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Cerebral Oximetry Readings in the Sitting Position Versus Supine Position for Patients Undergoing General Anesthesia

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CEREBRAL OXIMETRY READINGS IN THE SITTING POSITION VERSUS SUPINE POSITION FOR PATIENTS UNDERGOING GENERAL ANESTHESIA

by

Christopher Bradley Turner

Abstract of a Capstone Project
Submitted to the Graduate School
and the Department of Advanced Practice
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ABSTRACT

CEREBRAL OXIMETRY READINGS IN THE SITTING POSITION VERSUS SUPINE POSITION FOR PATIENTS UNDERGOING GENERAL ANESTHESIA

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Problem: Inadequate cerebral blood flow is a significant risk for patients undergoing surgery in the sitting position. Placing the patient in a sitting position may cause a drop in pressure at the level of the brain when compounded with induction and maintenance of general anesthesia. These changes may cause a decrease in cerebral blood flow and oxygenation. Inadequate perfusion for a prolonged period of time could produce negative neurological consequences in the short and long term postoperative period.

Purpose: The purpose of this project is to determine if there is a significant drop in cerebral oximetry, from baseline, when patients are placed in the sitting position for surgery, while under general anesthesia.

Methodology: Data were collected on 50 patients who underwent surgery in the sitting position. The following information was gathered retrospectively for each subject studied: Left and right hemisphere cerebral oximetry readings, age, gender, ASA score, temperature, end-tidal carbon dioxide ($ETCO_2$), blood pressure, and fraction of inspired oxygen (FiO_2). A repeated measures analysis of variance (ANOVA) was used for statistical analysis.

Results: A decrease in LCOR readings was noted between initial (M=71.46, SD=5.97) and 15 minute post sitting position (M=68.96, SD=6.55), a

statistically significant mean decrease of 2.5, 95% CI [0.95, 4.05], *p*=0.001. There was also a decrease in LCOR readings between initial (*M*=71.46, *SD*=5.97) and 30 minute post sitting position (*M*=68.86, *SD*=6.85), a statistically significant mean decrease of 2.6, 95% CI [0.84, 4.36], *p*=0.002. A decrease in RCOR readings was noted between initial (*M*=71.92, *SD*=5.88) and 15 minute post sitting position (*M*=69.12, *SD*=6.83), a statistically significant mean decrease of 2.8, 95% CI [1.01, 4.59], *p*=0.001. There was also a decrease in RCOR readings between initial (*M*=71.92, *SD*=5.88) and 30 minute post sitting position (*M*=68.36, *SD*=7.54), a statistically significant mean decrease of 2.56, 95% CI [0.37, 4.75], *p*=0.017.

Conclusion: Statistically significant differences were determined between initial cerebral oximetry readings and 15 minute post sitting position readings, as well as between initial readings and 30 minute post sitting position readings. This difference was noted for both left and right hemispheres.

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A Capstone Project
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LIST OF ABBREVIATIONS

AANA	American Association of Nurse Anesthetists
ANOVA	Analysis of Variance
ASA	American Society of Anesthesiologists
BCP	Beach Chair Position
CABG	Coronary Artery Bypass Graft
CBF	Cerebral Blood Flow
CDE	Cerebral Desaturation Event
CNS	Central Nervous System
CPP	Cerebral Perfusion Pressure
EPIC	Electronic Patient Integrated Care
$ETCO_2$	End-Tidal Carbon Dioxide
FiO_2	Fraction of Inspired Oxygen
ICP	Intracranial Pressure
IRB	Institutional Review Board
LCOR	Left Cerebral Oximetry Reading
LDP	Lateral Decubitus Position
MAP	Mean Arterial Pressure
NIRS	Near Infrared Spectroscopy
mmH_2O	Millimeter of Water
mmHg	Millimeter of Mercury
RCOR	Right Cerebral Oximetry Reading
rSO2	Cerebral Oxygen Saturation

SaO_2	Arterial Blood Oxygen Saturation
SCIP	Surgical Care Improvement Project
SpO_2	Peripheral Capillary Oxygen Saturation
SPSS	Statistical Package for the Social Sciences

CHAPTER I

INTRODUCTION

Anesthesia personnel provide anesthetics to every kind of patient imaginable. Once in the operating room, patients are under the care of the surgical team, and for most cases, under general anesthesia. This places homeostatic care in the hands of the anesthesia provider, who uses instruments to monitor and maintain the patient's vital signs while administering medication to maintain anesthetic depth. Every patient that undergoes general anesthesia is at risk of having a compromised airway in some form or manner. Anesthetics decrease or even eliminate the patients drive to breathe. This is why airway protection and ventilator support are needed. A prolonged lack of oxygen delivery to the brain could result in permanent neurological consequences.

Inadequate cerebral perfusion is a significant risk for patients undergoing shoulder surgery, or any surgery, in the sitting position. Placing the patient in a sitting position periodically causes a drop in perfusion pressure at the level of the brain when compounded with induction and maintenance of general anesthesia. These changes may cause a decrease in cerebral oxygenation. Inadequate perfusion for a prolonged period of time could produce negative neurological consequences in the short and long term postoperative period (Murphy et al., 2010). Declination of cerebral oximetry readings may also allude to insufficiency of other vital organs and tissues that can help direct provider response before permanent tissue damage occurs.

Traditionally, pulse oximetry is used on every patient to monitor oxygenation status. Commonly, it is placed on the finger, the ear, or the forehead. Pulse oximetry was originally developed in Japan in the 1970s, but didn't make its way into practice until the following decade. It uses two associated wave lengths of light, red and infrared. Red measures absorption into saturated hemoglobin while infrared measures desaturated hemoglobin. The monitor then takes this information and compares it to a database of information gathered in research of healthy individuals who were administered hypoxic levels of oxygen for calibration. Detecting peripheral capillary oxygen saturation (SpO_2) below 70% is very inaccurate. Alternatively, there is about 2% accuracy for saturation values above 90%. Pulse oximetry is cheap and effective in most surgeries, but the problem persists that it has a significant delay in comparison to cerebral oximetry, and does not provide information on cerebral oxygenation (Casey, 2011).

Cerebral oximetry and pulse oximetry have some similarities. They both use infrared light to determine oxygen saturation, have a light source, a light detector, and a unit to process the light signals to finally calculate oxygen saturation. Both of these technologies measure tissue absorption, but there are also many differences. Tissue absorption signals contain two different components: pulsatile and non-pulsatile. Non-pulsatile is greater than 100 fold stronger than pulsatile. Pulse oximetry looks at the weaker pulsatile view, which proves to be very inaccurate when inadequate blood flow is present. In opposition, cerebral oximetry looks at the much stronger, non-pulsatile view, which is not susceptible to failure related to perfusion. Both technologies are susceptible to inaccurate readings related to ambient light interference or motion artifact (Kurth, 2006).

A third option is near infrared spectroscopy (NIRS). This technology is also noninvasive and is another form of cerebral oximetry. According to Kurth (2006), the major difference is in what the monitor reads and how it is interpreted. NIRS measures oxyhemoglobin, deoxyhemoglobin and cytochrome aa_3. The concentrations of each are determined and an oxygen saturation is calculated. A main difference between NIRS and cerebral oxygen monitoring is that NIRS can be placed on extremities and muscle tissue saturation can be measured (Kurth, 2006). It is versatile in its usage.

The problem at hand is a drop in cerebral oximetry readings when patients enter the sitting position, which has a tendency to decrease blood flow to the brain. This technology, not very commonly in use, could help reduce the incidence of neurological injury related to such an incident. The need is to determine if the difference is significant enough to warrant a change in practice. Strengths include defining the difference in cerebral perfusion/oximetry between sitting and supine positioning. This could help decide if it is safer to choose another surgical position.

There is an opportunity to decrease neurological deficits and damage with adequate and timely pharmocologic or positional response to drops in cerebral perfusion. Detection of cerebral desaturation is not possible with traditional pulse oximetry. This raises the argument that cerebral oximetry monitoring is an important supplementary system for patients who are at risk for cerebral desaturation.

The purpose of this project is to determine if there is a significant drop in cerebral oximetry when patients are placed in the sitting position for surgery under general anesthesia. This position is frequently used, but cerebral oximetry monitoring is not currently available in most facilities. The research question being assessed is: In patients undergoing surgery with general anesthesia, does the sitting position, compared to the supine position, cause a significant reduction in cerebral oximetry readings?

Theoretical Framework

Nursing theory provides a foundation for nursing practice. The ideation is somewhat of a guide to patient care and how to improve practice and outcomes. The need for application of nursing theory in relation to this capstone project resulted in the discovery of Neuman's Systems Model. As stated by Neuman (2011), the model is "a comprehensive systems-based conceptual framework for nursing and other health care disciplines that is concerned with stressors, reactions to stressors, and the prevention interventions that address potential and actual reactions to stressors" (p. 13). She further points out five variables related to functional harmony. These variables, "physiological, psychological, sociocultural, developmental, and spiritual" must all be considered while managing patient care (p. 13). The hospital setting provides an environment that is full of stress. Neuman (2011) identifies stress as "…tension-producing stimuli with the potential for causing system instability" (p. 21). Stress can originate from any of the five aforementioned variables, and be perceived differently from one client to the next. This is why it is important to assess and treat each client individually based on their perception of the stressor. How the client is treated will help determine whether or not they have a positive hospital encounter. With this in mind, it is an important aspect of patient care to prevent as much stress as possible. This aids in providing the highest possible level of comfort and satisfaction.

According to Eldridge (2014), this model, developed in 1970, describes three different levels of prevention. These three levels of prevention, primary, secondary, and tertiary, are in place to support patient wellness. Primary prevention is the prevention of illness before symptoms arise. Health promotion is the goal (Neuman, 2011). Next is secondary prevention. The aim is to strengthen the patient's own endogenous resistance mechanisms after symptoms arise (Eldridge, 2014). Finally, tertiary prevention focuses on maintenance of wellness with system support (Eldridge, 2014).

Whetsell, Gonzalez, and Moreno-Fergusson (2011) further elaborate on Neuman's systems model by describing it as "…a comprehensive guide for nursing practice, research, education, and administration…" (p. 429). It can be applied to practically any aspect of the patient care spectrum. Specifically, this model concentrates on response to stressors and usage of the three levels of prevention to promote wellness (Whetsell et al., 2011).

Neuman's systems model, by Neuman (2011), can be applied to the field of anesthesia from multiple angles. One main purpose of anesthesia is to blunt the patient's response to stressors, both physical and emotional. The primary prevention stage of anesthesia comes with a thorough preoperative evaluation. Identification of potential risk factors aides in the development of a patient specific plan of care. Existing conditions and morbidities lead the anesthesia provider to determine what types of medications will, and will not, be used. Additionally, physical examination determines induction technique and what type of hardware or assistance is necessary. An example of secondary prevention is treating a drop in blood pressure with a vasopressor. Lastly, tertiary prevention is making adjustments in plan of care as well as administering agents to maintain blood pressure at a desirable level.

Neuman's systems model, by Neuman (2011), provides a perfect framework for patients undergoing anesthesia in the sitting position. The primary goal of care is to prevent complications associated with this position, while keeping the patient anesthetized throughout the procedure. The three levels of prevention, as applied to every patient who receives an anesthetic, can be applied here as well. There is a need to prevent decline in cerebral oximetry and blood pressure, treat declination that occurs, and maintain pressure and oximetry within acceptable limits. Neuman's systems model, when applied to practice, will help guide patient care, improve patient outcomes, and increase perioperative patient satisfaction.

CHAPTER II

REVIEW OF LITERATURE

To understand the effects certain surgeries have on the body, a basic understanding of the body and hemodynamic mechanisms, as well as their effect on cerebral blood flow and oxygenation is needed. In most cases, it is a general understanding that the high end of normal blood pressure is around the range of 120/80 mmHg. Significant levels above this range, greater than 140/90 mmHg, are referred to as hypertensive (Nagelhout & Plaus, 2013). On the other hand, significant levels below the normal range are referred to as hypotensive. These terms are relative and can vary depending on numerous factors such as illness, genetics, disease process, physical condition, diet, and age. With prominence of obesity and diabetes in the southern United States, hypertension is a very common finding in the surgical patient. An important thing to remember is that the patient with chronic hypertension will most likely be on medications to help control their blood pressure. As a SCIP (Surgical Care Improvement Project) measure, the patient needs to have taken their beta blockers the day of surgery, and care must be taken intraoperatively to keep the patients pressure from dropping below their normal limits. As stated by Hines and Marschall (2012), fluctuations in heart rate and blood pressure should be avoided, and it is a good rule of thumb to keep the blood pressure and heart rate within 20% of the patient’s normal value.

Hemodynamics

According to Fischer (2009), roughly 20% of the human body’s oxygen delivery is consumed by the brain. In the surgical setting, medications are given that have an effect on the patient’s blood pressure. Depending on the type and dose of medication, the patient’s normal regulatory mechanisms may not be able to maintain an adequate blood pressure that is needed to perfuse vital organs, such as the brain. An example of such a mechanism is explained by Nagelhout and Plaus (2013) as the “ischemic mechanism” of the central nervous system (CNS), which is a system that quickly responds when there are changes in blood pressure to a troublesome level below the normal range. If this occurs, the body attempts to recover the pressure to a level that the brain and other vital organs receive proper blood flow. When this and other regulatory mechanisms fail, volume restoring fluids or pharmacologic agents must be administered intravenously to counteract the drop in blood pressure, depending on the initial cause.

If blood pressure is not corrected, ischemic events can take place and result in cognitive impairment or tissue ischemia. Since this concept is of such high importance, guidelines have been developed to ensure adequate care is delivered. The American Association of Nurse Anesthetists (AANA) Scope and Standards of Nurse Anesthesia Practice states, under Standard V, that blood pressure, as well as heart rate must be documented at a minimum of every five minutes. The AANA further states that documentation of blood pressure should be every minute during the induction period because of the common blood pressure reduction associated with anesthetics. Documentation frequency should also be increased if the patient has a disease process that increases susceptibility to blood pressure depression.

Blood Pressure Maintenance

A thorough history and physical is essential to consider when a patient exhibits a drop in blood pressure or an increase in heart rate. For most patients, the increase in pressure can be attributed to stimulation and irritation related to direct laryngoscopy during intubation, being light on anesthesia, or having a physiologic response to a painful stimulus. In this situation, if the blood pressure and other vital signs warrant, pain medication or an increase in anesthetic depth may alleviate these symptoms. Another situation to consider is a reduction in the patient's vascular volume. The patient may be experiencing intravascular dehydration, which can cause an increase in heart rate, as well as a reduction in blood pressure (Nagelhout & Plaus, 2013). It is always important to consider these situations before administering vasopressor or beta-blocker type medications.

Intracranial Pressure

The location of the brain within the hard shell of the skull can be great for protection, but have negative effects if swelling occurs, or pressure is elevated within. Therefore, an increase in volume can cause an associated elevation of intracranial pressure (ICP) when regulatory mechanisms are exhausted. Stated in Nagelhout and Plaus (2013), normal values range from five to fifteen mm H_2O in the adult population. Intracranial pressure is a direct force that must be overcome by systemic blood pressure in order for proper perfusion of the brain to occur. This pressure, known as cerebral perfusion pressure (CPP) is calculated by subtracting ICP from the mean arterial pressure (MAP). If ICP reaches levels above 30 mmHG, cerebral blood flow (CBF) is inhibited in a progressive manner, causing a repetitive cycle of ischemia followed by edema, which causes further elevation in pressure (Nagelhout & Plaus, 2013). If this cascade is not treated, or the pressure is not relieved, death is most likely the end result.

Patients without ICP issues still see related effects from anesthetics. Systemically, reduction in MAP, plus the aforementioned increase in ICP, causes a reduced CPP. Severity of these effects is in relation to dose, as well as type of anesthetic. Isoflurane causes the highest elevation in cerebral blood flow and ICP, with sevoflurane and desflurane next in line. Nagelhout and Plaus (2013) concludes that often gentle hyperventilation can offset these elevations in ICP.

Under normal circumstances, where there is no tumor, bleed, or other pathology present to cause an increase in pressure, the body has a mechanism is place to counteract changes in ICP. This process, known as autoregulation, allows proper blood flow to an organ by dilation or constriction of vessels in response to changes in pressure (Nagelhout & Plaus, 2013). According to Yang, Wang, Chiang, and Peng (2003), this autoregulatory response supports steady cerebral blood flow even throughout broad changes in pressure. This effect also regulates pressure during positional changes. Pressure and blood flow throughout the entire body is not static. The body is very dynamic in the way it responds to changes and possible insults. Regulatory mechanisms that normally maintain homeostasis are sometimes compromised whether it is by invasive surgery or naturally occurring disease processes such as cancer or brain tumors. Autoregulation only compensates for a certain amount of change. It stops working properly once intracranial pressure exceeds 30 mm Hg (Yang et al., 2003). Once the body can no longer compensate for changes in pressure elevation, tissue damage will begin to occur. If elevated ICP is of significance during the intraoperative period, there are many ways to address the pressure depending on the cause. The treatment methods include, but are not limited to, (a) hyperventilation, (b) increasing anesthesia depth, (c) use of diuretics, (d) drainage of cerebrospinal fluid, (e) head elevation, and (f) cerebral vasoconstriction (Nagelhout & Plaus, 2013). Patients with no underlying issues that predispose them to elevations in ICP are not at particular risk under normal induction circumstances because of the aforementioned autoregulatory response to changes in pressure.

Cardiac Surgery

One major area of concern, and where the problem of adequate cerebral perfusion seems to be very prominent, is with the patient undergoing cardiac surgery. Newman et al. (2001) found that patients who show a decline in cognitive function immediately following surgery, which occurs in around 50% of coronary artery bypass graft (CABG) patients, have a higher risk for long lasting decline in cognitive ability and function. This makes apparent the risk involved with CABG surgery in relation to inadequate oxygen supply secondary to decreased blood flow, and can have a negative effect on every aspect of the patient’s life. Newman et al. (2001) showed further conclusion that there is a great clinical significance in impaired cognitive ability seen early on in the post coronary artery bypass grafting period, and is an indication of future cognitive decline. This means that cognitive declination seen post-operatively shows a correlation to prolonged cognitive impairment. Cerebral oximetry is used as a guide to manage patients intraoperatively, and evidence shows that outcomes are improved for cardiac surgery patients (Cowie, Nazareth, & Story, 2014). This is one major area that cerebral oximetry could be of great benefit to patient care.

Shoulder Surgery

Shoulder surgery is a very common orthopedic procedure. A large number of these surgeries are done in the sitting (beach chair) position. Pohl and Cullen (2005) point out that the sitting position began to be used more frequently in the mid to late 1980’s after correlations between the lateral decubitus position and brachial plexus and forearm nerve injuries began to be noticed and reported. They further explained that performing surgery on the shoulder in the sitting position can be executed without excessive manipulation of the joint anatomy and without causing impingement of the brachial plexus. The problem at hand is a possible drop in cerebral oximetry readings when patients enter the sitting position, which has a tendency to decrease cerebral perfusion pressure (CPP) and blood flow to the brain. In a study done by Ko et al. (2012), results revealed that regional hemoglobin oxygen saturation (rSO_2) significantly decreased when the patient was moved from supine to sitting position. Mean arterial pressure at the level of the brain also dropped with the change in position. Cerebral oximetry technology, not very commonly in use, could help reduce the incidence of neurological injury related to such an event. According to Murphy et al. (2010), the use of the beach chair position reduces strain to the brachial plexus, provides the surgeon better visualization, and allows an easier transition to an open approach if warranted. In the prospective study performed by Murphy et al. (2010), 124 patients were observed who underwent shoulder surgery. Once inclusion and exclusion criteria were met, patients were divided into their study group. Sixty-one patients were placed in the beach chair position (BCP) during the procedure, while sixty-three were placed in the lateral decubitus position (LDP). The results revealed that over 80% of the patients in the beach chair position showed evidence of a cerebral desaturation event (CDE), which was defined as greater than or equal to 20% decline from baseline, or less than or equal to 55% for greater than 15 seconds. Also revealed, was that there was no difference in heart rate, mean arterial pressure (MAP), or peripheral capillary oxygen saturation (SpO_2) between the BCP and LDP groups. This finding is significant in that it shows how unreliable traditional methods can be when monitoring a patient in the beach chair position.

An objective in a study done by Tobias (2008) was to monitor and compare the measurement of cerebral oximetry versus pulse oximetry in patients undergoing periods of apnea during surgery. The study involved patients undergoing laser airway surgery that required alternating phases of apnea and ventilation. This sequence was implemented to reduce the risk of a potential airway fire. During apnea, the time for the arterial blood oxygen saturation (SaO_2)

and regional hemoglobin oxygen saturation (rSO_2) to decrease by 5% (94 ± 8 sec for cerebral oximetry, 146 ± 49 for pulse oximetry) and 10% (138 ± 29 sec for cerebral oximetry, 189 ± 64 for pulse oximetry) were recorded and compared. The study was comprised of 10 patients with an age range from 1 month to 7 years old. Results revealed that cerebral oximetry is substantially faster in detecting desaturation when compared to traditional pulse oximetry.

YaDeau et al. (2011) evaluated a cohort of 99 shoulder surgery patients given intravenous sedation who also received regional anesthesia. No patients in this study underwent general anesthesia. Under these circumstances, a period of cerebral desaturation only occurred in 10% of the patients, while hypotension occurred in 99% of patients. Results revealed that cerebral desaturation occurred more frequently in patients who had risk factors for cerebrovascular disease. In this particular study, hypotension alone, as a cause of cerebral desaturation, could not be definitively ruled out.

Literature Inference

The future of cerebral oximetry is very promising; however, Grocott and Davie (2013) believe that there is not enough evidence yet to conclude which parameter cerebral oximetry is most indicative. Since the body has normal regulatory mechanisms to maintain blood pressure to the brain, is the reduction in cerebral oximetry a late sign of body tissue desaturation? If this is the case, it is possible that brain desaturation is a late sign of other tissue desaturation (Grocott & Davie, 2013). An argument can be made against this theory, in that cerebral oximetry is a supplemental monitoring system. Systemic blood pressure and pulse oximetry is also being monitored, and during major cases, arterial blood sampling is performed. Cerebral oximetry is not a stand-alone system in aiding in prevention of cerebral desaturation.

CHAPTER III

METHODOLOGY

Once approval was granted from the Institutional Review Board (IRB) at the University of Southern Mississippi and the Orthopedic Institute, data collection began. The first step was to obtain initial readings from the anesthesia record while the patient was in the supine position. Readings were then obtained at the fifteen and thirty-minute mark after the patient had been placed in the sitting position. The data was compiled into columns on a spreadsheet representing initial left cerebral hemisphere readings in column one, second readings in column two, and third readings in column three. The same format was followed to record the right hemisphere readings. Additional patient information included in data collection was age, gender, American Society of Anesthesiologist (ASA) classification, temperature, end-tidal CO_2 ($ETCO_2$), blood pressure, and fraction of inspired oxygen (FiO_2). $ETCO_2$, blood pressure, and FiO_2 were recorded at the same times as the cerebral oximetry measurements for comparison. Data was collected from anesthesia records within a 17 month time-frame, ranging from January, 2014, to May, 2015. A repeated measures analysis of variance (ANOVA) was used to assess the collected measures.

Setting

The setting for this retrospective chart analysis was an orthopedic facility in the southern Mississippi region. This facility houses 30 orthopedic beds, a preoperative area, 6 operating rooms, and a 10-bed postoperative recovery room. Patient information and records are stored using Electronic Patient Integrated Care (EPIC) software.

Technology

The site where data is being collected utilizes the CASMED FORE-SIGHT ELITE cerebral oximetry monitor and probes. Research by MacLeod, Ikeda, Cheng and Shaw (2013) on the fore-sight monitor compared cerebral oximetry readings simultaneously with right jugular bulb and radial arterial blood gas samples. Results revealed a precision of within 3.03% and 3.41% of reference manufacturer defined calculations.

Population

Data were collected from the anesthesia records of 50 subjects with ages ranging from 52 to 88 years (mean age of 70.16 years) who had undergone surgery in the sitting position. Twenty-six subjects were female, 24 were male. Thirteen subjects were classified as ASA 2, 36 were classified as ASA 3, and 1 was classified as ASA 4. Inclusion criteria consisted of patients who had undergone surgery in the sitting position, and were monitored with cerebral oximetry. If these two criteria were met, the anesthesia record was further inspected to ensure proper documentation of cerebral oximetry readings were recorded in conjunction with appropriate time slots that correlated with the transition from supine to sitting position. If these conditions were not met, the chart was excluded.

Barriers

The use of cerebral oximetry means that the anesthesia provider must perform additional steps in preparation for surgery. The monitor must be present in the room, the provider has to place the cerebral oximetry probe on the patient, and finally, the provider must record and monitor the readings. Anesthesia providers who are used to performing the induction and maintenance of anesthesia without cerebral oximetry monitoring may be resistant to change, or the addition of yet another monitoring device. Also, availability of cerebral oximetry probes may be limited by cost. Since cerebral oximeter use is currently a patient specific judgement call, instead of a standard of care, the number of subjects receiving cerebral oximetry monitoring is relatively scarce.

CHAPTER IV

ANALYSIS OF DATA

Since measurements were being assessed for change within a single group of individuals, a repeated measures analysis of variance (ANOVA), or within-subjects, test was performed on the 3 recorded measures (initial supine reading, 15 minutes post sitting position, 30 minutes post sitting position) of the following readings: (a) left cerebral oximetry reading (LCOR), (b) right cerebral oximetry reading (RCOR), (c) mean arterial blood pressure (MAP) in mm-Hg, and (d) end-tidal carbon dioxide output ($ETCO_2$) in mm-Hg. Since rSO_2 represents the numerical value for LCOR and RCOR, the terms will be used interchangeably throughout the text.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) software was used to assess the data. As part of the analysis, Mauchly's test of sphericity was calculated. Results revealed that the assumption of sphericity was not met, ((a) $\chi^2(2) = 15.898$, $p < 0.001$, (b) $\chi^2(2) = 17.854$, $p < 0.001$, (c) $\chi^2(2) = 12.492$, $p = 0.002$, (d) $\chi^2(2) = 13.937$, $p = 0.001$). ANOVA results were calculated using the Greenhouse-Geisser correction, and post hoc tests were performed with Bonferroni adjustment. The null hypothesis (H_0) states that group means at the 3 different time slots are equal ($\mu_{supine} = \mu_{15} = \mu_{30}$). The alternative hypothesis (H_A) states that at least 1 group mean is significantly different from the other 2. Values are considered statistically significant if $p < 0.05$. The tables below show the results of the basic descriptive statistics from each group:

Table 4.1

Descriptive Statistics for LCOR, RCOR, MAP, and $ETCO_2$

Measurement	Mean	Std. Deviation	N
LCOR First	71.46	5.97	50
LCOR Second	68.96	6.55	50
LCOR Third	68.86	6.85	50
RCOR First	71.92	5.88	50
RCOR Second	69.12	6.83	50
RCOR Third	69.36	7.54	50
MAP First	94.68	20.26	50
MAP Second	78.54	13.92	50
MAP Third	76.14	9.57	50
$ETCO_2$ First	38.90	4.71	50
$ETCO_2$ Second	36.20	5.26	50
$ETCO_2$ Third	36.00	4.48	50

Note. LCOR = Left Cerebral Oximetry Reading; RCOR = Right Cerebral Oximetry Reading; MAP = Mean Arterial Pressure; $ETCO_2$ = End Tidal Carbon Dioxide.

Left cerebral oximetry readings were statistically significantly different between the measured time points, $F(1.560, 76.446) = 12.124$, $p < 0.001$. Post hoc analysis with Bonferroni adjustment revealed where the statistically significant differences lie. There was a decrease in LCOR readings between initial (*M* = 71.46, *SD* = 5.97) and 15 minute post sitting position (*M* = 68.96, *SD* = 6.55), a statistically significant mean decrease of 2.5, 95% CI [0.95, 4.05], *p* = 0.001. There was also a decrease in LCOR readings between initial (*M* = 71.46, *SD* = 5.97) and 30 minute post sitting position (*M* = 68.86, *SD* = 6.85), a statistically significant mean decrease of 2.6, 95% CI [0.84, 4.36], *p* = 0.002. There was no statistically significant difference in LCOR readings between 15 minute post sitting position (*M* = 68.96, *SD* = 6.55) and 30 minute post sitting position (*M* = 68.86, *SD* = 6.85), with a mean decrease of 0.1, 95% CI [-0.95, 1.149], *p* = 1.0.

Right cerebral oximetry readings were statistically significantly different between the measured time points, *F*(1.526, 74.774) = 9.178, *p* = 0.001. Post hoc analysis with Bonferroni adjustment revealed where the statistically significant differences lie. There was a decrease in RCOR readings between initial (*M* = 71.92, *SD* = 5.88) and 15 minute post sitting position (*M* = 69.12, *SD* = 6.83), a statistically significant mean decrease of 2.8, 95% CI [1.01, 4.59], *p* = 0.001. There was also a decrease in RCOR readings between initial (*M* = 71.92, *SD* = 5.88) and 30 minute post sitting position (*M* = 68.36, *SD* = 7.54), a statistically significant mean decrease of 2.56, 95% CI [0.37, 4.75], *p* = 0.017. There was no statistically significant difference in RCOR readings between 15 minute post sitting position (*M* = 69.12, *SD* = 6.83) and 30 minute post sitting position (*M* = 68.36, *SD* = 7.54), with a mean increase of 0.24, 95% CI [-1.53, 1.05], *p* = 1.0.

Mean arterial blood pressure readings were statistically significantly different between the measured time points, $F(1.627, 79.730) = 38.633$, $p < 0.001$. Post hoc analysis with Bonferroni adjustment revealed where the statistically significant differences lie. There was a decrease in MAP readings between initial ($M = 94.68$, $SD = 20.26$) and 15 minute post sitting position ($M = 78.54$, $SD = 13.92$), a statistically significant mean decrease of 16.14 mm-Hg, 95% CI [10.04, 22.24], $p < 0.001$. There was also a decrease in MAP readings between initial ($M = 94.68$, $SD = 20.26$) and 30 minute post sitting position ($M = 76.14$, $SD = 9.57$), a statistically significant mean decrease of 18.54 mm-Hg, 95% CI [12.01, 25.07], $p < 0.001$. There was no statistically significant difference in MAP readings between 15 minute post sitting position ($M = 78.54$, $SD = 13.92$) and 30 minute post sitting position ($M = 76.14$, $SD = 9.57$), with a mean increase of 2.4 mm-Hg, 95% CI [-1.74, 6.54], $p = 0.472$.

End-tidal carbon dioxide readings were statistically significantly different between the measured time points, $F(1.597, 78.274) = 16.672$, $p < 0.001$. Post hoc analysis with Bonferroni adjustment revealed where the statistically significant differences lie. There was a decrease in $ETCO_2$ readings between initial ($M = 38.9$, $SD = 4.71$) and 15 minute post sitting position ($M = 36.2$, $SD = 5.26$), a statistically significant mean decrease of 2.7 mm-Hg, 95% CI [1.1, 4.3], $p < 0.001$. There was also a decrease in $ETCO_2$ readings between initial ($M = 38.9$, $SD = 4.71$) and 30 minute post sitting position ($M = 36$, $SD = 4.48$), a statistically significant mean decrease of 2.9 mm-Hg, 95% CI [1.4, 4.41], $p < 0.001$. There was no statistically significant difference in $ETCO_2$ readings between 15 minute post sitting position (*M* = 36.2, *SD* = 5.26) and 30 minute post sitting position (*M* = 36, *SD* = 4.48), with a mean decrease of 0.2 mm-Hg, 95% CI [-0.79, 1.19], p = 1.0.

Discussion

Based on the data, the null hypothesis was rejected, and the alternative hypothesis was accepted. Through post hoc tests with Bonferroni adjustment, the statistically significant differences were determined to be between initial readings and 15 minute post sitting position readings, as well as between initial readings and 30 minute post sitting position readings. This determination was found to be the case within all 4 variable groups that were analyzed using a repeated measures ANOVA.

Further analysis and comparison of individual results revealed that all subjects who had a decrease in cerebral oximetry greater than 15% also had a drop in MAP greater than 15% at some point between first and third readings. In contrast, very few patients who had a MAP drop of 15% or greater revealed a significant change in rSO_2. Murkin et al. (2007) defined cerebral desaturation as a value that falls below 70% of the patient's baseline reading for a period of 1 minute or longer. In comparison, Butterworth, Mackey & Wasnick (2013) state that a reduction that exceeds 25% of the patient's baseline reading (or a drop to ≤ 75% of the baseline value) may result in neurological complications (p. 136). As discussed in the literature review section in reference to blood pressure, Nagelhout and Plaus (2013) suggest to maintain the MAP within 20% of the normal baseline value.

Data points for SpO_2 did not show any correlation with other vital signs. One subject had a 6% drop from baseline to the second reading, while the remaining 49 subjects increased from baseline or stayed between 97% and 100% saturation. FiO_2 varied too widely between patients for a proper comparison to result. Some anesthesia providers started with 100% oxygen, then went to 50% for maintenance, while others maintained FiO_2 between 90% and 100% throughout the case.

Data collected for rSO_2 and MAP was compiled into categories to represent percent decline and how many subjects fell into each category within each particular measurement period. Subjects may fall into multiple categories from one measurement to the next. The following tables show the distribution of percent decline for each related measurement.

Table 4.2

Percent Decline Distribution for LCOR

% Decline	Number of Subjects LCOR1 to LCOR2	Number of Subjects LCOR1 to LCOR3
10-14.9	4	7
15-19.9	3	1
20+	0	1

Note: LCOR = Left Cerebral Oximetry Reading

Table 4.3

Percent Decline Distribution for RCOR

% Decline	Number of Subjects RCOR1 to RCOR2	Number of Subjects RCOR1 to RCOR3
10-14.9	8	4
15-19.9	2	3
20+	0	3

Note: RCOR = Right Cerebral Oximetry Reading

Table 4.4

Percent Decline Distribution for MAP

% Decline	Number of Subjects MAP1 to MAP2	Number of Subjects MAP1 to MAP3
10-14.9	8	5
15-19.9	4	10
20-29.9	10	13
30-39.9	10	6
40+	1	3

Note: MAP = Mean Arterial Pressure

CHAPTER V

SUMMARY

The main goal of this capstone project was to determine if placing the patient in the sitting position while under general anesthesia played a significant role in causing a reduction in cerebral oximetry readings. Additional vital sign measurements were recorded from the anesthesia record for relative comparison to cerebral oximetry readings. As outlined in the above section, in all 4 categories (LCOR, RCOR, MAP, $ETCO_2$), there was a statistically significant difference between initial readings and 15 minute post sitting position readings, as well as between initial readings and 30 minute post sitting position readings. Also of importance is that there was no significant difference between the 15 minute post sitting position and 30 minute post sitting position readings. Therefore, it is reasonable to conclude that placing the patient in the sitting position will cause a statistically significant drop in LCOR, RCOR, and MAP output.

Weaknesses

$ETCO_2$ can be affected by many factors. Most notably, the anesthesia provider may override the patient's drive to breathe with hyperventilation, increasing removal of carbon dioxide, and causing the measurement to decrease. There can also be a transient drop in $ETCO_2$ if tissue perfusion is inadequate, which can usually be well-monitored by blood pressure measurement. Therefore, it is likely that the $ETCO_2$ measurements recorded had little-to-no correlation with supine to sitting transitions alone.

This study also did not take into account the possible administration of vasoactive medications given to increase the patient's blood pressure if it fell below an acceptable level. Since cerebral oximetry readings were only recorded every 15 minutes on the anesthesia record, and blood pressure was recorded every 5 minutes, we are unable to determine which blood pressure reading it most accurately correlated with within that timeframe.

Another area of obscurity is within differing comorbidities. This study did consider the ASA score, but did not take into account specific disease processes that may have altered the variables to some degree. Comparing a young, healthy, individual to an older individual with multiple comorbidities could skew the results.

Lastly, the use of interscalene brachial plexus nerve block was not recorded. The use of an interscalene nerve block with shoulder surgery has not only shown evidence that may lead to a reduction in post-operative nausea and vomiting (Murphy et al., 2010), but also may reduce anesthetic requirements which could help maintain blood pressure and normal body autoregulation closer to baseline. The author suggests to consider these options for future related research.

Future Recommendations

Since this capstone project showed that there were statistically significant drops in cerebral oximetry after a transition from supine to sitting position in the population studied, future researchers may further expound upon the variables more specifically by addressing the weaknesses discussed, or evaluating specific variables more closely. Future research may also benefit from more strictly determined inclusion and exclusion criteria over a greater period of time.

Conclusion

Healthcare is constantly evolving to include new technologies, techniques, and standards of care. Although not a stand-alone technology, cerebral oximetry proves to be a valuable monitoring tool when used in conjunction with traditional monitoring standards. As discussed in the literature review section, and in comparison to the results of the collected data, there is no reliable correlation between SpO_2 and MAP in relation to cerebral oximetry readings. Therefore, it is suggested that cerebral oximetry monitoring be included as a supplemental monitor during surgery that involves the sitting position, or for patients at risk for decreased cerebral blood flow.

Having a statistically significant result merely concluded that there was a relationship between supine and sitting position and the other recorded variables. Statistically significant and physiologically significant are two separate concepts. Blood pressure is often used as an indirect method of estimating the adequacy of cerebral perfusion after a patient is placed in the sitting position. The results of this study provide evidence suggesting that method to be unreliable in relation to rSO_2.

APPENDIX A

FORREST GENERAL IRB APPROVAL LETTER

FORREST GENERAL HOSPITAL

DATE:	June 26, 2015
TO:	Christopher Turner
FROM:	Forrest General Hospital Institutional Review Board
STUDY TITLE:	[744645-1] Evaluation of cerebral perfusion and oxygenation in patients undergoing shoulder surgery in the sitting position
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
APPROVED FACILITY:	The Orthopedic Institute
DECISION DATE:	May 13, 2015

Thank you for your submission of New Project materials for this research study to be conducted at The Orthopedic Institute. Forrest General Hospital Institutional Review Board has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations. The Forrest General Hospital Institutional Review Board is the designated review board for all Forrest Health facilities including The Orthopedic Institute.

We will put a copy of this correspondence on file in our office.

If you have any questions, please contact Michele Stanley at 601-288-4324 or mstanley@forrestgeneral.com. Please include your study title and reference number in all correspondence with this office.

cc: Steve Jackson, Administrator The Orthopedic Institute

APPENDIX B

UNIVERSITY OF SOUTHERN MISSISSIPPI IRB APPROVAL LETTER

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 15072002
PROJECT TITLE: Evaluation of Cerebral Perfusion and Oxygenation in Patients Undergoing Shoulder Surgery in the Sitting Position
PROJECT TYPE: New Project
RESEARCHER(S): Christopher Turner
COLLEGE/DIVISION: College of Nursing
DEPARTMENT: Nurse Anesthesia Program
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 09/10/2015 to 09/09/2016
Lawrence A. Hosman, Ph.D.
Institutional Review Board

REFERENCES

Butterworth, J.F., IV, Mackey, D.C., & Wasnick J.D. (2013). Noncardiovascular Monitoring. In Butterworth, J.F., IV, Mackey D.C., & Wasnick J.D. (Eds.), *Morgan & Mikhail's Clinical Anesthesiology*, (5th ed.) (pp. 123-142). Whitby, ON: McGraw-Hill Companies

Casey, G. (2011). Pulse oximetry--what are we really measuring?. *Nursing New Zealand (Wellington, N.Z.: 1995)*, *17*(3), 24-29.

Cowie, D. A., Nazareth, J., & Story, D. A. (2014). Cerebral oximetry to reduce perioperative morbidity. *Anaesthesia & Intensive Care, 42*(3), 310-314.

Eldridge, C. R. (2014). Nursing science and theory: Scientific underpinnings for practice. In Zaccagnini, M. E., White, K. W. (Eds.), *The doctor of nursing practice* (pp. 3-36). Burlington, MA: Jones & Bartlett Learning.

Fischer, G. A. (2009). The Use of Cerebral Oximetry as a Monitor of the Adequacy of Cerebral Perfusion in a Patient Undergoing Shoulder Surgery in the Beach Chair Position. *Pain Practice, 9*(4), 304-307.

Grocott, H. P., & Davie, S. N. (2013). Future uncertainties in the development of clinical cerebral oximetry. *Frontiers in Physiology, 4*(1-3). doi:10.3389/fphys.2013.00360

Hines, R. L., & Marschall, K. E. (2012). *Stoelting's anesthesia and co-existing disease.* (6th ed). Philadelphia, PA: Elsevier Saunders.

Ko, S., Young Woo, C., Se Hun, P., Jeong, J., Shin, S., & Gun, K. (2012). Cerebral oxygenation monitoring of patients during arthroscopic shoulder surgery in the sitting position. *Korean Journal of Anesthesiology, 63*(4), 297-301. doi:10.4097/kjae.2012.63.4.297

Kurth, C. D. (2006). Near infrared spectroscopy (NIRS). Retrieved from http://www.pedsanesthesia.org/meetings/2006winter/pdfs/Friday_Kurth.pdf

MacLeod, D., Ikeda, K., Cheng, C., & Shaw, A. (2013). Validation of the next generation fore-sight elite tissue oximeter for adult cerebral tissue oxygenation saturation. *Anesthesia & Analgesia, 116*(SCA Suppl), 1-182. Retrieved from http://www.casmed.com/cerebral-oximetry

Murkin, J. M., Adams, S. J., Novick, R. J., Quantz, M., Bainbridge, D., Iglesias, I., Cleland, A., Schaefer, B., Irwin, B., & Fox, S. (2007). Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study. *Anesthesia and Analgesia*,*104*(1), 51-58.

Murphy, G. S., Szokol, J. W., Marymont, J. H., Greenberg, S. B., Avram, M. J., Vender, J. S., & ... Nisman, M. (2010). Cerebral Oxygen Desaturation Events Assessed by Near-Infrared Spectroscopy During Shoulder Arthroscopy in the Beach Chair and Lateral Decubitus Positions. *Anesthesia & Analgesia, 111*(2), 496-505.

Nagelhout, J. J., & Plaus, K. L. (2013). *Nurse Anesthesia* (5th ed.). St. Louis, MO: Elsevier Saunders.

Neuman, B. (2011). *Neuman Systems Model*. Retrieved from http://www.neumansystemsmodel.org

Newman, M. F., Kirchner, J. L., Phillips-Bute, B., Gaver, V., Grocott, H., Jones, R. H., Mark, D.B., Reeves, J.G., & Blumenthal, J. A. (2001). Longitudinal assessment of neurocognitive function after coronary-artery bypass surgery. *New England Journal of Medicine*, *344*(6), 395-402.

Pohl, A., & Cullen, D. J. (2005). Cerebral ischemia during shoulder surgery in the upright position: a case series. *Journal of Clinical Anesthesia, 17*(6), 463-469.

Tobias, J. D. (2008). Cerebral Oximetry Monitoring With Near Infrared Spectroscopy Detects Alterations in Oxygenation Before Pulse Oximetry. *Journal of Intensive Care Medicine (Sage Publications Inc.)*, *23*(6), 384-388.

Whetsell, M. V., Gonzalez, Y. M., & Moreno-Fergusson, M. E. (2011). Models and theories focused on a systems approach. In Butts, J. B. & Rich, K. L. (Eds.), *Philosophies and theories for advanced nursing practice* (pp. 413-443) Sudbury, MA: Jones & Bartlett Learning.

YaDeau, J. T., Liu, S. S., Bang, H., Shaw, P. M., Wilfred, S. E., Shetty, T., & Gordon, M. (2011). Cerebral oximetry desaturation during shoulder surgery performed in a sitting position under regional anesthesia. *Canadian Journal of Anesthesia-Journal Canadien D Anesthesie, 58*(11), 986-992.

Yang, J. l., Wang, K. Y., Chiang, Y. H., & Peng, G. S. (2003). Effect of head elevation on cerebral blood flow velocity in post-cerebral operation patients. *Journal of Nursing Research, 11*(2), 129-135.