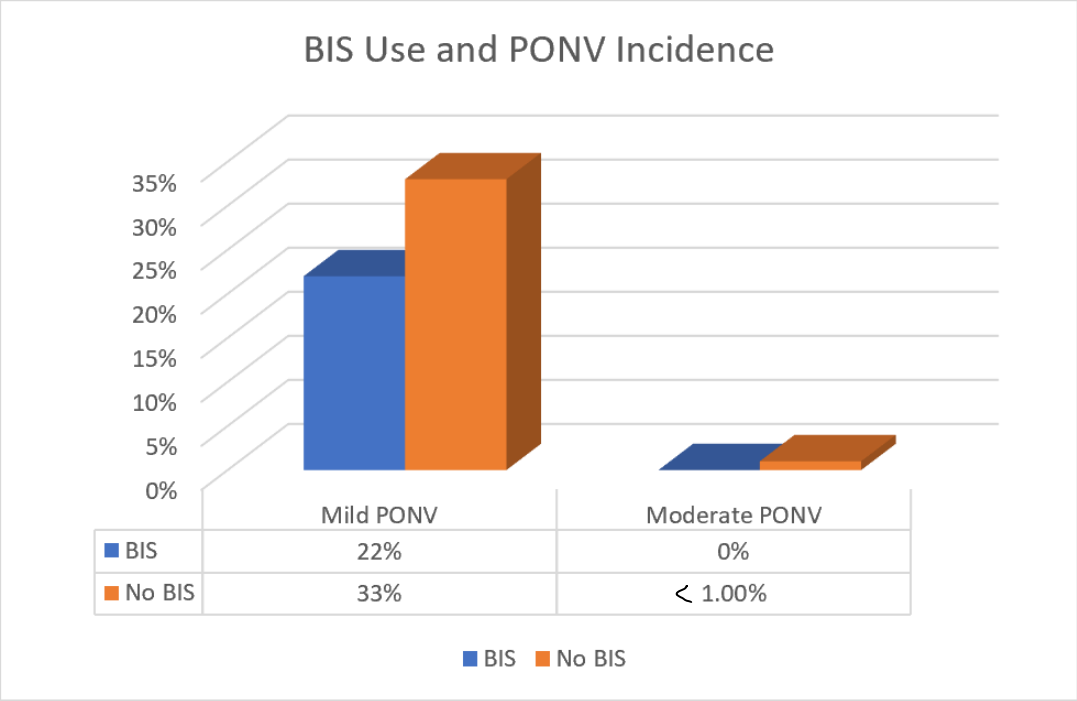

BIS Use and PONV Incidence
35%
30%
25%
20%
15%
10%
5%
0%
Mild PONV
Moderate PONV
BIS
22%
0%
No BIS
33%
< 1.00%
BIS
No BIS

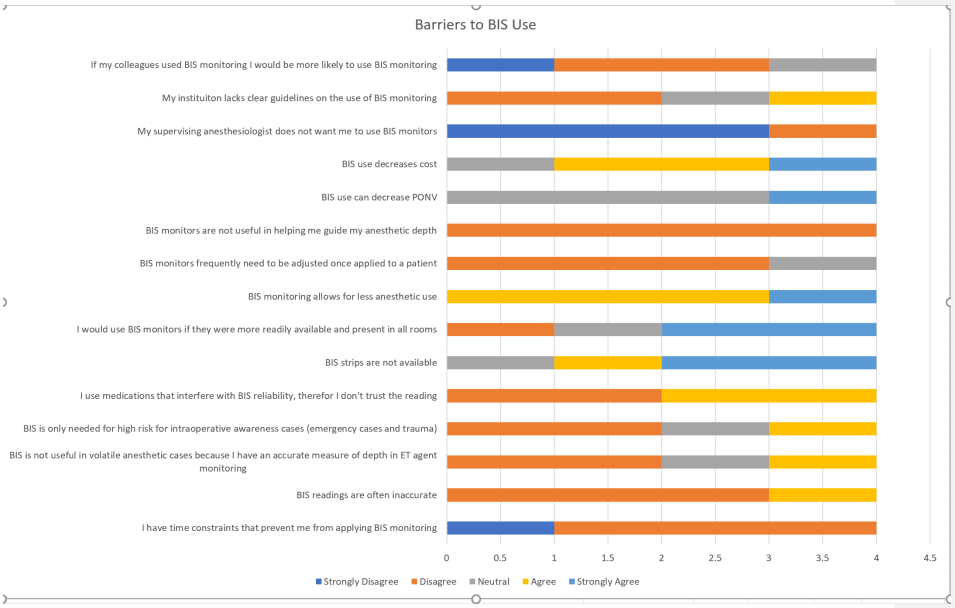
Table 5

Likert Survey Results

	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
2	I have time constraints that prevent me from applying BIS monitoring	1	3	0	0	0
3	BIS readings are often inaccurate	0	3	0	1	0
4	BIS is not useful in volatile anesthetic cases because I have an accurate measure of depth in ET agent monitoring	0	2	1	1	0
5	BIS is only needed for high risk for intraoperative awareness cases (emergency cases and trauma)	0	2	1	1	0
6	I use medications that interfere with BIS reliability, therefor I don't trust the reading	0	2	0	2	0
7	BIS strips are not available	0	0	1	1	2
8	I would use BIS monitors if they were more readily available and present in all rooms	0	1	1	0	2
9	BIS monitoring allows for less anesthetic use	0	0	0	3	1
10	BIS monitors frequently need to be adjusted once applied to a patient	0	3	1	0	0
11	BIS monitors are not useful in helping me guide my anesthetic depth	0	4	0	0	0
12	BIS use can decrease PONV	0	0	3	0	1
13	BIS use decreases cost	0	0	1	2	1
14	My supervising anesthesiologist does not want me to use BIS monitors	3	1	0	0	0
15	My instituiton lacks clear guidelines on the use of BIS monitoring	0	2	1	1	0
16	If my colleagues used BIS monitoring I would be more likely to use BIS monitoring	1	2	1	0	0

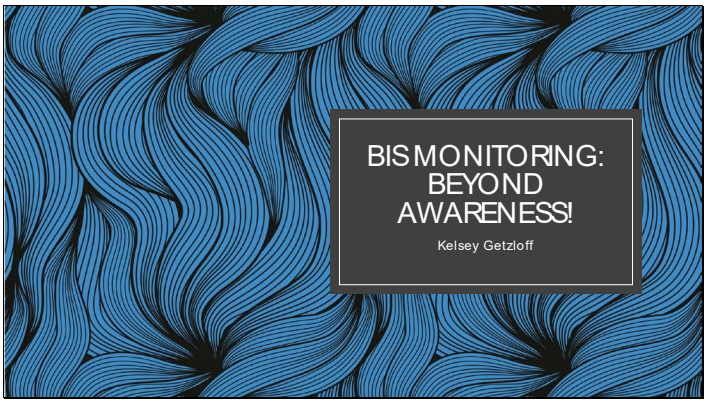
Table 6

Graph of Likert Style Means



Appendix A

BIS Education PowerPoint Presented to AAs and CRNAs



Current Practice

- Bispectral Index (BIS) is a monitoring tool that collects, processes, and converts cerebral metabolic activity to a number from 0 to 100, with higher level suggesting the patient is more awake.
- Cases where BIS use is highly recommended: Emergency cases, craniotomies, TIVAs sternotomy cases, cases utilizing long-acting paralytics, patients with a history of awareness, and patients at risk for bradycardia.
- Accidental awareness with recall is one of the most feared complications for patients undergoing general anesthesia and can lead to post-traumatic stress disorder in up to 70% of patients experiencing it.

TIVAS!

- Why do a TIVA? Less pain after surgery, less impact on neurocognitive function, less PONV, survival advantages in cancer surgery, good for the environment, mitigates risk for MH, pretty wake ups ☺
- Conflicting evidence on TIVAs increasing a risk for intraoperative awareness. Of the TIVA studies reported to have awareness; it was noted that poor clinical judgement, poor application of knowledge, and technical errors were the reason the TIVA awareness rates were higher.
- TIVA concerns: IV not working and no true pharmaceutical depth of anesthesia monitoring.
- BIS monitoring leads to decreased risk of intraoperative awareness vs. clinical judgement alone
- The National Institute for Health and Clinical Excellence and the Association of Anaesthetists of Great Britain and Ireland recommend that processed EEG monitoring be used with total intravenous anesthesia (TIVA).
- The Association of Anaesthetists/Society of Intravenous Anaesthesia and NAP5 reports support that BIS be used if TIVA + paralysis. These publications also suggest the IV be visible.

Anesthetic Totals

- There is a clear relationship between application of BIS and lowering of anesthetic totals, which in turn decreases the potentially harmful hemodynamic risks of anesthesia. These reductions in anesthetic totals throughout various studies ranged from negligible to upwards of 30%.
- Most of the studies looked at propofol totals, but there were a few studies that examined inhalational totals.
- Gaps in research: Balanced techniques and more research on inhalational only.
- ERAS: Precedex administration can decrease anesthetic requirements 30-50%. Apply BIS to see depth!

Hemodynamic Implications

- Evidence based improvements in hemodynamics throughout multiple RCTs and systematic reviews:

1. O2 sats were lower in non-Bis groups
2. Patients with obstructive sleep apnea did better intraoperatively with the application of BIS
3. Applying BIS resulted in less hypotension and bradycardia

- There is an emerging body of literature demonstrating an association between low intraoperative BIS readings and decreasing intermediate-term survival in both noncardiac and cardiac surgical patients.

PONV

- The risk for experiencing PONV increases with higher totals of anesthetic drugs.
- Multiple authors show evidence to support that BIS monitoring decreases PONV. BIS monitoring allows for less anesthesia to be used, resulting in less PONV.
- One study specifically showed PONV risk reduction of 12% in patients BIS monitoring.

Costs

- BIS monitoring can result in quicker times to extubation and swifter transitions from the OR to the post-anesthesia care unit (PACU).
- One study found that patients had an emergence time of 3 minutes faster with use of BIS monitoring. With some operating rooms costing up to $115 per minute of operating room time, that 3 minutes could potentially save over $300 per patient for the institution.
- Another study found that they were able to decrease PACU discharge time by 15 min in patients whose anesthetics were guided by BIS monitoring. Research supports that a 5-to-8-minute reduction in PACU recovery time could reduce OR delays by more than 20%
- Cost of BIS: 15$ per anesthetic for the strips. Monitor: $4,000. Cables: $300-$1000.
- Bottle of Iso: $25
- Bottle of Sevo: $74
- Bottle of Des: $149
- 100cc bottle of Propofol: $27.48

Can potentially save 30% off these costs!

Delirium

- BIS application allows patients to regain orientation faster and results in less post-op delirium.
- This risk for post-op delirium is increased in the geriatric population, which is a large subset of the individuals cared for by anesthetists.
- American Geriatrics Society Expert Panel on Postoperative Delirium recommends monitoring the depth of anesthesia during intravenous sedation or general anesthesia using processed EEG monitor.

Ketamine

- In a double-blind study with 0.5mg/kg ketamine vs. saline; the BIS went up anywhere from 10-15 points higher 5 min after admin and remained elevated for 10-15 min before returning to baseline. These parameters remains consistent throughout several RCTs.
- Both inhalationals and TIVAs when combined with ketamine resulted in similar numbers.
- In one study under stable propofol and remifentanil anesthesia, a slow bolus infusion of ketamine 0.2 mg kg administered over a 5 min period did not increase the BIS value over the next 15 min.
- Ephedrine and etomidate can also transiently increase BIS.

Does BIS make a difference?

- The plan:

1. 30-day chart review pre and post education session.
2. Going to be looking at: Was BIS used? Did the patient experience PONV? I will calculate anesthetic totals on these patients to establish if less anesthesia was used. Did the patients with BIS have less bradycardia/hypotension? Was there a decreased emergence time?

My ask from the AA/CRNA staff: Pop a BIS monitor on! Especially in the inhalational cases - let's see if it makes a difference!

Barriers to use of BIS/Post-survey

- After 30 days of (hopefully) increased BIS use, there will be an opportunity to report barriers to using it that you faced.
- Short survey will be left in the breakroom; results will be anonymous and will be kept in a locked box in the break room that only I have the key for. I will leave it there for 7 days to allow people to have time to fill it out.
- On Oct 3rd, I will get an email out to you all to remind you that the survey is available in the break room.
- This is your opportunity to give feedback! There were no stickers or monitors in the room, you didn't have time to put it on, you were using ketamine so you were concerned about accuracy, you don't trust the BIS at all, etc.

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Appendix B

Evaluation of Barriers Likert Post-Survey

1. I have time constraints that prevent me from applying BIS monitoring	1 -5
2. BIS readings are often inaccurate	1-5
3. BIS is not useful in volatile anesthetic cases because I have an accurate measure of anesthetic depth in ET agent monitoring	1-5
4. BIS is only needed for high risk for intraoperative awareness cases (emergency cases, and trauma)	1-5
5. I use medications that interfere with BIS reliability, therefor I don't trust the reading	1-5
6. BIS electrodes are not available	1-5
7. I would use BIS monitors if they were more readily available and present in all rooms	1-5
8. BIS monitoring allows for less anesthetic use	1-5
9. BIS monitors frequently need to be adjusted or replaced once applied to a patient	1-5
10. BIS monitors are not useful in helping guide my anesthetic depth	1-5
11. BIS use can decrease PONV	1-5
12. BIS use decreases cost	1-5
13. My supervising anesthesiologist does not want me to use BIS	1-5
14. My institution lacks clear guidelines on use of BIS monitoring	1-5
15. If my colleagues used BIS monitoring, I would be more likely to use BIS monitoring	1-5