Cerebral Desaturation Events in Beach Chair Position: Optimizing the Quality of Care

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Abstract

Positioning is one of many responsibilities required of anesthesia providers. A standard position utilized in surgery is called the beach chair position (BCP), an upright position. Sitting upright has many benefits such as the ability to provide the surgeon with an optimal view of the operative site; however, it has been associated with neurological complications and has been growing out of favor. The downfall of this position is with using conventional monitoring devices. The vital signs portrayed on standard monitors may not reflect actual oxygen saturation in the brain. This may lead to cerebral ischemia and neurological deficiencies. A reliable source of monitoring cerebral oxygenation is a necessity when performing anesthesia on patients at high risk for cerebral desaturation, such as with BCP. An extensive literature review was completed on fourteen articles. Research asserted positive outcomes when using cerebral oximetry in patients having surgery in BCP, among many other methods to optimize care for this patient population. The investigators aimed to explore possible monitoring solutions to provide a more reliable way of detecting and treating cerebral desaturation during surgeries in the BCP. Furthermore, the goal was to increase the knowledge base for the student registered nurse anesthetists (SRNAs) in the Nurse Anesthesia Program (NAP) at the Adventist University of Health Sciences (ADU) regarding physiological effects caused by BCP. To evaluate the response, a 30-minute evidence-based PowerPoint presentation was given to these students. Results from pre- and post-testing was analyzed utilizing a paired *t*-test procedure and revealed a significant increase in the students' knowledge base following the presentation. It was concluded that the PowerPoint presentation was effective in increasing this knowledge base, which can lead to safer clinical conditions by increasing caregiver competence.

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Introduction

The beach chair position (BCP) is a position utilized in various surgeries and, thus, is encountered by anesthesia providers. Its use is common in orthopedics during open shoulder surgeries such as shoulder arthroplasty and arthroscopy, as this position reduces injury and excess stretching to the brachial plexus and provides the surgeons with enhanced exposure and manipulation of the surgical site (Nagelhout & Plaus, 2014). Furthermore, sitting positions are also favored by neurosurgeons for procedures such as posterior fossa and cervical spine repair, for visualization of intracranial structures, and its facilitation of blood and cerebral spinal fluid (CSF) drainage from the wound. Patients in this position have been elevated anywhere from 30° to 90° (Songy, Siegel, Stevens, Wilkinson, & Ahmadi, 2017). Although there are benefits of the BCP, its use is unfortunately associated with serious adverse complications (Nagelhout & Plaus, 2014). Salazar et al. (2013a), assert multiple reports of complications from severe brain damage to death in healthy, low-risk adult patients undergoing an operation in the BCP. Although the most devastating of events owing to BCP are rare in comparison to alternative positions such as lateral decubitus, cerebral desaturation events (CDEs) are common and it is imperative that the anesthetist be abreast of best practice in the care of patients in this position (Pant, Bokor, & Low, 2014). Research suggests maintaining the MAP greater than 70 mmHg or a systolic blood pressure higher than 90 mmHg and to avoid a 20% decline in the patients' baseline blood pressure as hypotension can gravely compromise brain oxygenation.

Problem

Detrimental cerebral damage may occur as patients in the BCP inevitably experience a lower mean arterial pressure (MAP) due to various cofactors such as the use of anesthetics, head and neck mal-positioning, decreased blood pressure from upright positioning in of itself, and the request by surgeons to maintain lowered MAPs to prevent hemorrhage at the surgical site (Salazar et al., 2013a). In the constant goal to improve patient care, consideration of cerebral oxygenation problems that may originate from a patient undergoing an operation under anesthesia in an upright position is timely. The primary goal of the proposed research study was to increase the knowledge base of Adventist University student nurse anesthetists (ADU SRNAs) about current evidence-based findings regarding considerations of beach chair positioning and its associated adverse effects. Furthermore, the investigators aimed to disseminate information to this cohort of future anesthesia providers regarding methods to manage patients in the BCP, such as optimizing hemodynamics and the use of cerebral oximetry monitoring to provide safer patient care in this surgical position. Although various monitoring methods can aid in the assessment of cerebral saturation, such as direct arterial monitoring, FlowTrac, and jugular bulb pressure, this study excluded such invasive devices and focused on noninvasive monitoring devices when patients undergo BCP. Two main questions provided guidance for the literature review. The first question addressed the clinical problem: For anesthesia providers, what methods are currently being utilized for monitoring patients undergoing procedures in the BCP; furthermore, what is the most beneficial method to detect and prevent cerebral desaturation events associated with upright positioning? The second question addressed the intervention: Does an educational module given via PowerPoint presentation regarding BCP management, including the use of cerebral oximetry along with standard monitors, increase the knowledge base of ADU SRNAs? This review will describe BCP in depth, discuss physiologic effects of BCP, propose practical strategies to monitor and mitigate CDEs, and explore the effectiveness of cerebral oximetry based on current research data.

Review of Literature

Background

Regardless of the angle of elevation, beach chair positioning is associated with profound hemodynamic compromise leading to extensive neurocognitive complications related to cerebral ischemia (Jeong et al., 2012; Ko et al., 2012; Murphy et al., 2014; Salazar et al., 2013a; Salazar, Sears, Andre, Tonino, & Marra, 2013b; Scheeren, Schober, & Schwarte, 2012; Songy et al., 2017; Yu et al., 2016; Triplet, Lonetta, Levy, Everding, & Moor, 2015). Due to the brain requiring a substantial amount of oxygen, ischemia of the brain must be prevented. Intraoperative cerebral ischemia may inevitably lead to the detrimental diagnosis of stroke or even death; however, other complications may not be as evident during the surgical procedure itself. Postoperative complications such as cognitive dysfunction or a prolonged hospital stay may be prevented with proper management of patient care.

Conventional methods of monitoring cerebral perfusion, may be inadequate at ascertaining CDEs. Standard monitors commonly used in surgery include the non-invasive blood pressure (NIBP), electrocardiogram (EKG), and pulse oximetry. The literature reveals that, at best, these monitors can only estimate cerebral perfusion; moreover, they are unable to detect cerebral hypo-perfusion and assure the brain is adequately perfused, especially in its early stages (Salazar et al., 2013b). Of these monitors, measuring the MAP has been shown to be the most reliable in detecting abnormalities; however, hypotension is associated with positioning patients in the chair position and limits the brain's ability to auto-regulate perfusion pressures leading to cerebral desaturation (Kocaoglu et al., 2014; Pant et al., 2014). A review of the current literature suggests that there is a definite need for improvement in monitoring devices for cerebral hypo-perfusion in patients undergoing the BCP (Pant et al., 2014; Salazar et al., 2013b; Triplet et al., 2015). According to a case series on the effects of cerebral ischemia during shoulder surgery in chair position, several patients suffered severe brain damage, one case lead to death, and other cases resulted in stroke, vision loss, and ophthalmalgia (Ko, et al., 2012; Kocaoglu, Ozgen, Toraman, Karahan, & Guven, 2014).

There appears in the literature a lack of evidence in detailing the consequential effects of BCP leading to permanent neurological damage; therefore, further research is desirable. Previous studies have affirmed that this area requires further investigation, particularly regarding data quantifying the specific neurological complications from BCP (Kocaoglu et al., 2014). Moreover, research detailing the specific incidence of neurocognitive complications exists, although the literature reports such incidents and the likelihood of many to be underreported (Jeong et al., 2012; Kocaoglu et al., 2014; Moerman & Hert, 2015; Salazar et al., 2013b). Pant et al. (2014) assessed a study on American shoulder surgeons, who performed over 200,000 shoulder procedures. They reported only eight incidences of cerebrovascular events (0.003%) with all the reported events occurring in the BCP. The risk in BCP alone was found to be between 0.00382% and 0.00461%; moreover, the incidence of perioperative stroke in patients undergoing nonvascular, non-neurologic surgery was 0.08% to 1.0% (as cited in Pant et al., 2014). Although the most devastating of consequences due to BCP may be rare, as healthcare advocates to patients, it is essential for anesthesia providers to implement best practice methods, based on the most current evidence, which will not only lead to enhanced safety and promote improved patient outcomes, but also prevent adverse effects. Cerebral oximetry is underused in anesthesia. As previously asserted, the routine use of cerebral oximetry in patients in the BCP seems to have the potential to expand the science of the anesthesia profession and allow anesthetists to deliver higher quality patient care (Salazar et al., 2013a; Scheeren et al., 2012; Triplet et al., 2015; Moerman & Hert, 2015).

Ineffective Monitoring Methods

Patients in the BCP are at increased risk for cerebral hypo-perfusion due to cerebral ischemia; however, standard monitoring methods currently being used have proven to be unreliable in detecting this phenomenon early enough or at all (Kocaoglu et al., 2014; Triplet et al., 2015). A study by Salazar et al. (2013a) argued that various reports demonstrate the ill-effects of beach chair positioning led to significant neurological demise including cerebral damage and even death. The effects of BCP are evidenced in otherwise healthy, low-risk patients. CDEs are defined as a 20% or greater decrease in regional cerebral tissue oxygen saturation. The results of their study yielded an 18% (9/50) incidence of CDEs in these otherwise healthy, low-risk patients. Furthermore, the subjects were monitored via arterial blood pressure monitoring, and yet adequate cerebral perfusion was not maintained, suggesting that method of monitoring alone may be inadequate at guaranteeing adequate cerebral perfusion (Salazar et al., 2013a).

Triplet et al. (2015) confirmed the notion that conventional monitoring methods are unreliable in establishing true cerebral perfusion. Fifty-seven patients undergoing an elective shoulder surgery in the sitting position were monitored with a NIBP at the brachial artery, an estimated mean arterial pressure at the level of the temporal artery (ETMAP), and INVOS™ cerebral oximetry placed on the right and left side of the forehead. The results of their study concluded that the NIBP and ETMAP did not adequately depict cerebral perfusion. The lack of correlation between not only the NIBP but even temporal blood pressure measurements and cerebral perfusion advocates the necessity for continuous cerebral oximetry monitoring to establish cerebral perfusion when patients are placed in the sitting position (Triplet et al., 2015).

Blood pressures measured at the brachial artery (arm) can overestimate cerebral perfusion pressure, giving a false sense of adequate tissue oxygenation in the brain. The pulse oximeter can provide information regarding arterial saturation of the peripheral tissues; however, this information is poorly reflected when hemodynamic values are abnormal. In the case of hemodynamic parameters being abnormal, namely blood pressure, cardiac output, and hemoglobin levels, venous oxygenation, rather than arterial saturation, becomes the primary indicator of tissue vitality. Venous oxygenation is not affected by changing hemodynamic parameters. Furthermore, the use of general anesthesia impedes the body's ability to compensate for the hemodynamic changes caused by upright positioning (Kocaoglu et al., 2014).

Ko et al. (2012) conducted a study comparing the relationship between using cerebral oximetry via near infrared spectroscopy (NIRS) and the MAP as a means to detect any CDEs. The MAP was measured at the level of the brain (external auditory canal) and the heart. The study proved that both MAP and cerebral oxygenation decrease with changing position from supine to sitting. The MAP measured at the level of the brain was notably consistent with the measurement of the NIRS monitor. In contrast, the MAP measured at the degree of the heart failed to coordinate with the NIRS monitor, concluding that the MAP may be an unreliable method to evaluate cerebral perfusion and oxygenation in patients undergoing procedures in the BCP (Ko et al., 2012).

The unreliability of conventional methods for monitoring vital signs are unable to quantify the hemodynamics and oxygenation status of the brain; therefore, there is a need for a more reliable and consistent method to continuously measure cerebral perfusion in patients in the

BCP (Kocaoglu et al., 2014; Moerman & Hert, 2015; Scheeren et al., 2012). According to Nagelhout and Plaus (2014), when patients are in the upright position, the site of the blood pressure measurement does not correlate to brain perfusion, due to a significant hydrostatic gradient. Nagelhout and Plaus (2014) state that "the magnitude of the gradient is approximately 2 mmHg per inch of height differential. When the cuff is on the upper arm, this difference can easily be 25 mmHg" (p.1165). Superior monitoring devices and early detection of cerebral compromise will enhance patient safety and mitigate the adverse effects of inadequate cerebral tissue oxygenation (Kocaoglu et al. 2014; Moerman & Hert, 2015; Scheeren et al., 2012).

Cerebral Oximetry Monitoring

The current standard monitoring devices do not provide an adequate representation of cerebral saturation when patients are in the sitting position; however, NIRS has been found to optimize the overall clinical picture and give anesthesia providers a more reliable depiction of cerebral oxygenation (Ko et al., 2012; Murphy et al., 2014; Pant et al., 2014; Salazar et al., 2013a; Scheeren et al., 2012; Triplet et al., 2015). The determinates of cerebral tissue oxygenation consist of cerebral oxygen delivery, oxygen demand, and the metabolic rate of cerebral oxygen. Due to the human skull being translucent, Yu et al. (2016) describes that NIRS utilizes near-infrared light which trans-illuminates specific wavelengths ranging from 700-1000 nanometers. This light has the means to penetrate the external surface beneath the scalp of about two centimeters measuring the correspondence between oxygenated hemoglobin and deoxygenated hemoglobin (Yu et al., 2016). The frontal lobe measurement consists of about 75% venous blood (Kaplan et al, 2011). This proportion of venous blood flowing throughout the frontal lobe can be different for each person, leading to variability in individual readings and objective interpretations of cerebral hypo-perfusion (Kaplan et al., 2011; Yu et al., 2016). Other variations that may prove inconsistent readings are skin pigmentation, gender, and the fraction of arterial versus venous blood contained in the frontal lobe. Although these limitations may seem inconclusive, the ultimate determination should be clinically investigated and decided upon from changes in the patient's specific baseline values and of the clinical setting, rather than of an observed value (Kaplan et al., 2011; Yu et al., 2016).

Comprehension of the technological limitations to the NIRS are significant to utilizing the monitoring system correctly. Correct placement of the NIRS is fundamental in the function of the monitor. Kaplan et al. (2011) explains that the light source of the NIRS contains a self-adhesive covering which adheres to the hairless skin around the scalp such as the forehead. The oximetry sensors are to be positioned on the forehead, due to the limited amount of hairless skin on the human cranium, as hair can skew the results. The NIRS monitor detects the anterior and middle cerebral arteries and monitors the blood flow throughout that area. However, it limits the monitoring of the posterior circulation (Kaplan et al., 2011). Hair with dark pigment can absorb the near-infrared light and obscure the signal ratio. Other interferences include, but are not limited to, hematomas, sensors covering the venous sinus, and skull deformities (Kaplan et al., 2011). Careful and meticulous assessment and evaluation of each patient is of the utmost importance before placing any monitoring device.

NIRS has been advocated among the current research as a cost-effective, non-invasive, and necessary implementation in practice to continuously assess cerebral oxygenation, particularly in adult patients undergoing surgical procedures in the BCP (Pant et al., 2014). NIRS non-invasively allows continuous monitoring of cerebral oxygenation and has been able to recognize CDEs which would otherwise go undetected with standard monitors alone (Moerman & Hert, 2015). Cerebral oximetry utilizing NIRS has been found to have a significant correlation when measuring cerebral oxygenation (Scheeren et al., 2012). Evidence has shown that early detection of CDEs has resulted in improved clinical outcomes (Kocaoglu et al., 2014; Salazar et al. 2013a; Scheeren et al., 2012). Cerebral oximetry is an excellent tool in detecting early decompensation in patients (Triplet et al., 2015). Early detection may result in a timely initiation of treatment, minimizing the potential for adverse events, thus improving patient outcomes.

NIRS has been proven to be useful in aiding the intraoperative assessment of cerebral oxygenation in patients in the BCP (Triplet et al., 2015). Cerebral oximetry utilizing NIRS can detect cerebral desaturation episodes that go otherwise undetected by standard monitors (Kocaoglu et al., 2014; Moerman & Hert, 2015; Pant et al., 2014; Scheeren et al., 2012). NIRS non-invasively measures cerebral oxygenation via the Beer-Lambert Law, and when utilized intraoperatively, can provide the anesthetist with a continuous, real-time measure of cerebral saturation (Pant et al., 2014). Furthermore, the near-infrared wavelengths of light penetrate the skin, skull, and soft tissues of the frontal lobe, directly measuring arterial and venous tissue perfusion (Jeong et al., 2012; Pant et al., 2014; Triplet et al., 2015). This innovation provides the ability to detect cerebral hypo-perfusion and brain tissue desaturation as evidenced by a 20% decline from the baseline readings on the NIRS monitor (Songy et al., 2017). Additionally, Yu et al. (2016) provide insight from the current literature advocating the use of cerebral oximetry in distinguishing early diagnoses of CDEs; however, the literature lacks the best methods to treat cerebral tissue desaturation (Yu et al., 2016).

Optimizing Cerebral Oxygenation

Various cofactors could affect cerebral oxygenation during surgery such as anesthetics, positioning, hemodynamic parameters, and ventilation methods. With proper monitoring, these ischemic episodes might be reduced (Kocaoglu et al., 2014; Moerman & Hert, 2015; Salazar et al. 2013a; Scheeren et al., 2012). An alternative method to better improve cerebral oxygenation is by maintaining the end-tidal carbon dioxide level ($ETCO_2$) around 40-42 mmHg. Murphy et al. (2014) assessed patients undergoing surgery in BCP. Their findings concluded that cerebral oxygenation was better managed when $ETCO_2$ was maintained at 40-42 mmHg in comparison to an $ETCO_2$ of 30-32 mmHg. They assert that “arterial carbon dioxide is an important regulator of cerebral blood flow (CBF), independent of autoregulation” (pg. 623). Higher $ETCO_2$ may raise blood pressure which in turn will cause an increase in cerebral perfusion pressure, increasing cerebral oxygenation. Modifying mechanical ventilation in order to elevate the $ETCO_2$ is a simple solution for increasing cerebral blood flow and oxygenation. Nonetheless, subsequent alterations in cerebral blood flow following changes in ETCO2 can also be impacted by the baseline blood pressure and blood flow, which in turn could be compromised in BCP (Murphy et al., 2014).

These parameters can be challenging due to diversified patient needs. Patients with a baseline hypertension may not be able to tolerate these parameters; furthermore, in order to prevent excessive bleeding in the field, surgeons may require lower blood pressures (Kocaoglu et al., 2014; Moerman & Hert, 2014; Pant et al., 2014). Kocaoglu et al. (2015) declare that obvious signs of cerebral desaturation occurred when the MAP fell below 60 mmHg.

As patient positioning falls within the scope of anesthesia care, it is essential that the anesthetist assures correct positioning to avoid head and neck mal-rotation which may lead to cerebral hypo-perfusion and decreased cerebral oxygenation saturation (Salazar et al., 2013b; Scheeren et al., 2012). A study by Songy et al. (2017) suggested that the angle of the BCP directly affects cerebral oxygenation and they recommended an angle of 30° to 45° to avoid the adverse positioning effects.

General anesthesia and other anesthetics can play a role in increasing the chance for cerebral desaturation, as previously stated. Aguirre et al. (2016) assessed the use of regional anesthesia in place of general anesthesia, which is associated with greater risk factors. Two studies compared the effects of regional anesthesia versus general anesthesia on cerebral saturation. Ko et al. (2012) found a higher incidence of CDEs with patients undergoing general anesthesia (56.7%) compared with regional anesthesia (0%) and a greater hemodynamic instability with general anesthesia, with a decrease in MAP greater than 20%, in 73.3% of the subjects compared to only 10% in those using regional anesthesia. Another study by Aguirre et al. (2016) also found a higher incidence of CDEs in the general anesthesia group (71.1%) compared with regional anesthesia (2.2%) and more hemodynamic instability from the use of general anesthesia. In the event that general anesthesia is unavoidable, it may be beneficial to use sevoflurane in comparison to desflurane as sevoflurane has been found to preserve cerebral oxygenation (Moerman & Hert, 2014).

Treatment for Cerebral Desaturation Events

The most efficient treatment of perioperative cerebral hypoxia leading to ischemia is distinguishing an early diagnosis through the implementation of effective monitoring methods (Yu, Lu, Meng, & Han, 2016). Having appropriate monitors, such as the NIRS, aids in the detection of CDEs. Once recognized, a treatment plan should be addressed. Soeding, Hoy, S., Hoy, G, Evans, and Royse (2013) conducted a study on the effects of using phenylephrine during hypotensive events in patients undergoing procedures in upright positions. It was concluded that although phenylephrine did prove to sustain the arterial pressure, it had no significant effect on cerebral desaturation when the patient is in the upright position (Soeding et al., 2013). The drug was ultimately supporting preload and producing an increase in systemic vascular resistance to prevent hypotension and was also proving to reduce cardiac output (Soeding et al., 2013). Literature has, however, addressed the importance of maintaining optimal hemodynamic status in order to ascertain brain perfusion (Kocaoglu et al., 2014; Moerman & Hert, 2014; Pant et al., 2014).

Contribution and Dissemination/Justification

The target population of interest for this study was the first and second-year nurse anesthesia students. This cohort consists of 26 first-year students and 24 second-year students. The aim of the proposed study was to increase the knowledge base regarding the various considerations and interventions to safely care for patients in BCP based on the most recent review of the literature to date. The goal was to increase awareness of the current void of adequate monitoring of brain tissue oxygenation in these patients. The knowledge base of this target population was limited as methods such as cerebral oximetry are under-utilized in the management of patients undergoing surgeries at Florida Hospital, especially for BCP. This project allowed the SRNAs to obtain an adequate understanding of NIRS monitoring and be able to safely and competently utilize evidence-based methods in the care of patients undergoing surgeries in the BCP. Dissemination of the study occurred in Fall 2017. More information regarding this can be found in the proposed "timeline" of this paper.

Project Aim

The purpose of this quantitative research study was to expand the knowledge base of future anesthesia providers (ADU SRNAs) about evidence-based data regarding monitoring and management of cerebral desaturation, a common BCP complication, in order to improve patient safety. The subjects' (ADU SRNAs) knowledge base was evaluated immediately prior to the administration of the educational PowerPoint presentation (Appendix C). The independent variable of the study was the PowerPoint presentation (Appendix C). The dependent variable was the difference between the mean pre-and post-test scores (Appendix D). Moreover, an increase in mean post-test scores compared with mean pre-test scores indicates an increase in knowledge base and validates the effectiveness of the PowerPoint presentation.

Project Methods

The investigators proposed a problem statement and two scholarly questions, one addressing the clinical problem and the other focusing on innovations, to be addressed by an extensive literature review. The project was constructed from a thorough review of the most current literature addressing BCP considerations and the use and efficacy of cerebral oximetry. Throughout the project implementation, correspondence was maintained via email updates and face-to-face meetings with both the project mentor, Thomas Andrews, M.D., and the project chair, Steve Fowler, DNP, CRNA, who both guided the investigators throughout the progression of the project.

A scholarly project proposal was submitted to ADU's Scientific Review Board (SRB) and Institutional Review Board (IRB). Once SRC response and IRB approval or exemption from ADU was obtained, the implementation process of the project was initiated. During the 2017 Fall trimester, an educational PowerPoint (Appendix C) was presented to a convenience sample of 50

SRNAs at ADU from the class of 2017 and 2018. Prior to receipt of the educational PowerPoint (Appendix C), informed consent (Appendix A) was obtained from willing participants and a pre-test (Appendix B) was administered. An identical post-test (Appendix B) was administered immediately after completion of the presentation. Students who did not complete an informed consent (Appendix A), a pre-test and a post-test (Appendix B), and who were not present for the educational lecture were excluded from the study.

The educational PowerPoint (Appendix C) consisted of information gathered from the current body of related research obtained by conducting a thorough literature review. Information obtained from the literature review highlighted the complications and physiology of upright positioning, particularly cerebral desaturation, the role and drawbacks of conventional devices in monitoring cerebral oxygenation, and an overview of the use and efficacy of cerebral oximetry via NIRS. A 30-minute PowerPoint presentation (Appendix C) was given during the Fall 2017 Clinical Conference course of the Nurse Anesthesia Program at ADU on November 16, 2017. Informed consent (Appendix A) was discussed and obtained before the presentation, addressing the nature of the study, potential risks and benefits, and the participants' right to refuse participation in the study. To assess the baseline knowledge of the subjects, a pre-test (Appendix B) consisting of 10 multiple choice questions was given before the presentation. After the PowerPoint presentation, the subjects immediately retook the same 10 question written test (post-test) (Appendix B). When the pre-and post-test results were graded, the mean test scores were emailed to Dr. Lukman (ADU's statistician) for statistical analysis (Appendix D). Anonymity was assured by extracting personal identifiers on the written assessments. Data generated was stored on a personal laptop, therefore not accessible to the general public, but only to the investigators, to be destroyed upon completion of the research study.

Timeline

The final presentation took place in the Fall of 2017 on November 16, 2017. The proposed study was introduced to the first and second year SRNAs with a PowerPoint presentation (Appendix C). A pre-and post-test (Appendix B) was given, and the test results (Appendix D) were reviewed. Project implementation commenced through analysis of the data for statistical value, and the results were used to construct an informational poster board for a visual depiction of the scholarly project to be presented at the Graduate Poster Board Presentation at ADU in April 2018.

- August-December 2017: Scholarly Project presentation (November 16, 2017), implement plan and collect data from pre-and post-tests.
- January-April 2018: Analyze all data and findings and formulate results and conclusions; complete final draft of the paper; develop the poster presentation and complete any additional project requirements.

Data Collection

Informed consent (Appendix A) was signed and received by the willing subjects, who were then given a 10 question pre-test (Appendix B) highlighting pertinent information to be covered in the presentation by the investigators. The pre-test (Appendix B) was collected by the investigators upon its completion. A 30-minute PowerPoint lecture (Appendix C) was given, and immediately following the conclusion of the presentation, a post-test (Appendix B), consisting of the exact same questions as the pre-test, was distributed to and taken by all the subjects. All the tests were collected by the investigators for evaluation.

Evaluation

When all the tests were scored, the data was entered into a simple Excel spreadsheet (Appendix D). This data was then given to the ADU statistician, Dr. Lukman, and analyzed through the computer program SPSS. Using paired *t*-test analysis utilized with a conventional significance level of **$p < 0.001$**, the data was examined for a difference between the mean pre and mean post-test scores to quantify the efficacy of the PowerPoint presentation (Appendix C) given to the subjects. The aim was to see an increase in the mean post-test scores as compared to the mean pre-test scores, to assure the PowerPoint presentation (Appendix C) was effectively in increasing the knowledge base of the subjects.

Results/Findings

The paired samples *t*-test was conducted for data analysis. The pre-test scores revealed a mean score of 39.3478%, with a standard deviation of 18.79%, and a standard error mean of 2.77%. The results of the post-test displayed a mean score of 77.3913%, with a standard deviation of 18.31%, and a standard error mean of 2.67%. The mean increase in scores from the pre-test to the post-test was 38.04%. The obtained *t*-value was -10.142 **($p < .001$).** See "Appendix D" for a more detailed illustration of the results.

Conclusion/Limitations

According to our findings, it is evident that there was a significant knowledge base deficit regarding the management of BCP, namely CDEs, and the use of cerebral oximetry as a tool in caring for patients undergoing procedures in the BCP. The mean pre-test score was only 39.3478%. Results from the pre and post-test (Appendix B) administered to the subjects showed a significant increase in the students' knowledge **base as the mean** test scores revealed a 38.04%

increase from the initial mean pre-test scores following the educational lecture, indicating the efficacy of the PowerPoint presentation (Appendix C) as an educational tool for the ADU SRNAs. The negative *t*-value (-10.142) confirms that there was a significant increase in the mean scores. This obtained *t*-value corresponds to a p-value of <.001, further indicating statistical significance as this is well below the cut-off p-value of .05. The investigators concluded that there was, indeed, a need for educating the undergraduate SRNAs to increase their knowledge base as future anesthesia providers as it is not uncommon for this cohort to encounter patients in BCP in the future. The presentation was effective and the goal effectively achieved, as evidenced by the significant increase in mean post-test scores.

Although the overall results exceeded the investigators' expectations and the goal was successfully met, several limitations were noted throughout the progression of this scholarly project. First, the small convenience sample population of SRNAs may not have been adequate to truly quantify a significance in the results. It was initially our goal to have a sample size reflecting all the students from the junior and senior ADU SRNAs; however, not all the prospected students were accounted for, as only 46 informed consent forms (Appendix A) were received, therefore, four students were excluded from the study Secondly, the knowledge gap between the junior and senior students could have skewed the results. There is no way to tell if students unaccounted for in the study were juniors or seniors; however, there may have been a change in the statistical analysis if they were accounted for. Lastly, due to time constraints, there was limited time to lecture on the material, and the post-test (Appendix B) was given immediately after which may have limited the ability to not only further increase knowledge, but adequately assess knowledge retention. Furthermore, only 10 minutes was given to the students to complete the pre-test (Appendix B) and 10 minutes for the post-test (Appendix B) which may have rushed the SRNAs in their completion of the exams. In conclusion, the aim of this scholarly research project was to expand the knowledge base of ADU SRNAs to better prepare them to safely and competently manage and optimize the care for patients undergoing procedures in the BCP. The mean scores between pre-test (Appendix B) and post-test (Appendix B) increased significantly, therefore, it can be concluded that the educational PowerPoint lecture (Appendix C) was a successful and necessary aid in helping the investigators reach their goal. The knowledge gained through the teaching module can be used by the SRNAs in the clinical setting, and be utilized throughout their anesthesia career, thus improving patient safety. The clinical implications of this research project would be to present the PowerPoint presentation (Appendix C) to future nurse anesthesia students to continue to grow the body of knowledge across the anesthesia community and mitigate knowledge gaps pertaining to the management of BCP and cerebral oximetry as a useful monitor for patients in the BCP, as the statistical analysis proved the teaching module to be effective.

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APPENDIX A

ADU NAP CAPSTONE PROJECT – INFORMED CONSENT

Our names are Ettinas T. Mzumara and Sheneka Ware, and we are MSNA students in the Nurse Anesthesia Program (NAP) at Adventist University of Health Sciences (ADU). We are presenting a Scholarly Project entitled *Cerebral Desaturation in Beach Chair Position: Optimizing the Quality of Care*. This project was guided under the supervision of Steve Fowler DNP, CRNA and Thomas Andrews M.D. We invite you to participate in this project. The primary objective of this consent is to provide information about the project so you may decide whether or not you want to participate.

WHAT IS THE PROJECT ABOUT?

The purpose of this project is to educate the junior and senior classes of student registered nurse anesthetists (SRNAs) currently attending ADU, regarding the management of patients undergoing procedures in the beach chair position (BCP), in particular, the recognition, prevention, and treatment of cerebral desaturation events, as proposed by the current literature. We also want to make aware of any optimal monitoring devices that may enhance the quality of care for this population of patients utilizing BCP.

WHAT DOES PARTICIPATION IN THIS PROJECT INVOLVE?

If you decide to participate in this project, you will be asked to complete an anonymous pre-test attend a 30-minute classroom presentation, and then complete an anonymous post-test. The assessment will address the complications and physiology of upright positioning, particularly cerebral desaturation, the drawbacks of conventional devices in monitoring cerebral oxygenation, and an overview of the use and efficacy of cerebral oximetry via NIRS (near-infrared spectroscopy) monitoring system. Your participation by attendance at the presentation and completion of the survey is anticipated to take approximately 60 minutes.

WHY ARE YOU BEING ASKED TO PARTICIPATE?

You have been invited to participate as part of a convenience sample of the 2017-2018 students currently enrolled in the ADU Nurse Anesthesia Program. Participation in this project is voluntary. If you choose not to participate or to withdraw from the project, you may do so at any time. You also may refuse to answer any question asked of you at any point in the project.

WHAT ARE THE RISKS INVOLVED IN THIS PROJECT?

Although no project is entirely risk-free, we do not anticipate that you will be harmed or distressed by participating in this project.

ARE THERE ANY BENEFITS TO PARTICIPATION?

We do not expect any direct benefits to you from participation in this project. The possible indirect benefit of involvement in the project is the opportunity to gain additional knowledge about evidence-based data regarding monitoring and management of the negative effects associated with patients undergoing procedures in the BCP. This, therefore, may lead to improved patient safety.

HOW WILL THE INVESTIGATORS PROTECT PARTICIPANTS' CONFIDENTIALITY?

To maintain the confidential nature of this study, the results of the project will be published excluding your name or identity. Confidentiality of the assessments will be assured as the investigators will utilize a randomized numbering system that includes the same numerical identification for the pre-assessment as well as the post-assessment instead of using the participants' names. This will assure that the investigators will not have access to the participants' identities.

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

Your participation will cost approximately 60 minutes of your time but will require no monetary cost on your part. Furthermore, you will not be paid to participate.

VOLUNTARY CONSENT

By signing this form, you are saying that you have read this form in its entirety, you understand the risks and benefits of this project, and you are aware of what you are being asked to do. The investigators will be happy to answer any questions you have about the project. If you have any questions, please feel free to contact Ettinas T. Mzumara (ettinas.mzumara@my.adu.edu) or Sheneka Ware (sheneka.ware@my.adu.edu). If you have concerns about the process of this project or the investigators, please contact the Nurse Anesthesia Program at (407) 303-9331.

____ ________________

Participant Signature Date

____

Participant Name (PRINTED LEGIBLY)

APPENDIX B

ADU SCHOLARLY PROJECT PRE-AND POST-TEST QUESTIONS

Bold = Correct Answer

1. In order to minimize cerebral hypo-perfusion in the beach chair position (BCP), the mean arterial pressure (MAP) should be maintained greater than how many mmHg?
   a. 70
   b. 60
   c. 90
   d. 80

2. What are cerebral desaturation events (CDEs)?
   a. A 20% or GREATER decrease in baseline regional cerebral tissue oxygen saturation.
   b. A 20% or LOWER increase in baseline regional cerebral tissue oxygen saturation.
   c. A 15% or GREATER decrease in baseline regional cerebral tissue oxygen saturation.
   d. A 15% or LOWER increase in baseline regional cerebral tissue oxygen saturation.
3. Standard monitors used in procedures in the beach chair position (BCP), as of today, include?
   a. NIBP, EKG, pulse oximetry, ETCO2 and the NIRS (near-infrared spectroscopy)
   b. NIBP, EKG, pulse oximetry, and ETCO2
   c. NIBP, EKG, pulse oximetry, ETCO2, NIRS, and A-line
   d. NIBP, EKG, pulse oximetry, ETCO2, and A-line
4. Which characteristic does not interfere with NIRS readings?
   a. Skin pigmentation
   b. Gender
   c. Variability in the fraction of arterial vs. venous blood in the frontal lobe
   d. Skin temperature
5. When patients are in the upright position, the hydrostatic gradient between the site of the BP cuff and brain perfusion is about ____ mmHg per inch of height differential.
   a. 10
   b. 2
   c. 5
   d. 20
6. Which non-invasive monitor effectively monitors cerebral desaturation?
   a. A-line
   b. Bispectral Index Monitor (Bis Monitor)
   c. Jugular bulb pressure
   d. Cerebral oximetry
7. Which law does NIRS monitoring follow?
   a. Boyle's Law
   b. Gay Lussac’s Law
   c. Beer-Lambert Law

    d. LaPlace's Law
8. What is an alternative method of improving cerebral oxygenation?
    a. Maintaining the ETCO2 30-32 mmHg
    b. Maintaining the ETCO2 40-42 mmHg
    c. Maintaining the ETCO2 50-52 mmHg
    d. ETCO2 makes no difference in cerebral oxygenation
9. What is the most efficient treatment of perioperative cerebral hypoxia?
    a. Vasopressors
    b. Regional anesthesia
    c. Lateral or supine position
    d. Distinguishing an early diagnosis
10. Which problem has the highest reported prevalence during procedures in the BCP?
    a. PONV
    b. Stroke
    c. Cerebral desaturation
    d. Ophthalmalgia

APPENDIX C

1/5/2018

CEREBRAL DESATURATION EVENTS IN BEACH CHAIR POSITION: OPTIMIZING THE QUALITY OF CARE

Ettinas T. Mzumara, BSN, CCRN, RN and Sheneka Ware, BS, MSN, RN
Project Mentor: Thomas Andrews, M.D.
Project Chair: Steve Fowler DNP, CRNA

OBJECTIVES

- Review the anatomy & physiology pertaining to the beach chair position (BCP)
- Discuss adverse events associated with BCP
- Present current, evidence-based clinical guidelines for the assessment and management of BCP, including anesthetic management
- Provide education to increase the knowledge base of ADU SRNAs, regarding the use of cerebral oximetry as a tool in the management of BCP

2

CASE SCENARIO

- **Patient**: 47-year-old, healthy female
- **Sx**: GA for shoulder arthroscopy
- **Preop BP**: 125/83 mmHg
- **Anesthesia**:
  - **Induction**: 50 mg lidocaine, 100 mcg Fentanyl, 200 mg propofol, 100 mg succinylcholine.
  - **Maintenance**: 2% Sevoflurane and oxygen.
  - **Position**: BCP
- 20 mins in case, BP decreased to 100/60 mmHg; systolic BP remained 80-90 mmHg remainder of the case. Oxygen saturation 100% and $ETCO_2$ 30s throughout the case.
- **PACU**: BP 113/60 mmHg, pt unarousable, remained intubated
  - Intervention:
    - Given Narcan 0.1 mg IV, pt remained unresponsive
    - Given 3 more doses of Narcan and 2 doses of physostigmine
- Neuro eval suggestive of possible brain infarction.
- Baseline CT normal initially; 5 days later CT indicative of cerebral edema and obliteration of cistern.
- MRI 1 week later showed changes in both cerebral hemispheres suggesting cortical infarcts.
- Intracranial bleed not evident.
- Pt after 2 weeks
  - Glasgow coma scale 3
  - Fundi clear and crisp.
  - Corneal reflexes, positive gag, negative doll's eyes, hyperreflexive with increased tone, and unresponsive to noxious stimuli in all 4 extremities.
  - Unfortunately, patient expected to remain in a persistent vegetative state.

4

WHAT IS BEACH CHAIR POSITION?

- An upright (sitting) position where head of the patient is 30-90 degrees elevated.
- Common in orthopedics with open shoulder surgeries such as shoulder arthroplasty and arthroscopy
  - Reduces excess stretching to the brachial plexus
  - Enhances exposure and manipulation of the surgical site
  - Better access to airway
- Favored by neurosurgeons for procedures such as posterior fossa and cervical spine repair
  - Enhances visualization and facilit blood and CSF drainage from wo

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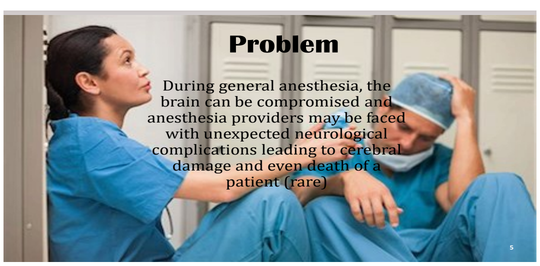

PROBLEM (CONT'D.)

- Cerebral damage may occur as patients in BCP inevitably experience hypotension due to various cofactors including:
  - Hypoxia
  - Decreased partial pressure of carbon dioxide in arterial blood
  - Anesthetic medications
  - Blood loss (anemia)
  - Positioning (elevated head position along with anesthetics will decrease cerebral blood flow which reduces cerebral oxygenation)
  - Increased BMI was found to have a statistically significant association with intraoperative CDE
- Standard monitoring devices used by anesthesia providers have proven unreliable in detecting cerebral desaturation events (CDEs).

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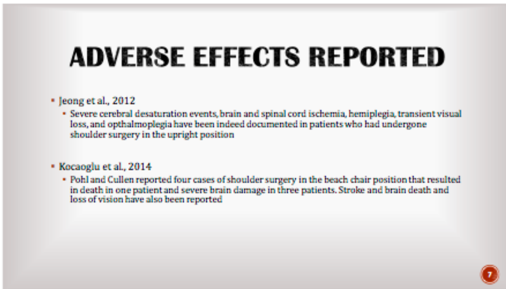
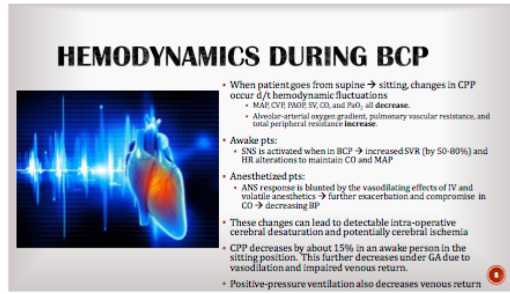
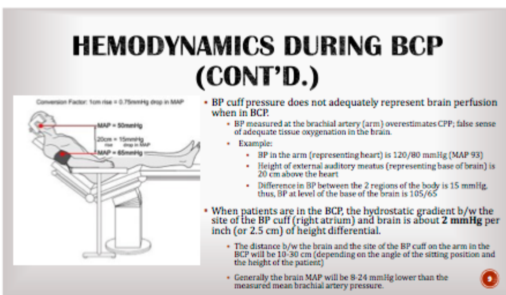
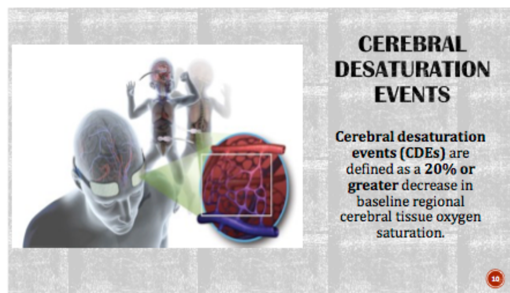
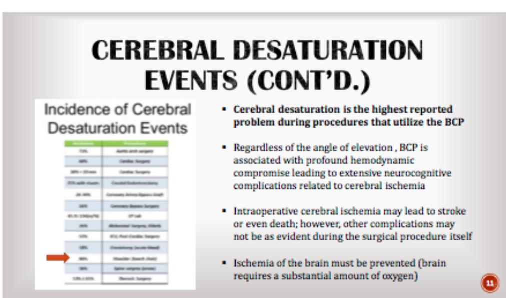
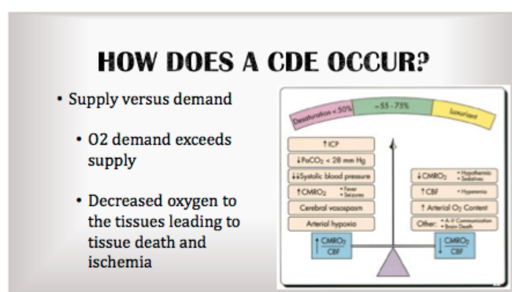

ADVERSE EFFECTS REPORTED
Jeong et al., 2012
Severe cerebral desaturation events, brain and spinal cord ischemia, hemiplegia, transient visual loss, and opthalmoplegia have been indeed documented in patients who had undergone shoulder surgery in the upright position
Kocaoglu et al., 2014
Pohl and Cullen reported four cases of shoulder surgery in the beach chair position that resulted in death in one patient and severe brain damage in three patients. Stroke and brain death and loss of vision have also been reported
7

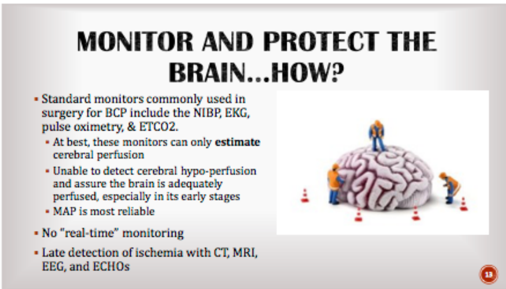

HEMODYNAMICS DURING BCP
When patient goes from supine → sitting, changes in CPP occur d/t hemodynamic fluctuations
MAP, CVP, PAOP, SV, CO, and PaO2 all decrease.
Alveolar-arterial oxygen gradient, pulmonary vascular resistance, and total peripheral resistance increase.
Awake pts:
SNS is activated when in BCP → increased SVR (by 50-80%) and HR alterations to maintain CO and MAP
Anesthetized pts:
ANS response is blunted by the vasodilating effects of IV and volatile anesthetics → further exacerbation and compromise in CO → decreasing BP
These changes can lead to detectable intra-operative cerebral desaturation and potentially cerebral ischemia
CPP decreases by about 15% in an awake person in the sitting position. This further decreases under GA due to vasodilation and impaired venous return.
Positive-pressure ventilation also decreases venous return

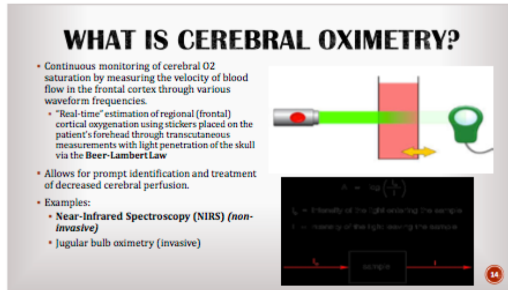

HEMODYNAMICS DURING BCP (CONT'D.)
Conversion Factor: 1cm rise = 0.75mmHg drop in MAP
MAP = 50mmHg
20cm = 15mmHg
rise drop in MAP
MAP = 65mmHg
BP cuff pressure does not adequately represent brain perfusion when in BCP.
BP measured at the brachial artery (arm) overestimates CPP; false sense of adequate tissue oxygenation in the brain.
Example:
BP in the arm (representing heart) is 120/80 mmHg (MAP 93)
Height of external auditory meatus (representing base of brain) is 20 cm above the heart
Difference in BP between the 2 regions of the body is 15 mmHg, thus, BP at level of the base of the brain is 105/65
When patients are in the BCP, the hydrostatic gradient b/w the site of the BP cuff (right atrium) and brain is about 2 mmHg per inch (or 2.5 cm) of height differential.
The distance b/w the brain and the site of the BP cuff on the arm in the BCP will be 10-30 cm (depending on the angle of the sitting position and the height of the patient)
Generally the brain MAP will be 8-24 mmHg lower than the measured mean brachial artery pressure.
9

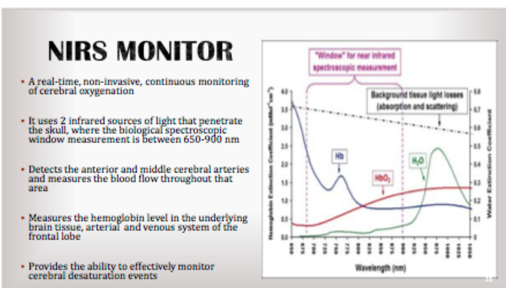

CEREBRAL DESATURATION EVENTS
Cerebral desaturation events (CDEs) are defined as a 20% or greater decrease in baseline regional cerebral tissue oxygen saturation.
10

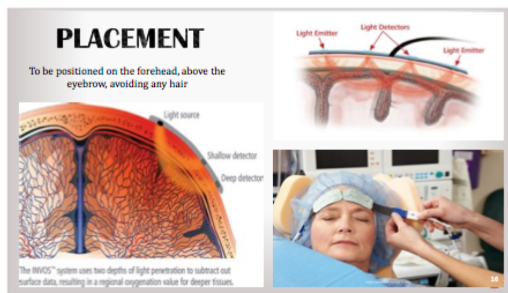

CEREBRAL DESATURATION EVENTS (CONT'D.)
Incidence of Cerebral Desaturation Events
Cerebral desaturation is the highest reported problem during procedures that utilize the BCP
Regardless of the angle of elevation , BCP is associated with profound hemodynamic compromise leading to extensive neurocognitive complications related to cerebral ischemia
Intraoperative cerebral ischemia may lead to stroke or even death; however, other complications may not be as evident during the surgical procedure itself
Ischemia of the brain must be prevented (brain requires a substantial amount of oxygen)
11

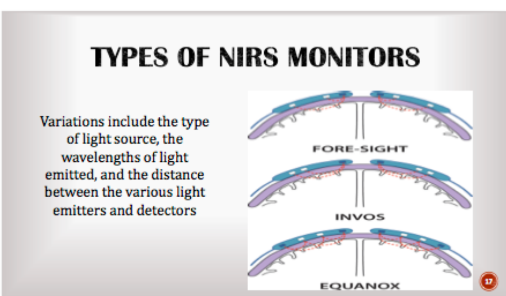

HOW DOES A CDE OCCUR?
Supply versus demand
O2 demand exceeds supply
Decreased oxygen to the tissues leading to tissue death and ischemia
Desaturation < 50%
~55-75%
Saturated
↑ICP
↓PaCO2 < 28 mm Hg
↓↓Systolic blood pressure
↑CMRO2
Cerebral vasospasm
Arterial hypoxia
↓CMRO2
↑CBF
↑ Arterial O2 Content
Other:
CMRO2
CBF

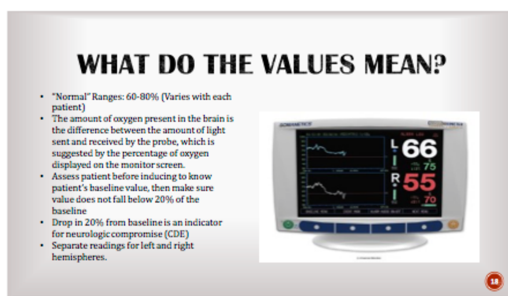

MONITOR AND PROTECT THE BRAIN…HOW?
Standard monitors commonly used in surgery for BCP include the NIBP, EKG, pulse oximetry, & ETCO2.
At best, these monitors can only **estimate** cerebral perfusion
Unable to detect cerebral hypo-perfusion and assure the brain is adequately perfused, especially in its early stages
MAP is most reliable
No "real-time" monitoring
Late detection of ischemia with CT, MRI, EEG, and ECHOs
13


WHAT IS CEREBRAL OXIMETRY?
Continuous monitoring of cerebral O2 saturation by measuring the velocity of blood flow in the frontal cortex through various waveform frequencies.
"Real-time" estimation of regional (frontal) cortical oxygenation using stickers placed on the patient's forehead through transcutaneous measurements with light penetration of the skull via the **Beer-Lambert Law**
Allows for prompt identification and treatment of decreased cerebral perfusion.
Examples:
Near-Infrared Spectroscopy (NIRS) ***(non-invasive)***
Jugular bulb oximetry (invasive)
14

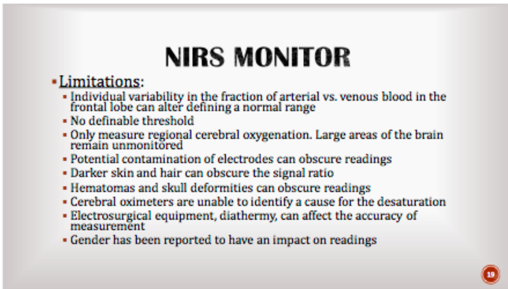

NIRS MONITOR
A real-time, non-invasive, continuous monitoring of cerebral oxygenation
It uses 2 infrared sources of light that penetrate the skull, where the biological spectroscopic window measurement is between 650-900 nm
Detects the anterior and middle cerebral arteries and measures the blood flow throughout that area
Measures the hemoglobin level in the underlying brain tissue, arterial and venous system of the frontal lobe
Provides the ability to effectively monitor cerebral desaturation events
"Window" for near infrared spectroscopic measurement
Background tissue light losses (absorption and scattering)
Hb
HbO2
H2O
Wavelength (nm)
Water Extinction Coefficient

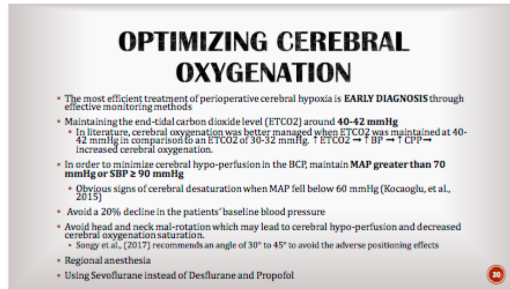

PLACEMENT
To be positioned on the forehead, above the eyebrow, avoiding any hair
Light Emitter
Light Detectors
Light Emitter
Light source
Shallow detector
Deep detector
The INVOS™ system uses two depths of light penetration to subtract out surface data, resulting in a regional oxygenation value for deeper tissues.
16

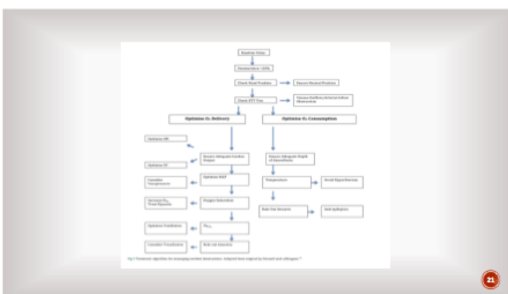

TYPES OF NIRS MONITORS
Variations include the type of light source, the wavelengths of light emitted, and the distance between the various light emitters and detectors
FORE-SIGHT
INVOS
EQUANOX
17


WHAT DO THE VALUES MEAN?
"Normal" Ranges: 60-80% (Varies with each patient)
The amount of oxygen present in the brain is the difference between the amount of light sent and received by the probe, which is suggested by the percentage of oxygen displayed on the monitor screen.
Assess patient before inducing to know patient's baseline value, then make sure value does not fall below 20% of the baseline
Drop in 20% from baseline is an indicator for neurologic compromise (CDE)
Separate readings for left and right hemispheres.
L 66
75
R 55
70
18

1/5/2018


NIRS MONITOR
Limitations:
Individual variability in the fraction of arterial vs. venous blood in the frontal lobe can alter defining a normal range
No definable threshold
Only measure regional cerebral oxygenation. Large areas of the brain remain unmonitored
Potential contamination of electrodes can obscure readings
Darker skin and hair can obscure the signal ratio
Hematomas and skull deformities can obscure readings
Cerebral oximeters are unable to identify a cause for the desaturation
Electrosurgical equipment, diathermy, can affect the accuracy of measurement
Gender has been reported to have an impact on readings
19


OPTIMIZING CEREBRAL OXYGENATION
The most efficient treatment of perioperative cerebral hypoxia is EARLY DIAGNOSIS through effective monitoring methods
Maintaining the end-tidal carbon dioxide level (ETCO2) around 40-42 mmHg
In literature, cerebral oxygenation was better managed when ETCO2 was maintained at 40-42 mmHg in comparison to an ETCO2 of 30-32 mmHg. ↑ETCO2 → ↑BP → ↑CPP → increased cerebral oxygenation.
In order to minimize cerebral hypo-perfusion in the BCP, maintain MAP greater than 70 mmHg or SBP ≥ 90 mmHg
Obvious signs of cerebral desaturation when MAP fell below 60 mmHg (Kocaoglu, et al., 2015)
Avoid a 20% decline in the patients' baseline blood pressure
Avoid head and neck mal-rotation which may lead to cerebral hypo-perfusion and decreased cerebral oxygenation saturation.
Songy et al., (2017) recommends an angle of 30° to 45° to avoid the adverse positioning effects
Regional anesthesia
Using Sevoflurane instead of Desflurane and Propofol
20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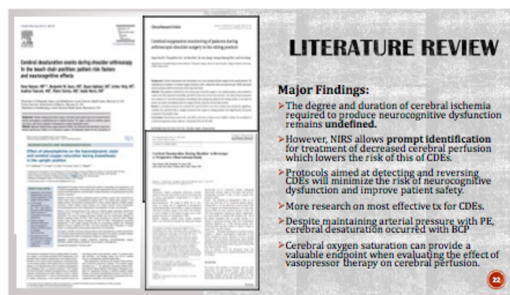
LITERATURE REVIEW
Major Findings:
The degree and duration of cerebral ischemia required to produce neurocognitive dysfunction remains undefined.
However, NIRS allows prompt identification for treatment of decreased cerebral perfusion which lowers the risk of this of CDEs.
Protocols aimed at detecting and reversing CDEs will minimize the risk of neurocognitive dysfunction and improve patient safety.
More research on most effective tx for CDEs.
Despite maintaining arterial pressure with PE, cerebral desaturation occurred with BCP
Cerebral oxygen saturation can provide a valuable endpoint when evaluating the effect of vasopressor therapy on cerebral perfusion.
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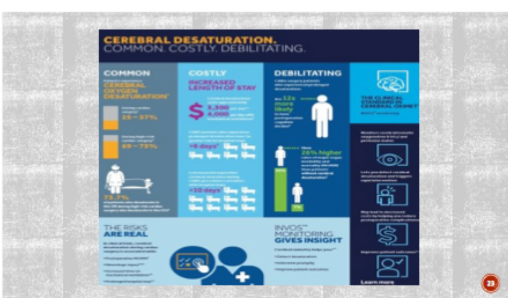
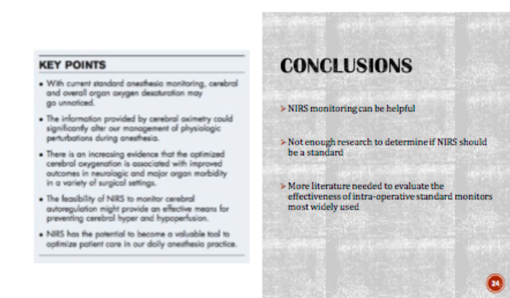

CEREBRAL DESATURATION.
COMMON. COSTLY. DEBILITATING.
23


KEY POINTS
With current standard anesthesia monitoring, cerebral and overall organ oxygen desaturation may go unnoticed.
The information provided by cerebral oximetry could significantly alter our management of physiologic perturbations during anesthesia.
There is an increasing evidence that the optimized cerebral oxygenation is associated with improved outcomes in neurologic and major organ morbidity in a variety of surgical settings.
The feasibility of NIRS to monitor cerebral autoregulation might provide an effective means for preventing cerebral hyper and hypoperfusion.
NIRS has the potential to become a valuable tool to optimize patient care in our daily anesthesia practice.
CONCLUSIONS
NIRS monitoring can be helpful
Not enough research to determine if NIRS should be a standard
More literature needed to evaluate the effectiveness of intra-operative standard monitors most widely used
24

FUTURE ANESTHETIC IMPLICATIONS

- Regional anesthesia
- More research on cerebral oximetry
- Use of cerebral oximetry with getting the baseline value on each patient before giving any anesthetic medication
- Placing NIRS on in Pre-op to get baseline values (may not be very appealing to the eye but it's safe!)
- Education on proper use and understanding of values
- Education on proper treatment of CDEs

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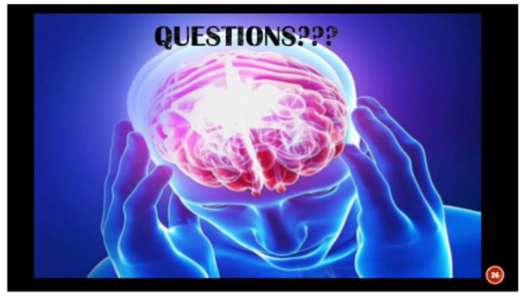

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Appendix D

Total number of subjects: 46

Pre-Test Scores	Post-Test Scores
50%	90%
50%	30%
60%	90%
40%	40%
50%	80%
50%	80%
50%	70%
10%	70%
60%	60%
20%	50%
60%	70%
40%	90%
30%	60%
30%	70%
50%	80%
50%	70%
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60%	100%
30%	100%
10%	100%
20%	100%
30%	100%
60%	70%
60%	100%
50%	70%
80%	80%
40%	100%
50%	90%
10%	90%
40%	90%
60%	100%

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	39.3478	46	18.78559	2.76978
	Post-Test	77.3913	46	18.31026	2.69970

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 1	Pre-Test - Post-Test	-38.04348	25.44009	3.75094	-45.59825	-30.48870	-10.142	45	.000