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Effects of Steep Trendelenburg Positioning on Intraocular Pressure

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EFFECTS OF STEEP TRENDELENBURG POSITIONING ON INTRAOCULAR PRESSURE

by

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ABSTRACT

Title: Effects of Steep Trendelenburg Positioning on Intraocular Pressure

Background: The frequency of robot assisted procedures including robot assisted prostatectomies is increasing. The steep Trendelenberg position required for this procedure puts patients at an increased risk for complications such as postoperative vision loss. Anesthesia professionals must be aware of the potential complications and the current evidence for prevention of devastating complications such as postoperative vision loss.

Purpose: The purpose of this paper is to provide a case report and to provide a review of the current evidence for preventative measures related to complications within the case report.

Process: A literature search was conducted utilizing the databases PubMed and CINAHL primarily. These databases were accessed utilizing the University of North Dakota's Health Sciences Library. References selected were carefully reviewed and determined applicable for inclusion.

Results: Current evidence in the prevention of the physiologic changes that lead to increased intraocular pressure and subsequent potential postoperative vision loss are focused on prevention and early identification. Visual inspection of the eye has been shown to be reliable in indicating the presence of elevated intraocular pressure > 40 mmHg (the critical range). Scleral edema would be present in this range and if noted, would indicated that intervention is needed to reduce intraocular pressure and improve ocular perfusion pressure. The most promising current proposed intervention for lowering the intraocular pressure include preoperative administration of dorzolamide-timolol eye drops to the patient's eyes. This was found to lower the intraocular pressure by as much as 26% intraoperatively in comparison to a control group. Other current promising measures include use of a modified steep Trendelenburg positioning, known as modified Z positioning, administration of a dexmedetomidine infusion, and a propofol based total intravenous anesthetic technique.

Implications: Several interventions to reduce intraocular pressure were noted in the literature, however, more research is needed to generate generalizable data that would lead to the development of best practice guidelines that would enhance patient safety and outcomes. At this time, no specific recommendations may be made with the current evidence available.

Keywords: Steep Trendelenburg, head down tilt, intraocular pressure, robot-assisted prostatectomy, robot-assisted procedures, postoperative vision loss.

Effects of Steep Trendelenburg Positioning on Intraocular Pressure

Robot assisted procedures (RAP) are on the rise within medicine. “An estimated total of 205,000 robotic cases were performed in 2009, and approximately 1.5 million cases were performed worldwide in 2013” (Lee, 2014, p. 231). The first robot approved for laparoscopic surgery was the da Vinci system in 2000 (Lee, 2014). As this type of procedure increases in popularity, it brings a new set of concerns for the anesthesia professional to consider for patient management.

The prostatectomy is one of the most commonly performed procedures that utilizes a robot. Performing a prostatectomy in this manner is said to tout numerous benefits for the patient including shorter hospital stays, less blood loss, and a decreased recovery time (Gainsburg, Wax, Reich, Carlucci, & Samadi, 2010). In fact, when compared to a traditional open radical prostatectomy, one study found that there was a 96% decrease in estimated blood loss with the robotic assisted surgery.

However, despite the reported benefits of these robot assisted procedures, they still carry significant risks that must be addressed. One such reported risk is the increased risk for postoperative vision loss (POVL). The risk for POVL is thought to significantly increase related to the increased intraocular pressure (IOP) associated with steep Trendelenburg and pneumoperitoneum. “Increased IOP, arterial pressure, and central venous pressure are observed during [robot assisted laparoscopic radical prostatectomy], and high IOP and impaired perfusion may harm the optic disc, optic nerve, or retina” (Taketani, et al., 2015, p. 2).

The loss of vision intraoperatively is not to be taken lightly and should be considered by practitioners and patients alike. As the incidence of robot assisted procedures requiring steep Trendelenburg position increases, there is a possibility that this complication may effect more patients. In this paper, a case study of a patient who experienced significant eye irritation following a complicated robot assisted radical prostatectomy will be presented. In addition, a literature review of relevant pathophysiology and various new methods aimed at reducing this complication will be presented.

Case Report

A 59-year-old, 173 cm, 105 kg male presented to the OR for resection of his prostate gland via da Vinci laparoscopic radical prostatectomy with pelvic lymph node biopsy for treatment of prostate cancer. His past medical history included allergic dermatitis, hyperlipidemia, paroxysmal atrial fibrillation, inguinal hernia, prostatitis, verruca vulgaris, obstructive sleep apnea with home CPAP, and he was a former smoker (quit in 1990). This patient's past surgical history included a knee arthroplasty with meniscectomy, hernia repair, inguinal hernia repair, colon surgery, colonoscopy, and cardiac ablation. No prior surgeries or procedures had any reported anesthetic complications. The patient had no known drug allergies and his home medications included fish oil supplements, Claritin, ibuprofen, and a multivitamin. Preoperative labs were as follows: hemoglobin (hgb) 15.7 g/dL, hematocrit (hct) 44.4%, platelets (plts) 258 $x10^9$/L, blood urea nitrogen (BUN) 16 mg/dL, sodium (Na) 140 mmol/L, potassium (K) 4.3 mmol/L, chloride (Cl) 105 mmol/L, glucose 115 mg/dL, creatinine 1.13 mg/dL, carbon dioxide (CO_2) 24 mEq/L, and calcium (Ca) 9.6 mmol/L.

A pre-operative evaluation of the patient, including airway examination, revealed a Mallampati class III, a thyromental distance of two fingerbreadths, a reduced thyrohyoid distance, and an inter-incisor distance of 4 fingerbreadths. The patient had intact dentition with the exception of a chipped left front incisor. He also presented with a thick neck with full range of motion. These findings indicated a potential difficult airway. Prior anesthetic records indicated that the patient was an easy mask with the use of an oral airway and laryngoscopy was performed and a grade I view was achieved with a Miller 2 blade. The anesthesia team planned to proceed with a standard induction with direct laryngoscopy and arranged for a video laryngoscope to be readily available in the room.

Intravenous (IV) access was established in the pre-operative area and the patient was transported to the operating room. Midazolam 2mg IV was administered to the patient for anxiolysis and anterograde amnesia while standard non-invasive monitors were applied. The patient was pre-oxygenated with a mask and 100% O_2 at 12 liters per minute. After five minutes of pre-oxygenation, anesthesia was induced with fentanyl 200 mcg, rocuronium 5mg, lidocaine 40 mg, and propofol 200 mg all administered IV.

After the patient demonstrated apnea and a failure to follow verbal commands, his anesthetic depth was determined to be adequate. Subsequently his eyes were taped closed and mask ventilation was performed successfully with the aid of an oral airway. Immediately following successful ventilation, rocuronium 45 mg IV was administered. Direct laryngoscopy was performed utilizing a miller 2 blade and a Cochrane grade II view was obtained. An 8.0 mm cuffed endotracheal tube (ETT) was successfully passed through the larynx and vocal cords. Appropriate placement of the ETT was confirmed with positive end-tidal carbon dioxide ($ETCO_2$), presence of bilateral breath sounds, equal chest rise, and fogging in the ETT. General anesthesia was then maintained with a dexmetetomidine infusion at 0.3 mcg/kg/hr and Desflurane 5% inspired concentration with a mixture of air 0.8 L/min and oxygen 0.8 L/min. Intraoperatively, the patient also received rocuronium 100 mg, decadron 10 mg, hydromorphone 1 mg, ondansetron 4 mg, and phenylephrine 450 mcg.

After 3 hours spent in the steep Trendelenburg position for a robot facilitated prostatectomy, it was determined that the patient's prostate was too large to continue with resection in this minimally invasive manner. The robot was then undocked, the patient returned to a supine position, and the procedure was converted to an open prostatectomy. The open prostatectomy lasted approximately 3 additional hours.

During this portion of the procedure, the patient began losing significant amounts of blood. In the fourth hour of the procedure, the patient lost an estimated 500 mL of blood, followed by 700 mL in hour five and another 500 mL in hour six. The total estimated blood loss for the case was 1,700 mL. The patient's starting hemoglobin (hgb) was 15.7 g/dL. Given the blood loss, a repeat hgb was drawn during hour 5 of the procedure revealing a result of 9.5 g/dL. The patient received a total of 1,000 mL of albumin and 5,100 mL of Lactated Ringers.

At the conclusion of the six hour procedure, the patient was noted to have significant scleral and facial edema. The neuromuscular blockade was reversed with glycopyrrolate 0.8 mg and neostigmine 5 mg. After the patient returned to spontaneous respirations, a leak test was performed to identify presence of significant laryngeal edema and a leak was confirmed. When the patient was able to lift his head for >5 seconds and the patient was inspiring consistent tidal volumes greater than or equal to 400 mL, the ETT was removed. The patient was placed on 2 L/min O_2 via nasal cannula and transported to the post-anesthesia care unit (PACU).

In the PACU, the patient began to experience "extreme" eye irritation. He was further evaluated by the anesthesia team for a corneal abrasion and given antibiotic eye drops. The patient was instructed to stay in an upright position to aid in promoting facial edema drainage. Within twenty four hours, the scleral edema had subsided and the patient stated he no longer had any eye irritation.

Purpose

The purpose of this paper is to provide a critical look at current evidence of the relationship between IOP and steep Trendelenburg positioning during robot assisted procedures (RAP). If a significant relationship is identified, a further aim is to provide evidence based recommendations for anesthesia professionals regarding the prevention of increased IOP in these patients.

Methodology

Databases and Search Terminology Utilized

The databases utilized for this literature search were primarily PubMed and CINAHL. A search of CINAHL provided more limited results than Pubmed, but still provided quality articles. Initial search terms were “steep Trendelenburg”, “anesthesia” and “blood loss”. This yielded three results that were all three deemed applicable to the PICO question. As this search was found to be too narrow, so “steep Trendelenburg” and “anesthesia” were searched with seven results. Following that, the terms “robot assisted surgery” and “blood loss” were searched with 30 results.

Subsequent searches utilizing terms such as “steep Trendelenburg” and “anesthetic management”, “steep Trendelenburg” and “blood loss”, as well as “robot assisted surgeries” and “anesthetic management” yielded limited results already found in previous searches. Finally, my last CINAHL search began with the search terms “patient positioning” and “postoperative complications” which yielded over 300 results. This was further narrowed by designating only peer reviewed articles, those in English, and articles written between the years of 2010 and 2016 in order to provide the best quality evidence as well as the most recent. While research published within the last five years was desired, due to the emerging nature of this topic, some older studies were included due to limited availability of applicable recent research. This narrowing resulted in 133 articles found. Last to further constrict this search, the search term blood loss was added. This resulted in 10 articles.

A search within PubMed yielded significantly more results that may be utilized to address the concern for POVL in patients undergoing RAP. The first search consisted of the terms "head down tilt" and "anesthetic management". This yielded 15 results. Subsequent searches of with the terms "fluid administration" and "head down tilt" yielded 44 results, of which 3 articles were determined to be pertinent to the search. The next search attempted utilized the terms "robotic assisted procedures" and "head down tilt". This search produced 47 results. After careful review, 15 articles were determined to be applicable. The final search utilizing PubMed consisted of the terms "robotic assisted procedures" and "intraocular". These terms found 26 results, of which 10 were either already included or identified as pertinent to the search.

Discussion

Regulation of Blood Flow in the Eye

A basic concept of perfusion within the eye is critical to understand how certain derailments may lead to POVL. The perfusion to the optic nerve is determined by the perfusion pressure within the arteries in the globe. This ocular perfusion pressure (OPP) is represented by the equation OPP = MAP – IOP, where MAP stands for mean arterial pressure and IOP stands for intraocular pressure. With this in mind, if there is an increase in IOP or a decreased in MAP, the ocular perfusion pressure may suffer and thus compromise perfusion to the optic nerve (Gilbert, 2008).

Resistance to flow within the globe is also auto regulated. Thus, perfusion to the optic nerve is most efficient when the MAP and IOP fluctuate. The vasculature within the eye is influenced to vasoconstrict by thromboxane A2 or to vasodilate by nitric oxide and prostacyclin. As with cerebral autoregulation, there is also a perfusion pressure within which ocular autoregulation is effective. This range differs from patient to patient, but as a general rule of thumb critically high IOP (> 40 mmHg) or low MAP will result in poor perfusion within the eye. (Gilbert, 2008).

Risk Factors for POVL

There are certain clinical indicators that may alert a practitioner that their patient is at an increased risk for postoperative vision loss. If the patient has a BMI > 35 kg/m^2, is older than 62 years old, a diabetic, has vascular disease, hypertension, atherosclerosis or a prior history of glaucoma or smoking they are at high risk for increased IOP intraoperatively and thus POVL (Molloy, 2016).

Types of surgeries also place patients at increased risk for POVL. Incidence of POVL during cardiac surgery is as high as 4.5%. In comparison to spinal surgery, the second most commonly reported surgery associated with POVL, carries a risk of 0.2% for POVL (Gilbert, 2008). POVL has also been associated with “neck dissection, abdominal procedures, hip surgery, cholecystectomy, parathyroidectomy, prostate surgery, pleurodesis, and rotator cuff surgery” (Gilbert, 2008, p. 194).

Intraoperative factors that may affect IOP and MAP are increased CVP, hypotension, severe hypertension, acute hemorrhage, large fluid boluses and positioning also increase the risk for developing POVL. Certain positions, such as the prone position, if executed incorrectly can lead to direct compression of the eye. Direct compression on the globe has been known to lead to

"…orbital ischemia, ecchymosis, orbital congestion and ultimately visual loss" (Gilbert, 2008, p. 195). However, even when positioned appropriately prone, IOP has been shown to suffer in a time dependent manner regardless. There is a direct connection between the time spent in the prone position and IOP (Gilbert 2008).

Pathophysiology of Steep Trendelenburg and POVL

In order to understand the pathophysiology behind post-operative vision loss related to steep Trendelenburg (ST) positioning, it is first important to understand the angle that patients are in when placed in this position. When placed in ST, patients are put either supine or in the lithotomy position. They are then tilted head down to an angle of 45 degrees (Mondzelewski, et al., 2015). While this position is utilized in order to shift the abdominal contents away from the surgical site (Chalmers, Cusano, Haddock, Staff, & Wagner, 2015), the severe angle required causes an increase in blood flow to the central compartment. This increase in blood flow will cause a rise in hydrostatic pressure, MAP, and CVP (Schramm, et. al., 2013).

"The major determinants of IOP are aqueous humor flow, choroidal blood volume, central venous pressure (CVP) and extraocular muscle tone" (Hoshikawa, et al., 2014, p. 307). The increase in venous flow to the central compartment that is elicited by ST positioning is thought to lead to increased congestion within the eye and a decreased ocular perfusion pressure. These physiologic changes translate to an increased intraocular pressure within the eye. IOP increases of greater than 35 mmHg are "…associated with incremental damage to the optic disc and retinal nerve fibers" and ocular hypertension occurs when a pressure of greater than 22 mmHg is generated (Raz, et al., 2015, p. 1218). Thus, it is reasonable to presume to use IOP measurements as a means of determining perfusion to the ocular nerve (Yoo, et al., 2014).

In addition, the insufflation of the patient's abdomen causes an increase in choroidal blood volume. This is also known to increase IOP (Hosikawa, et al., 2014). The anesthetist can indirectly assess IOP and choroidal congestion intraoperatively with examination of the patient's end tidal CO_2 (ET_{CO2}) trends. It has been reported that a low ET_{CO2}) is a significant predictor for an increased IOP (Awad, et al, 2009). "…[C]ontinous absorption of intraperitoneal CO_2 and increased pressure on the diaphragm resulted in lower delivered tidal volumes and subsequently increased arterial P_{CO2} levels" (Hoshikawa, et al., 2014, p. 307). This is what will ultimately cause the increase in choroidal blood volume leading to an increased IOP. These deviations ultimately result in the most common type of POVL, ischemic optic neuropathy (Yoo, et al., 2014).

Laparoscopic surgery requiring insufflation is an independent factor that has been documented to be associated with elevated IOP. The increase it causes has been found to be time dependent, and worsens when steep Trendelenburg positioning is added to the pneumoperitoneum (Yoo, et al., 2014). It was found that there was a clinically significant decrease in ocular perfusion pressure (OPP) after about 120 – 160 minutes in the steep Trendelenburg position (Molloy, 2011). In addition, patient's ocular autoregulation was found to suffer after about 160-170 minutes in the steep Trendelenburg position thus increasing the risk for periorbital and conjunctival edema and subsequent POVL. (Molloy, 2016). This is a clinically significant finding within the literature as it relates to the outlined patient in the case study. That patient endured steep Trendelenburg positioning for approximately three hours. This placed him outside the range at which OPP and ocular autoregulation both suffer.

There have been some conflicting reports on whether the documented rise in IOP during ST positioning truly leads to ischemic optic neuropathy. Hoshikawa, et al., determined that while a quantifiable increase in IOP occurred in patients undergoing robotic assisted prostatectomies in ST, it was not significant enough to ischemia or postoperative vision loss (2014). They reasoned that despite IOP increases, the best corrected visual acuity and the retinal nerve fiber layer showed no changes from pre to post op (Hoshikawa, et al., 2014).

However, a consensus amongst current literature points towards the increase in IOP causing significant visual field defects (Molloy, 2011; Yoo, et al., 2014; Chalmers, et al., 2015; Raz, et al., 2015). Taketani, et al., found that local visual field defects were detected in the patients following RAP despite no abnormal findings on the optic nerve head or the retina (2015). They established that factors such as IOP and retinal nerve fiber layer thickness "…did not differ significantly between eyes with and without postoperative visual field defects, and parameters of [optical coherence tomography] measurements were not altered after surgery" (Taketani, et al., 2015, p. 1).

Evaluation of Intraocular Pressure

Several methods have been proposed as possible methods for evaluating IOP intraoperatively. This poses a challenge to anesthetists as in an early study by Molloy (2011), anesthetists were required to be trained to measure IOP utilizing a hand held device. This meant that only select anesthetists were capable of performing this measurement and participating in the study. The limitation this posed to the study also translates to a limitation to implementation in everyday practice. Use of a handheld device will require additional training, which may not be available to all anesthetists.

To address the issue of ease of evaluation, a visual assessment was proposed. When examining the eyes of a patient, eyelid edema alone is a sign that IOP is rising, and should be addressed (Molloy, 2012). When eyelid edema expands to include conjunctival edema (chemosis) this is a valuable predictor to an anesthetist of an IOP > 40 mmHg (Molloy, 2012). IOP of > 40 mmHg is a critical result that is recommended for treatment by ophthalmologists. By this visual standard, it is clear that the patient described within the earlier case study suffered from increased IOP. The patient displayed clear facial, eyelid, and conjunctival edema that lead to clinically significant eye irritation. Due to that, this measure would indicate that the patient had an IOP > 40 mmHg which would have warranted intervention.

Proposed Preventative Measures

POVL is a relatively uncommon complication, occurring in only 0.0002% to 0.2% of cases. But this does not negate the fact that when it does occur it has a significant impact on the patient's life (Yoo, et al., 2014). Ischemic optic neuropathy leading to POVL has been documented in patients following ST positioning in RAP (Chalmers, et al., 2015). Robotic assisted prostatectomies are being performed with increased frequency and the current literature points to a direct connection between the ST positioning required during these cases. Several authors have proposed and studied potential preventative measures to mitigate the increase in IOP and hopefully reduce the likelihood of POVL. It should be noted that many of these proposed preventative measures will require further research before a true change in practice may be recommended.

Dexmedetomidine infusion. Precedex, or dexmedetomidine, is a potent selective α_2-adrenergic agonist. It has known analgesic, sedative, sympatholytic activities and hypnotic effects without causing significant respiratory depression. This makes it a lucrative agent for use in anesthesia. Dexmedetomidine has been previously shown in studies to alleviate the rise in IOP that occurs with direct laryngoscopy and intubation (Kim, et al., 2015).

The exact mechanism for dexmedetomidine’s impact on IOP is unclear. One proposed mechanism is the “…direct vasoconstriction in afferent blood vessels of the ciliary body results in decreased aqueous humor production, which may affect the decrease in IOP” (Kim, et al., 2015, p. 315). It is also theorized that dexmedetomidine may actually increase the aqueous humor outflow by decreasing the vasomotor tone of the drainage system within the eye (Kim, et al., 2015).

In the study by Kim, et al., sixty eight patients undergoing robot assisted laparoscopic prostatectomy in ST were randomly separated into two study groups. The experimental group received an infusion of dexmedetomidine at a rate of 0.4 mcg/kg/hr without a loading dose in order to prevent side effects of hypotension and bradycardia in participants (2015). The control group received equivalent amounts of normal saline as well as a general anesthetic consisting of sevoflurane and remifentanil.

Between the control group and experimental group, significant reductions in IOP were identified via a linear mixed model analysis ($p < 0.001$). Thus, it was determined that “…dexmedetomidine may help to alleviate IOP increase in patients undergoing [robotic assisted laproscopic radical prostatectomies] in the ST position” (Kim, et al., 2015, p. 310). There were no identified differences between the two groups in regards to their OPP, MAP, or heart rate.

Propofol based TIVA. While dexmedetomidine has been examined as a possible solution for reducing IOP in RAP patients in ST, propofol has also been examined for this purpose. The study by Yoo, et al., compared an anesthetic based on sevoflurane to a propofol based TIVA technique in patients undergoing laparoscopic surgeries in ST position (2014). In this study sixty-six were randomly placed into two groups, one group receiving a maintenance anesthetic of remifentanil and sevoflurane and one receiving remifentanil and propofol.

Results of a linear mixed model analysis showed that propofol was superior to sevoflurane in attenuating IOP increases in addition to providing a higher OPP (Yoo, et al., 2014). There was a statistically significant ($P < 0.001$) increase in IOP found in those patients that received sevoflurane and remifentanil but no significant increase in those patients receiving propofol and remifentanil infusions (Yoo, et al., 2014). This result was supported by the earlier research of Schafer, et al, whom also found that IOP was significantly lower in patients when a propofol based TIVA technique was utilized (2002).

While the Yoo, et al., study was not specifically targeted at reducing postoperative ocular complications, it is already known that a reduction in OPP and a subsequent increase in IOP can lead to visual defects and potentially POVL (2014). Thus, current evidence is pointing to the fact that propofol may aid in reducing the incidence of POVL. Further research is needed to determine if this finding is generalizable.

Modified Z positioning. Raz and colleagues proposed an interesting solution to the problem of increased IOP during ST positioning. They provided a modification to the standard steep Trendelenburg positioning. In standard ST position, the patient is supine and tilted head down to a maximum of 45 degrees. The modification proposed is to maintain the head and shoulders in a horizontal position while tilting the patient in a head down ST position (Raz, et al., 2015).

In order to study this modified positioning, a prospective randomized controlled study was performed. This study included fifty patients undergoing robot assisted laparoscopic radical prostatectomy were divided into two groups. One group contained twenty-nine patients in the modified Z Trendelenburg position and a second group of twenty-one patients in standard ST positioning (Raz, et al., 2015).

Modified Z positioning was shown to decrease the rise in IOP that occurs with ST position without any significant compromise to either the surgical field or the anesthetic (Raz, et al., 2015). In addition, it should be of note that the patients who were placed in a modified Z Trendelenburg position exhibited a normal facial soft tissue appearance. When those in standard ST position were examined they exhibited visible facial edema. This was not detailed in the study further as it was not within their measurements, however it is still of note as increased periorbital edema may lead to a reduced OPP (Molloy, 2016). This study, while promising, is limited by its relatively small sample size and some limited IOP measurements.

Timolol eye drop administration. Dorzolamide-timolol eye drops are a commonly prescribed ophthalmic solution to attenuate the rise of IOP. Dorzolamide hydrochloride itself is a carbonic anhydrase II inhibitor which effects "…IOP by decreasing the production of aqueous humor" (Molloy, 2016, p. 190) while timolol, a B_2-adrenergic receptor that acts to block the beta adrenergic receptors within the ciliary processes. A prior study by the same author, demonstrated that dorzolamide-timolol eye drops successfully lowered IOP when administered to patients whose IOP measurements reached >40 mmHg during ST positioning in RAP (Molloy & Cong, 2014).

In order to further build upon the early Molloy study, it was examined whether dorzolamide-timolol ophthalmic solution may be utilized prophylactically in order to prevent an increase in IOP intraoperatively. This particular study utilized ninety patients, forty-six patients received dorzolamide-timolol eye drops and forty-four received a basic salt solution eye drops. One drop of an ophthalmic solution containing dorzolamide 20 mg and timolol 5 mg was administered to one group of patients and compared to a control group. It should be noted that in all patients participating in this study, if their IOP reached > 40 mmHg intraoperatively they were administered one drop of the dorzolamide-timolol solution (Molloy & Cong, 2014).

The study concluded that those patient that were administered the dorzolamide-timolol solution demonstrated statistically significant ($P < 0.05$ to $P < 0.001$) lower IOPs throughout the procedure when compared to the control group. In fact, IOP was reduced by an average of 26% from the experimental group to the control group. In addition, it was found that patients who received the prophylactic eye drops experienced less periorbital edema. These results are significant as they provide a simple method for treating and preventing IOP increases in individuals without prolonging surgery or causing significant side effects (Molloy, 2016).

Evidence Based Recommendations

The current literature has proposed multiple recommendations to attempt to reduce the incidence or likelihood of patient's experiencing the complication of post-operative vision loss. These recommendations are detailed above and include interventions such as timolol eye drop administration and a modified Z Trendelenburg positioning. While the interventions do show promise, the current evidence is insufficient to support a major recommendation given the small sample sizes and the results are not generalizable to the broader patient population. The current proposed interventions should be further tested and validated beyond these initial studies in order to corroborate their stated outcomes. Despite this, the early research that is being done does show significant promise for the future of anesthetic care of patients who are at an increased risk for the development of postoperative vision loss.

Conclusion

Postoperative vision loss is a relatively rare but catastrophic complication that can occur in the perioperative period. Certain procedures and positioning have been shown to place the patient at an increased risk for this life changing complication. With the advent of robotic procedures and their use increasing in frequency, the requirement for steep Trendelenburg positioning has also increased. While the patient presented in the case study experienced eye irritation that subsided, the complication could have been more severe. Anesthesia professionals should be diligent in evaluating patients risks associated with POVL. As more evidence emerges, it is hoped that improved mechanisms for prevention will be developed.

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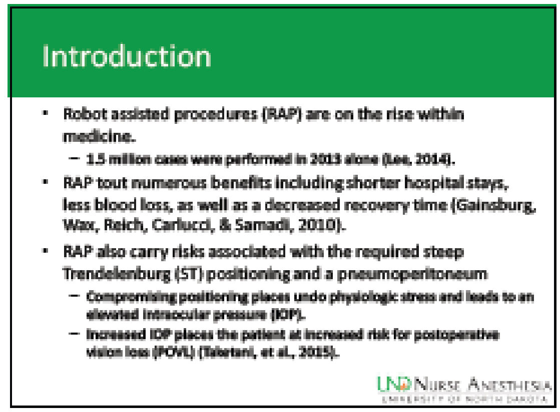
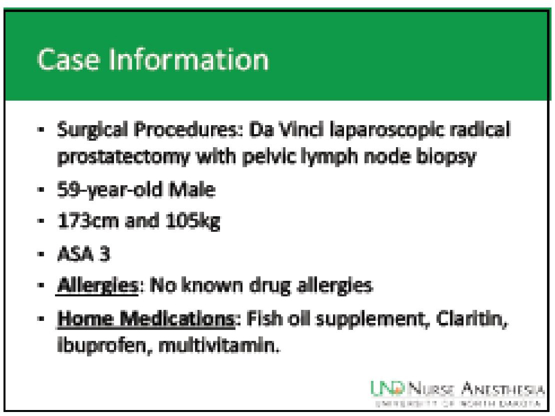
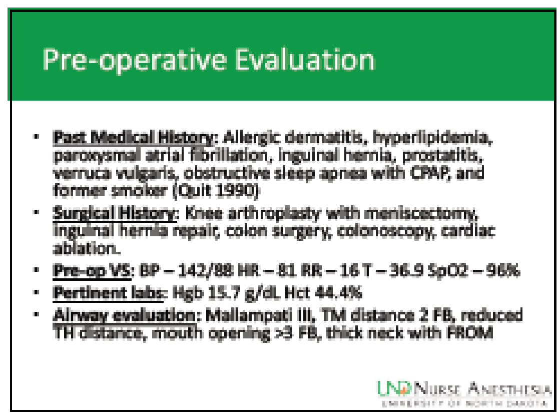
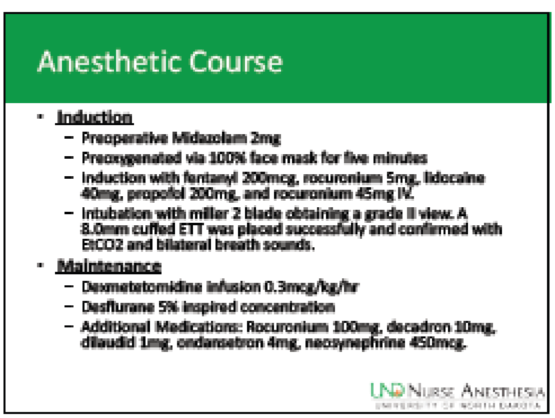
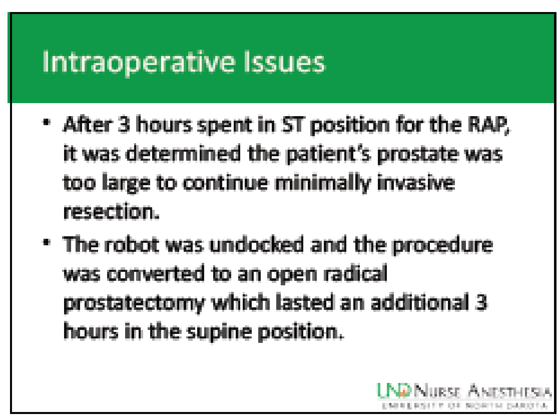
Appendix A: NDANA Presentation











Intraoperative Issues

- After converting open, the patient began losing significant amounts of blood
  - 4th hour EBL: 500 mL
  - 5th hour EBL: 700 mL
  - 6th hour EBL: 500 mL
- Estimated total blood loss was 1,700 mL.
- A repeat hgb was drawn during the 5th hour and resulted at 9.5 g/dL.
- The patient received a total of 1,000 mL of albumin, and 5,100 mL of Lactated Ringers.

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Intraoperative Issues

- At the conclusion of the procedure, the patient was noted to have significant scleral and facial edema.
- The neuromuscular blockade was reversed with glycopyrrolate 0.8 mg IV and neostigmine 5 mg IV. Once the patient returned to spontaneous respirations, a leak test was performed and was positive for an air leak.
- Once appropriate extubation criteria was met, the patient was extubated and placed on 2 L/min O2 NC.

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PACU

- In PACU, the patient began to describe painful eye irritation.
- Further evaluation by the anesthesia team was done to rule out a corneal abrasion
  - Prophylactic antibiotic eye drops were administered.
- The patient was instructed to stay in the upright position to promote facial edema drainage.
  - Within 24 hours, the scleral edema had subsided and the patient denied any further eye irritation.

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Physiology of Blood Flow in the Eye

- Perfusion to the optic nerve is determined by the ocular perfusion pressure (OPP).

  OPP = MAP – IOP
- An increase in IOP or a decrease in MAP will cause OPP to suffer
  - Compromised perfusion to the optic nerve.
- Ocular blood flow is also auto regulated and perfusion is best when IOP and MAP fluctuate.
  - There is a perfusion pressure range in which ocular autoregulation is effective.
  - General rule of thumb, IOP > 40mmHg or a low MAP will result in poor perfusion (Gilbert, 2008)

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Risk Factors for POVL

- **Patient Factors:**
  - BMI > 35 kg/m2
  - Age > 62 years old
  - Diabetes
  - Vascular Disease
  - Hypertension
  - Atherosclerosis
  - Glaucoma
  - Smoking History
  - (Molloy, Cong, & Watson, 2016)
- **Surgeries**
  - Cardiac Surgery (4.5% incidence)
  - Spinal Surgery (0.2% incidence)
- **Intraoperative Factors**
  - Increased CVP
  - Hypotension
  - Severe Hypertension
  - Acute Hemorrhage
  - Large fluid boluses
  - Positioning (Prone)
  - Pneumoperitoneum
  - (Gilbert, 2008)

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Pathophysiology of RAP and POVL

- True ST occurs when a head down tilt of 45 degrees is performed.
  - Effectively shifts blood flow to central compartment
  - Increases hydrostatic pressure, MAP, and CVP (Schramm, et al., 2013)
- Determinants of IOP are aqueous humor flow, choroidal blood volume, CVP, and extraocular muscle tone (Hoshikawa, et al, 2014).
  - ST and increased central compartment blood lead to increased congestion within the eye, decreased OPP, and increased IOP.

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Pathophysiology of RAP and POVL

- IOP increases of ≥ 35mmHg lead to "…incremental damage to the optic disc and retinal nerve fibers" (Raz, et al., 2015, p. 1218).
  – IOP ≥ 22 mmHg lead to ocular hypertension
- Pneumoperitoneum causes an increase in choroidal blood volume thus increasing IOP.
  – May be assessed utilizing ETCO2
  – High ETCO2 correlates with an increase in choroidal blood volume and IOP.
  – The increase may result in the most common type of POVL known as ischemic optic neuropathy (Yoo, et al., 2014).

Pathophysiology of RAP and POVL

- Pneumoperitoneum continued…
  – The associated increase in IOP has been shown to be time dependent, and increases when ST is added (Yoo, et al, 2014)
  – According to Molloy (2011), a clinically significant reduction in OPP occurs after 120-160 minutes in ST.
    - After 160-170 minutes in ST, ocular autoregulation has been found to suffer
    - Increases the risk for periorbital and conjunctival edema and POVL.

Evaluation of Intraocular Pressure

- In 2012, Molloy proposed a visual assessment for anesthetists to perform quick evaluations of IOP.
  – Eyelid edema alone is a reliable sign of increasing IOP.
  – If conjunctival edema (chemosis) is present, it is a reliable sign of an IOP > 40mmHg.
    - Critical range and intervention is recommended by opthalmologists.

Proposed Preventative Measures

- Dexmedetomidine Infusion (Kim, et al., 2015)
  – Potent selective α2-adrenergic agonist
    - Analgesic, sedative, sympatholytic and hypnotic effects without significant respiratory depression.
  – Exact mechanism for impact on IOP is unclear.
  – Proposed mechanism is the "…direct vasoconstriction in afferent blood vessels of the ciliary body [results] in decreased aqueous humor production, which may affect the decrease in IOP" (p.315).
  – Infusion rate of 0.4mcg/kg/hr without a loading dose was utilized.
  – Between the control and experimental group, significant reductions in IOP were seen in the experimental group.

Proposed Preventative Measures

- Propofol Based TIVA (Yoo, et al., 2014)
  – Study compared a sevoflurane based anesthetic to a propofol based TIVA anesthetic.
  – Propofol was shown to be superior in attenuating IOP increases in addition to providing a higher OPP.
    - Result supported by Schafer and colleagues, whom also found a lower IOP in patients when a propofol based TIVA was used (2002).
  – Further research is needed to determine if this finding is generalizable, and will reduce incidence of POVL.

Proposed Preventative Measures

- Modified Z Positioning (Raz, et al., 2015)
  – Modified ST position: head and shoulders remain in a horizontal position while tilting the patient in ST position.
  – The modification reduced the rise in IOP
  – No compromise surgical exposure, robot docking, anesthetic, or the procedure with modification.
  – Patients displayed normal facial soft tissue post operatively
    - Those in ST displayed visible facial edema.
  – Limited study related to a small sample size and some limited IOP measurements

Proposed Preventative Measures

- **Timolol Eye Drop Administration (Molloy & Cong, 2014)**
  - Dorzolamide (carbonic anhydrase II inhibitor) acts to decrease production of the aqueous humor and timolol (B2-adrenergic blocker) blocks beta receptors in ciliary body.
  - One drop of the solution was administered to an experimental group undergoing RAP in ST.
    - However, ALL patients received a drop of the solution if their IOP > 40 mmHg.
  - The experimental group had an average of 26% lower IOP than the control throughout the procedure.
  - Participants who received the drops experienced less periorbital edema.

Recommendations

- Current literature has proposed multiple recommendations to attempt to reduce the incidence of POVL.
- However, it is unwise at this time to recommend a new standard or change to practice based on current evidence.
- Due to small sample sizes and many being the first studies of their kind, it must be concluded that these results are not yet generalizable to the broader patient population.

Conclusion

- RAP are increasing in incidence and their role in surgical medicine is expanding.
  - As this surgical technique expands, anesthesia must adapt with it.
- While the outlined case study patient recovered without significant complications, his eye irritation may serve as a warning of the potential complications that may occur during RAP in ST.

References

References

References


References
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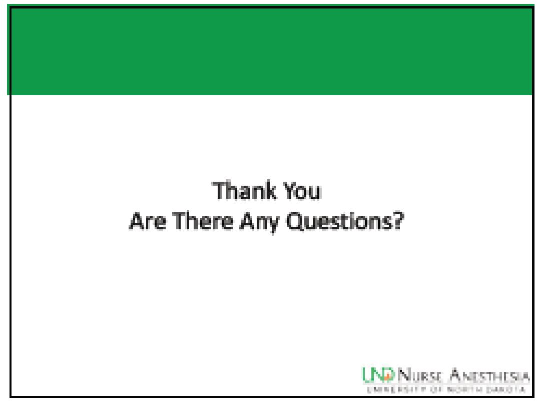
Thank You
Are There Any Questions?
UND Nurse Anesthesia