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Front Cover:
Samantha Sanders Tuchek, BSN, RN and Nermana Smajic, BSN, RN, doctoral students enrolled in the University of Kansas Medical Center Nurse Anesthesia Program, use the Orchestra Base Primea target-controlled infusion (TCI) System (Fresenius Kabi France) during a mission trip to provide anesthesia in Lima, Peru. Ms. Sanders has a case report describing its use in this issue.

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Case Reports

Encephaloduroarteriosynangiosis in a Patient with Moyamoya Disease

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Keywords: Moyamoya disease, encephaloduroarteriosynangiosis, EDAS, anesthesia management

Moyamoya disease (MMD) is a rare and progressive cerebrovascular stenotic disorder of the intracranial vessels.[1] Moyamoya is a Japanese term that describes the cluster of collateral vessels that resemble a "puff of smoke" under cerebral angiography.[1] Children with MMD primarily display ischemic symptoms, whereas adults primarily exhibit hemorrhagic complications.[1] Surgical intracerebral revascularization via encephaloduroarteriosynangiosis (EDAS) is often required to increase collateral blood flow to ischemic areas of the brain and prevent devastating neurological sequelae.[2] The purpose of this case report is to discuss the anesthetic goals and management of a pediatric patient with MMD undergoing EDAS.

Case Report

A 15-year-old female (101.4 kg, 180 cm, BMI 31.3 kg/m^2) presented for right-sided indirect extracranial to intracranial bypass EDAS for treatment of MMD. Her past medical history was significant for an increased frequency of migraines in the last 4 months. The migraines occurred at least twice a week lasting for 30 to 45 minutes. She also had one episode of paroxysmal supraventricular tachycardia in April 2018, which was successfully treated with adenosine. The patient denied a history of transient ischemic attacks (TIAs). No neurological deficits were noted. Home medications included albuterol, magnesium, aspirin, and vitamin B12 supplementation.

The patient was taking aspirin 81 mg oral therapy for seven days before surgery and received aspirin 325 mg the morning of surgery. Oral acetaminophen 1000 mg was administered 45 minutes before the procedure. No preoperative sedation was given. The anesthesia practitioners and surgeon agreed on maintaining an intraoperative systolic blood pressure (SBP) goal of 130 to 200 mm Hg. In the operating room, standard non-invasive anesthesia monitors were applied. Preoxygenation was achieved with O_2 10 L/min for 5 minutes via a standard anesthesia mask. Intravenous induction commenced with fentanyl 100 mcg, lidocaine 50 mg, propofol 200 mg. Neuromuscular blockade was achieved with rocuronium 60 mg IV. Direct laryngoscopy was performed, and the patient's trachea was intubated with a 7.5 mm cuffed endotracheal tube. End-tidal carbon dioxide ($EtCO_2$) was maintained between 33 to 37 mm Hg with a tidal volume 6 mL/kg of ideal body weight.

General anesthesia was maintained with desflurane 3.0% expired concentration in a mixture of O_2 1 L/min and air 1 L/min. A continuous propofol infusion of 100 to 150 mcg/kg/min was started. An additional 18 gauge IV was obtained in the right forearm. Under sterile ultrasound guidance, a 20 gauge arterial catheter was inserted in her left radial artery, and a double-lumen 7 Fr central venous catheter (CVC) was inserted in her left femoral vein. Somatosensory evoked potentials (SSEP) and electroencephalography (EEG) were monitored by a separate technician

and were reported as normal throughout the procedure. The degree of neuromuscular blockade was monitored via the adductor pollicis muscle with a peripheral nerve stimulator. Cisatracurium 2 mg IV was administered as needed for muscle relaxation. Additional propofol 50 mg IV and esmolol 70 mg IV were administered for subsequent placement of Mayfield skull pins. The patient's systolic blood pressure (SBP) was 121-139 mm Hg during Mayfield pinning. Norepinephrine infusion was titrated between 2-8 mcg/min and norepinephrine 4-8 mcg IV boluses were administered as needed to maintain a SBP 130-200 mm Hg. Intraoperative SBP was 130-155 mm Hg throughout the EDAS procedure. A total volume of crystalloid 2500 mL and albumin 5% 500 mL were administered for this 200 minute anesthetic. The estimated blood loss was 50 mL, and the total urine output was 650 mL.

Near conclusion of the procedure, ondansetron 8 mg IV was administered. During emergence, the norepinephrine infusion was gradually discontinued as the SBP was > 130 mm Hg. Once the Mayfield skull pins were removed, neuromuscular blockade was antagonized with neostigmine 5 mg and glycopyrrolate 0.8 mg IV. The patient's airway was suctioned, and the endotracheal tube was removed once she was able to open her eyes and squeeze her hand to verbal command. Further neurologic function was immediately assessed by the surgeon. The patient was alert and oriented to person, place, and time, and followed verbal commands. She was transported to the pediatric intensive care unit (ICU) and was discharged four days later with no neurologic sequelae.

Discussion

Patients with MMD are at increased risk of neurological complications, including TIAs, seizures, strokes, and stroke-related deaths. Surgical revascularization procedures such as EDAS are indicated for patients with MMD, as studies show improved cerebral neoangiogenesis in previous areas of ischemia.[2-4]

Gonzalez et al[3] studied the long-term effects of EDAS after 24 months in 107 patients with some form of vaso-occlusive disease. Forty-six of those patients diagnosed with MMD who underwent early EDAS exhibited a TIA-free survival probability of 99.7% at 2 years.[3] Follow-up angiographies showed evidence of neovascularization as early as 7 days after surgery.[3] All patients demonstrated angiographic evidence of revascularization, with 92% in the MMD group at 20 months.[3]

Preoperative antiplatelet or anticoagulation practices vary between institutions. Some institutions may continue utilization of aspirin-only therapy until the day of surgery,[3] while others may discontinue aspirin a week or more before surgery and bridge with low molecular weight heparin.[1,2,4] The patient in this case study received aspirin-only medication regimen similar to what is published in the literature[5] and presented with a normal coagulation profile on the day of surgery. Despite the variations in preoperative practices, many studies recommend that daily antiplatelet medication should be resumed one day after surgery to reduce the risk of cerebrovascular thrombosis.[2-4]

Perioperative hemodynamic stability is of the utmost importance to avoid ischemic-related sequelae and other neurologic complications. Intraoperative anesthetic management includes

maintenance of SBP above the patient's baseline, normal to modest hypervolemia, and normocapnia.[3-6] The discussion hereinafter will address how these goals were accomplished.

Patient preparation often begins the day before surgery. Fluid management goals include normovolemia to moderate hypervolemia with a target hematocrit range of 30%-50%.[3] This patient was admitted the night before for IV hydration while NPO to avoid hypovolemia and reduce the risk of decreased perioperative cerebral blood flow (CBF), particularly under general anesthesia when blood pressure fluctuations are likely to occur.[2]

Control of blood pressure and intracranial pressure during induction requires judicious and balanced administration of anesthetic drugs to level of stimulation.[4] Intravenous fentanyl and lidocaine were administered to attenuate the sympathetic response to tracheal intubation.[2] Propofol was administered slowly over 3 minutes to avoid ischemia to the abnormal vessels caused by excessive hypotension.[1] Non-depolarizing muscle relaxants were used to prevent consequences associated with histamine release that may otherwise be seen with a depolarizing agent such as succinylcholine.[1,2,6]

Intravenous access and methods of circulatory and cerebral monitoring need to be considered in revascularization procedures. At least two large-bore peripheral IVs and consideration of CVC insertion allows for safe administration of crystalloids, colloids, blood products, and vasoactive medications. Hemodynamic monitoring with an intra-arterial catheter allows for rapid assessment and treatment of the patient's blood pressure.[1,2,6] Both SSEP and EEG are used to monitor CBF and possible cerebral hypoperfusion (ischemia).[1,2,6]

Cerebrovascular tone and CBF are highly affected by arterial CO_2.[2,6] Gonzalez et al recommends that the $EtCO_2$ should be maintained between 35-45 mm Hg.[3] When $PaCO_2$ decreases to 29 mm Hg or below, decreased regional cerebral blood flow is observed.[2] Hyperventilation must be avoided to prevent cerebral vasoconstriction.[3]

There are currently no specific recommended anesthetic agents to achieve general anesthesia for patients with MMD undergoing EDAS. There are mixed conclusions about which anesthetic technique [inhalation or total intravenous anesthesia (TIVA)] provides the best outcomes.[4] Due to concern of inducing the intracerebral steal phenomenon with volatile agents, some studies suggest propofol-based TIVA may provide improved postoperative outcomes, as it preserves regional cerebral blood flow in the frontal lobe.[2,7] However, Adachi et al revealed no significant difference in postoperative complications between the two anesthetic methods two weeks after surgery.[8] In this particular case study, general anesthesia was maintained with both low-dose desflurane and continuous low-dose propofol infusion. Desflurane is the least blood-soluble volatile agent compared to sevoflurane and isoflurane, which allows for quick and precise control of anesthetic depth.[1] Propofol possesses antiemetic properties, does not affect SSEP monitoring, and has a relatively short and predictable context-sensitive halftime.[1,7] This technique merged the advantageous anesthetic properties of both agents to achieve general anesthesia without interfering with SSEP monitoring, and allowed for a rapid emergence for immediate postoperative neurological assessment.

The anesthetic management of patients with MMD undergoing EDAS will depend on the disease progression. The ultimate anesthetic goal is to maintain a balance between cerebral oxygen supply and demand to prevent ischemia-related neurological deficits. This goal is accomplished with preoperative IV fluid hydration, perioperative anticoagulation therapy, modest hypervolemia, SBP maintenance at or above patient's baseline, normocapnia with controlled mechanical ventilation, and postoperative ICU monitoring.[1,3,6]

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Anesthesia in the Radiology Setting: Patients with Trisomy 21

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Keywords: Down syndrome, Trisomy 21, radiology, magnetic resonance imaging, airway, anesthesia, obstructive sleep apnea, upper airway obstruction

Trisomy 21 is the most common chromosomal disorder, occurring in one out of every 700 live births.[1] Patients with Trisomy 21 pose unique anesthetic challenges in the radiology setting. Anatomical and physiological anomalies associated with Trisomy 21 significantly increase the risk of anesthetic complications, while behavioral abnormalities make it difficult for these

patients to remain still for prolonged periods. This creates the dilemma of exposing these patients to the risks of anesthesia for a non-invasive procedure.[2] There is little consensus on the most appropriate anesthetic management of patients with Trisomy 21 in the radiology setting.

Case Report

An 18-year-old female presented with new onset incontinence for magnetic resonance imaging (MRI) of the cervical spine. The patient had no known allergies, weighed 59.3 kg, was 161 cm in height, and had a normal body mass index of 23. The patient's past medical history included Trisomy 21 with developmental delay and chronic regional pain syndrome of the neck secondary to atlantoaxial instability (AAI). The patient was prescribed olanzapine for a non-specific mood disorder and levothyroxine for hypothyroidism. The patient's surgical history included myringotomy and tube placement at age 15-months with no anesthetic complications. The patient's laboratory and diagnostic test results were unremarkable. The patient's airway examination revealed micrognathia and a Mallampati score of III. Thyromental distance was not measured to maintain neutral neck positioning and avoid subluxation due to the patient's AAI. While this patient was of adult age, her healthcare was being managed at a local children's hospital to accommodate her developmental delay.

Patients undergoing an MRI must lie still for an extended period to facilitate adequate image capture. The patient presented above was unable to lie still for such an extended period, necessitating a deep plane of anesthesia. A peripheral intravenous (IV) catheter was placed in the pre-procedure holding area, but no premedication was administered to expedite recovery and reduce length of stay. In the MRI suite, an initial bolus of propofol 180 mg IV was administered, which provided adequate sedation and maintained spontaneous ventilation. Standard non-invasive monitors and a nasal cannula with $EtCO_2$ monitoring capabilities were applied once the patient was asleep. The patient received oxygen 2 L/min. A propofol infusion was initiated at a rate of 250 mcg/kg/min. A laryngeal mask airway (LMA), laryngoscope handle and blade, and endotracheal tube (ETT) were readily available.

An obstructive pattern was noted on the EtCO2 waveform within the first 10 minutes of the scan. This progressed to intermittent breath holding. The scan was paused to assess the patient, who was found to be obstructing in the upper airway. The obstruction was corrected by pulling the chin downward to displace the tongue and the propofol infusion was decreased to 225 mcg/kg/min. However, the scan was paused twice more to alleviate upper airway obstruction, which increased procedure time and the patient's exposure to anesthetics. The airway was secured with a size 3 LMA after the third procedure pause. An additional propofol 90 mg IV was administered and the infusion rate was increased to 250 mcg/kg/min. The MRI was completed without further complications.

Discussion

The MRI procedure area can be a stressful environment for patients with behavioral or development delays, such as Trisomy 21, because it is noisy and involves lying still for prolonged periods in an enclosed space.[3] These patients often require general anesthesia to acquire diagnostically accurate images without motion artifacts.[2] However, airway abnormalities

associated with Trisomy 21 predispose these patients to difficult intubation, upper airway obstruction, and postoperative respiratory complications.[4] The patient discussed above presented with several of these airway abnormalities, specifically, AAI, micrognathia, a small mouth opening, and a high Mallampati score, all of which factored into the resultant upper airway obstruction. It was deemed inappropriate to alleviate the obstruction with an oral or nasal airway. The placement of an oral or nasal airway without deepening sedation could have induced a laryngospasm, while deepening sedation to avoid a laryngospasm could lead to further respiratory compromise.[5] Instead, the propofol infusion rate was decreased to 225 mcg/kg/min to lighten sedation and prevent repeated obstruction; decreasing the infusion rate any further posed the risk of inadequate sedation. The initial decision not to instrument the patient's airway was made due to the increased risk of airway complications. General anesthesia was induced despite multiple unsuccessful attempts to alleviate the obstructed airway.

Approximately 22% of patients with Trisomy 21 have AAI, which is characterized by increased mobility at the articulation of the C1 and C2 vertebrae due to laxity of the transverse ligament and/or malformation of the odontoid bone.[6] AAI is often not detectable in the history and physical and many patients lack cervical spine imaging studies. This patient population should be considered at risk for acute dislocation. The probability of spinal injury from intubation or surgery in these patients is low, but the consequences can be severe.[1] Turning the above patient's head to one side to alleviate the upper airway obstruction was considered but not implemented due to the risk for spinal cord injury and impaired image capture.

The prevalence of obstructive sleep apnea (OSA) in patients with Trisomy 21 is estimated to be 50-100% in children and almost 100% in adults, regardless of body habitus.[7] Patients with OSA are especially susceptible to the respiratory depressant and airway obstructive effects of anesthetics due to their propensity for airway collapse and sleep deprivation. General anesthesia with a secure airway is preferable to deep sedation in patients with OSA. The Society for Ambulatory Anesthesia recommends assessing every ambulatory patient for the presence of OSA using the STOP-Bang Questionnaire (figure 1). If undiagnosed OSA is suspected, the

Figure 1: STOP-BANG Questionnaire

Choose either "yes" or "no" for each question	Yes	No
Do you **S**nore?		
Are you often **T**ired?		
Has anyone **O**bserved apnea?		
Is your blood **P**ressure high?		
Is your **B**MI > 35 kg/m2?		
Is your **A**ge > 50 years?		
Is your **N**eck circumference > 40 cm / 15.75 in.?		
Is your **G**ender male?		

Each "yes" = 1 point → add together for a total score
Total score interpretation: 0-2 = low risk, 3-4 = intermediate risk, ≥ 5 = high risk
Adapted from Joshi et al[8]

anesthesia practitioner should proceed with the assumption that the patient has OSA.[8] The high prevalence of OSA in patients with Trisomy 21 suggests the STOP-Bang Questionnaire would have been an appropriate tool in this case. The results may have indicated general anesthesia as the most appropriate course of action, which could have avoided procedural delays and repeated upper airway obstruction.

Lewanda et al[1] suggest an LMA is most appropriate for patients with Trisomy 21 undergoing short procedures, to maintain oxygenation and ventilation and avoid respiratory complications. However, an ETT is often utilized due to these patients' abnormal airway anatomy, increased risk for aspiration, and developmental and behavioral anomalies.[3] The anesthesia provider should assume some degree of subglottic stenosis when intubating a patient with Trisomy 21. The ETT should be 0.5 – 1 mm smaller in diameter than expected to prevent post-extubation stridor and the development of more severe airway stenosis. It should be taken into consideration that intubating this patient population may lead to chronic inflammation and scarring of the subglottic airway due to congenital and iatrogenic tracheal stenosis.[6]

It is often difficult to obtain quick, high-quality study images without sedating patients with developmental or behavioral disabilities, such as Trisomy 21. The procedure can increase stress and anxiety due to environmental factors and the prolonged need to lie still in an enclosed space. Patients with developmental or behavioral disabilities often have difficulty cooperating, resulting in motion artifacts and rendering study images useless. General Anesthesia can have significant consequences in the patient with Trisomy 21. Sufficient knowledge of the health problems that accompany Trisomy 21 and skillful perioperative anesthetic management are essential to avoid perioperative complications. Ultimately, this case was completed without detriment to the patient. Utilization of the STOP-Bang questionnaire may have illuminated the patient's likely undiagnosed OSA and thus altered the anesthetic plan to prioritize securing the airway with an LMA or ETT.

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Epistaxis in a Patient with Daily Cannabinoid Use

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Key words: Cannabinoid, naso-pharyngeal airway, marijuana, epistaxis

Cannabis sativa, also called marijuana, is the most commonly consumed psychoactive drug in the United States with over 30 million users.[1] This number has exploded in recent years due to many states passing legislation decriminalizing its use. It is expected that more states will legalize marijuana for medicinal and recreational use and sale, which may lead to a continued increase in the number of users. As more patients who use cannabis present for surgery, the implications of cannabinoid use that can affect anesthesia care require consideration.

Case Study

A 24-year-old woman presented with dysmenorrhea and pelvic pain for a diagnostic laparoscopy to rule out endometriosis. The patient weighed 66 kg and was 152 cm in height. Her medical history included iron deficiency anemia, anxiety and depression. Her preoperative anesthetic interview revealed marijuana usage multiple times each day in addition to occasional alcohol and tobacco use. The last documented marijuana use was 16 hours earlier. The procedure was scheduled for up to 2 hours with a possibility for ablation/fulguration of lesions. Midazolam 2 mg was administered intravenously (IV) in the preoperative holding area.

Induction of anesthesia was performed using lidocaine 50 mg, fentanyl 100 mcg, propofol 100 mg and rocuronium 50 mg. The trachea was intubated without difficulty following three minutes of easy mask ventilation. A maintenance anesthetic of inhaled sevoflurane 2% was used with O_2 and air at 1 L/min each. After a 20-minute exploratory laparoscopy, the surgeons declared they had found nothing to contribute to her symptoms and deflated the abdomen. The patient demonstrated one twitch when assessed for train of four. Neuromuscular blockade was antagonized using sugammadex, 300 mg. Sevoflurane was discontinued with O_2 administered at 6 L/min.

The patient began coughing, gagging, and biting on the endotracheal tube. An additional 50 mg of propofol was administered and a soft bite block inserted. The patient was extubated when she

had regained rhythmic and regular spontaneous respirations of sufficient tidal volume with eyes midline. Following extubation, the patient's airway was maintained with a jaw thrust. A lubricated 6 cm nasopharyngeal airway (NPA) was inserted through the right naris without improvement of the airway obstruction. This NPA was subsequently removed and a second size 7 cm NPA was inserted into the left naris.

Shortly after placement of the second NPA, the patient experienced a large amount of epistaxis and hemoptysis. She demonstrated disinhibition and thrashed vigorously. It became difficult to maintain a patent airway. The patient became hypertensive with a systolic blood pressure of 170 to 180 mm Hg. Her SpO_2 decreased to 60%. At no point had the patient been able to follow commands.

The patient was given propofol 100 mg and succinylcholine 100 mg and rapidly reimtubated. A propofol infusion was initiated for sedation. The bleeding slowed considerably and stopped once the patient was sedated and blood pressure controlled. An otolaryngologist was consulted to perform an examination to assess her nasal cavity. Her nasal passage was sprayed with oxymetolazone prior to the evaluation. A small mucosal tear in the right nostril was identified. It was unclear to the otolaryngologist if this tear was the source of bleeding, so bilateral nasal packings were inserted. After dexmedetomidine 16 mcg and response to commands were established, the patient was extubated. She was discharged home later that day.

Discussion

Epistaxis is a known complication of NPA insertion. It can occur when resistance is met during insertion or if an improper insertion technique is used.[2,3] Each naris has two pathways to the pharynx, the upper and lower pathway. The upper pathway lies between the inferior and middle turbinate, while the lower pathway lies below the inferior turbinate and along the floor of the nose. The middle turbinate is a more vascular structure and when damaged, hemorrhage can be significant.[2] It also lies next to the cribiform plate, which is an important pathway to the brain if a basilar skull fracture is present.[3] For this reason, passage of an NPA ideally follows the lower nasal pathway, where there is less chance of bleeding and damage to the middle turbinate or cribiform plate. Aiming the NPA back towards the occiput, rather than cephalad, will lessen the likelihood of passing the NPA along the upper pathway.[3]

Cannabis can contain up to 60 different cannabinoids, the most prevalent being tetrahydrocannabinol (THC), which is also the compound that causes the mind-altering effects of cannabis.[1] Cannabinoids exert their effect on g-protein coupled receptors of the endocannabinoid system. THC is a partial agonist at these receptors. It is important to note that some synthetic cannabinoids act as full agonists on these receptors and have a much greater potency than THC.[1] Cannabinoids have been associated with a range of perioperative issues. There is evidence that their use can lead to an inhibition of hemostatic mechanisms and platelet aggregation, as well as decreased platelet counts.[4,5] This mechanism could have contributed to the large amount of epistaxis observed. Research has also shown that cannabis may interfere with the metabolism of vitamin K antagonists, leading to a potentiation of those drugs.[1] Some synthetic cannabinoids have also been found to contain vitamin K antagonists, used as rodenticides, resulting in INRs greater than 20 in some patients.[6] This effect could result in increased intraoperative bleeding

and or devastating side effects of neuraxial/regional anesthesia. PT/INR should be checked on known patients concurrently using these agents and synthetic cannabinoids should be included in the differential diagnosis for unexplained coagulopathy. There was no unexpected surgical blood loss during our case until the time of epistaxis. There was also no coagulation study on the record.

Some research has suggested that cannabis users are at an increased risk of cardiovascular complications, especially while acutely intoxicated, including atrial arrhythmias and myocardial infarctions.[1,5] These events have occurred in young, healthy patients. These complications could be related to increased levels of carboxyhemoglobin leading to an increased myocardial oxygen demand.[5] Sinus tachycardia, increasing dose dependent bradycardia, hypertension, heart blocks and PVCs have all been observed.[1,5] Surgery and anesthesia should be delayed until the patient is no longer under the acute effects of cannabinoids, when possible. Our patient was outside of what would be considered the "acute" phase of intoxication, though the half life of cannabis can be prolonged from 4 to 6 hours up to 2 to 3 weeks in the setting of chronic consumption.[1] There have been multiple case reports of uvular edema following tracheal intubation in chronic inhaled marijuana users, often leading to airway obstruction upon extubation.[1,5] Compared to cigarettes when inhaled, cannabis also increases the patient's carboxyhemoglobin levels by 5 times, causing a leftward shift of the oxyhemoglobin dissociation curve in addition to increasing their exposure to tar and carcinogens due to the lack of a filter.[1,5] Other respiratory effects of chronic inhalation of cannabis include emphysematous changes, chronic bronchitis, and an obstructive respiratory presentation, as well as an increased incidence of lung cancer. Marijuana smoke is more damaging to mucosa than cigarette smoke, and some studies indicate that patients may present with significant respiratory symptoms up to 10 years earlier than cigarette smokers.[5] Our patient was not one we would have anticipated having an obstructive breathing pattern as her airway exam was benign and she was not obese and pre induction mask was easy. Although we cannot definitively attribute it to her marijuana use, the patient demonstrated unanticipated post-extubation upper airway obstructions.

Cannabis can also act as a potentiator of nondepolarizing neuromuscular blocking agents due to depletion of acetylcholine.[5] This effect may have contributed to the more profound level of blockade than expected. This depletion of acetylcholine also causes cannabis to have anticholinergic properties and can contribute to the tachycardia seen at low doses.[5] Chronic users of marijuana have increased anesthetic requirement possibly due to upregulation of the cytochrome P450 system.[1,5]

A larger dose of midazolam prior to induction or dexmedetomidine during the case may have smoothed the patient's emergence. Waiting to perform a completely awake extubation on this patient may have avoided the NPA being required. However, deeper extubations may be performed to smooth the emergence process in order to avoid coughing and gagging on the endotracheal tube. The patient exhibited signs of obstruction immediately, and an NPA is an airway adjunct that will remain tolerable to the lightly anesthetized patient longer when compared to an oropharyngeal airway. Once the NPA was in place and the bleeding interfered with airway management, the appropriate stepwise algorithm to protect the patient's airway and determine the source of bleeding was followed.

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Anesthetic Implications for Hyperthermic Intraperitoneal Chemotherapy

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Keywords: peritoneal carcinomatosis, pseudomyxoma peritonei, cytoreductive surgery, hyperthermic intraperitoneal chemotherapy, HIPEC.

Pseudomyxoma peritonei (PMP) is a rare form of peritoneal carcinomatosis characterized by a clinical presentation of recurrent mucinous ascites.[1] Patients diagnosed with peritoneal carcinomatosis often have poor prognosis and limited therapeutic options.[1] However, advances in surgical techniques and oncological therapies such as cytoreductive debulking followed by hyperthermic intraperitoneal chemotherapy (HIPEC) instillation, have shown to improve prognosis by 5-10 years.[1] Anesthesia professionals play a vital role in the complex interventions associated with cytoreductive surgery (CRS) and the administration of heated chemotherapy. This case study analyzes the anesthetic management and considerations for patients undergoing a CRS/HIPEC procedure.

Case Report

A 66-year-old, 90 kg, 170 cm male presented for CRS with HIPEC to treat PMP. The patient's past medical history included hypertension, hyperlipidemia, and diverticulitis. His preoperative course spanned over three years and consisted of: perforated diverticulitis requiring small intestine surgery with ostomy, abdominal distention and pelvic abscesses requiring drainage, right inguinal hernia repair, a positron emission tomography/computed tomography (CT) scan that showed increased activity in the right lower quadrant (RLQ), and CT imaging that showed a multilobulated cystic structure in the RLQ with a biopsy revealing a diagnosis of PMP. Preoperative laboratory values were unremarkable. The patient's medications included

amlodipine, aspirin, lisinopril, and metoprolol. Preoperative vital signs were BP 142/88 mmHg, HR 61/min, RR 18/min, SpO_2 100%, and temperature 35.4 ºC. A 16-gauge peripheral intravenous (IV) catheter was inserted in his left hand. Acetaminophen 975 mg per os (PO), gabapentin 600 mg PO, and midazolam 2 mg IV was administered in the preoperative area.

Upon arrival to the operating room (OR), standard noninvasive monitors were applied and oxygen 2 L/min was administered via nasal cannula. Lactated Ringers (LR) solution was initiated at 100 mL/min and fentanyl 50 mcg IV was administrated. A thoracic epidural was placed in the sitting position at level T10. General anesthesia was induced with midazolam 2 mg, lidocaine 1% 60 mg, propofol 160 mg, fentanyl 50 mcg, and vecuronium 15 mg IV. Endotracheal intubation was performed with an 8.0 mm endotracheal tube and placement was confirmed by auscultation of bilateral breath sounds and end-tidal CO_2. Two additional IVs, a 14-gauge and a 16-gauge, were obtained in bilateral arms and an arterial line was placed in the left radial artery. A nasogastric tube was inserted and a baseline pulse pressure variation (PVV) of 2% was calculated via the patient's arterial line. General anesthesia was maintained with Sevoflurane 1.5 - 2.0% with a flow mixture of O_2 1 L/min and air 1 L/min.

Hypotension during tumor debulking was treated with LR 2L, 5% albumin 500 mL, and ephedrine 10 mg. Fluid resuscitation responsiveness was measured by the patient's hemodynamics and PPV. At the end of CRS, the HIPEC preparation began and a baseline arterial blood gas (ABG) was obtained. At this time, the body warmer was set to ambient and the cooling blanket was set to the lowest possible temperature of 34 ºC. Famotidine 20 mg, dexamethasone 10 mg, and diphenhydramine 50 mg were administered IV. Prior to the initiation of HIPEC, a 10 mL bolus of 0.05% bupivacaine with fentanyl 2 mcg/mL was given via the epidural, and vecuronium 5 mg was given IV. LR solution was infused to achieve a urine output goal of 1 mL/kg/h. During the HIPEC infusion, the heated chemotherapy temperature ranged from 41.7 – 42.3 ºC and the abdomen was continuously agitated to ensure maximal peritoneal absorption. HIPEC was instilled for a total of 90 minutes during which the patient's temperature ranged from 36.3-36.6 ºC. Post HIPEC, an ABG was obtained and a continuous epidural infusion of bupivacaine 0.05% with fentanyl 2 mcg/mL was initiated at 3 mL/h for the remainder of the surgery.

The total procedure time from incision to closure was 7 hours and 34 minutes. A total of LR 6 L and 5% albumin 750 mL were given. On emergence, ondansetron 4 mg was administered, a 2/4 train of four count was obtained, and neuromuscular blockade was antagonized with neostigmine 4 mg and glycopyrrolate 0.6 mg IV. The patient was stable following endotracheal tube extubation and was transported to the post anesthesia care unit (PACU) with O_2 4 L/min administered via nasal cannula. Upon arrival to the PACU, pain was assessed and patient reported a pain score of 0/10.

Discussion

Pseudomyxoma peritonea are rare cases of peritoneal carcinomatosis with an estimate of 1-3 per million diagnoses annually.[1] The location of the abnormal cells makes systemic oncological treatments ineffective. Currently, the standard therapeutic option for PMP is CRS/HIPEC.[1] Anesthesia providers are crucial in the perioperative management of patients receiving this

procedure. A multitude of challenges are associated with the surgery including hemodynamic fluctuations, temperature regulation, electrolyte and coagulation disturbances, fluid management, and chemotherapeutic toxicities.[2]

CRS/HIPEC present significant postoperative complications and an estimated mortality rate of 15-20%.[3] Due to the extensive process of tumor removal and the instillment of heated chemotherapy, patient selection is highly specified to optimize surgical success. Candidates are selected based on preoperative examination of the tumor burden for excision, co-morbidities, and overall physiological state. The goal of CRS is to remove all visible tumors, with a complete cytoreductive score (CCR) of 0 or 1,[1,3] to maximize the infiltration of HIPEC. In the case discussed, the patient had well-controlled hypertension, surgically resolved diverticulitis, no abnormal preoperative laboratory values, and a CCR of 0, indicating no residual tumor was visible[3] prior to the start of HIPEC.

Along with the usual physiological changes that occur with surgery, anesthetic management of patients undergoing CSR/HIPEC presents added challenges. Perioperative considerations include, blood loss, fluid shifts, temperature control, adequate urine output, and electrolyte imbalances.[4]

During CRS, there are risks of hypothermia and significant blood loss due to surgical exposure and the long duration and extent of tumor dissection. In this case, the patient's core body temperature was continuously monitored via the nasopharynx, and body and fluid warmers were used. The patient remained normothermic throughout the duration of CRS and no thermoregulation complications were detected. Hemodynamics and fluid responsiveness were closely monitored via arterial line and PPV calculations. In contrast, hyperdynamic changes occur during HIPEC due to increased metabolic rate secondary to hyperthermia. Hemodynamic changes associated with HIPEC include increased cardiac output, increased heart rate, increased oxygen consumption, and decreased systemic vascular resistance.[5] The HIPEC carrier solution is heated to a temperature of 40-43^{o} C and normothermia must be maintained to avoid the determinantal effects of hyperthermia such as cardiac arrhythmias, liver and renal injuries, disseminated intravascular coagulation, seizures, and peripheral neuropathies.[4] Approximately 15 minutes prior to HIPEC instillation a controlled hypothermic state is initiated to prevent hyperthermia.[5] Recommended interventions include turning off fluid warmers, setting body warmers to ambient, initiating a cooling blanket and ensuring ice packs are available.[2] In addition, prophylactic medications are given to minimize the possibility of a hypersensitivity reaction prior to the administration of chemotherapy. In this case, all recommendations were followed. Fluid warmers were turned off, the body warmer was set to ambient, and the cooling blanket was started at the lowest possible temperature of 34^{o} C. Prophylactic medications, famotidine 20 mg, dexamethasone 10 mg, and diphenhydramine 50 mg were administered IV. The patient's body temperature measured 36.3-36.6^{o} C throughout the HIPEC treatment and there were no signs of a hypersensitivity reaction.

Fluid management is another important component to monitor during the 90-minute period of HIPEC. Renal function can be affected by the duration of the procedure, perioperative fluid shifts, temperature variations, and chemotoxicity. Currently, no guidelines are available in the literature regarding best practices for fluid administration and maintenance of adequate renal

perfusion during HIPEC. Urine output is an indicator of organ perfusion and should be recorded every 15 minutes during this part of the procedure.[5] The patient in this case had a urine output of 0.5 – 1 ml/kg/hour during the duration of the treatment. Electrolyte imbalances are also associated with the chemotherapy agents used and related to the extent of the procedure.[3] The standard displayed electrocardiogram rhythm is monitored for cardiac arrythmias. Patient specific hemodynamic responses during HIPEC can help gauge the optimal frequency of blood sampling[4] and the necessity for electrolyte corrections. In the case discussed, the patient exhibited minimal hemodynamic changes and a normal cardiac rhythm during HIPEC treatment. Arterial blood sampling was obtained prior to the start of treatment and post treatment. Laboratory values from the ABG samples did not require any interventions.

In addition, pain management, related to a large incision for surgical exposure, is essential for perioperative patient comfort and recovery. The use of regional anesthesia can help minimize IV opioid requirements and side effects, promoting earlier patient recovery. In the case discussed, a thoracic epidural was utilized, and a total of fentanyl 100 mcg IV was given for the induction of anesthesia with no additional IV opioids required. The patient was extubated in the OR and pain was appropriately managed by continuous infusion through the thoracic epidural for the duration of the case and into the post-operative period.

Pseudomyxoma peritonei, a disorder that was once considered to have limited therapeutic options, has an improved prognosis due to oncological and surgical advancements. CRS with HIPEC has become the gold standard of treatment for select patients diagnosed with PMP.[3] Anesthesia practitioners should have a thorough understanding of the physiological requirements and changes that occur during this procedure, as they play a vital role in the management and successful outcome of patients undergoing CRS/HIPEC.

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Use of Tranexamic Acid in Cesarean Section Hemorrhage

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Keywords: postpartum hemorrhage, tranexamic acid, cesarean section hemorrhage

The leading cause of postpartum hemorrhage (PPH) is uterine atony.[1]A distended uterus, prolonged labor, and an infected uterus are all risk factors that increase chances of uterine atony.[1]Patients who have received oxytocin during labor have a greater risk of developing PPH.[1]An antifibrinolytic medication, tranexamic acid, has been used in surgeries to lessen the amount of transfusions and decrease bleeding.[1]Tranexamic acid has been shown to lessen the volume of hemorrhage in PPH patients by inhibiting early fibrinolysis.[2] This is important to anesthesia professionals when managing large volumes of blood loss in postpartum patients.

Case Report

A 30 year old, G1P0, 82.6kg female was brought to the operating room as a Grade 2 cesarean section for arrest of dilation after 30 hours of labor. The patient presented with a functional epidural in place at the L3-L4 interspace and a 20g intravenous catheter (IV) in the left antecubital. The IV had Lactated Ringers infusing and nothing through the epidural. The patient had a diagnosis of chorioamnionitis and had been receiving an oxytocin infusion at 26 mU/min and ampicillin and gentamicin, up until arriving to the operating room (OR). The patient had an active type and crossmatch, O positive and negative antibody screen, and 4 units of packed red blood cells (PRBC) in the blood bank. The patient's starting hemoglobin was 13.3 g/dL, hematocrit of 38%, platelets 203 10^9/L, and no coagulopathy.

The patient was placed supine with left uterine displacement. Standard noninvasive monitors and oxygen via nasal cannula at 3 L/min were applied. The epidural was bolused with lidocaine, 2% with sodium bicarbonate 2 mEq, and epinephrine 100 mcg, for a total of 17 mL. The epidural was bolused periodically throughout the procedure with lidocaine, 2% for a total of 5 mL. A T4 sensory dermatome level was achieved via epidural medications and the surgeon performed an allis test by pinching the patients belly with an allis to test adequacy of the epidural. A phenylephrine infusion was initiated at 15 mcg/min and titrated to keep mean arterial pressure (MAP) greater than 80 mm Hg.

The procedure began without incident. Upon delivery of the fetus, oxytocin 40 units in normal saline (NS) 1L was initiated IV and titrated. Uterine atony persisted and methylergonovine maleate 0.2 mg was given intramuscularly (IM) in the right deltoid. Seven minutes later carboprost tromethamine 250 mcg was given IM in the left deltoid and misoprostol 400 mcg was given sublingually. Bleeding continued and tranexamic acid 1,000 mg was given IV via the left antecubital IV over ten minutes. With uterine atony still present and persistent bleeding, another dose of carboprost tromethamine 250 mcg was given IM in the right deltoid. After multiple attempts a second 20 g IV was placed in the right hand and the labs obtained were a complete blood count, coagulation factors, and an arterial blood gas. The patient began to present with hypotension (BP 70/43 mm Hg), tachycardia (HR 132/min), and pallor. Albumin 5%, 250 mL

was infused and ten minutes later a second Albumin 5% 250 mL was given. One unit of PRBCs was given due to laboratory results reporting with a hemoglobin of 8.9 g/dL, hematocrit of 26%, platelets 203 x 10^9/L, prothrombin time of 12.5 seconds, INR 1.1, PTT 25.3 seconds, fibrinogen of 2.7 g/L, and lactic acid of 4.4 mmol/L. An arterial line was inserted in the left radial artery, and the surgeon placed a uterine balloon to tamponade the bleeding. Incision was closed, preservative free morphine 4 mg was given through the epidural, and then remained in place for postoperative pain management. A second unit of PRBCs was given and the patient was transported to the postoperative care unit (PACU). The patient had a total estimated blood loss of 3200 mL and urine output of 1000 mL. The patient received 2300 mL of NS, 900 mL of Lactated Ringers, and 600 mL of PRBCs.

Discussion

PPH is defined as blood loss greater than 500 mL in vaginal delivery, 1,000 mL after cesarean section or any amount of blood loss that causes hemodynamic instability.[3] Coagulopathy due to hemorrhage after uterotonics and sutures have failed is generally the cause of large quantities of blood loss.[1] The coagulopathy that is associated with PPH can be due to a multitude of things such as failure of the liver to synthesize clotting factors, hemodilution, or disseminated intravascular coagulation (DIC).[1] When the placenta separates from the uterine wall it exposes open arteries and causes bleeding throughout. The main method of controlling the bleeding is the contraction of the uterus.[1] When bleeding does not subside or the uterus is unable to contract, there are a few maneuvers that can be performed to decrease bleeding. Management of bleeding is done by ensuring the uterus is empty, massaging the uterus to encourage it to contract or giving uterotonics to stimulate the uterus, uterine tamponade, removal of the blood supply to the uterus, and at worst case scenario removal of the uterus.[1] The leading cause of coagulopathy and PPH is uterine atony.[1]

There are many risk factors that can increase the chances of PPH such as obesity, chorioamnionitis, and preeclampsia.[1] This patient had a known diagnosis of chorioamnionitis. Women who have been exposed to large amounts of oxytocin during labor have been found to have a desensitization to oxytocin receptors in the postpartum period.[1] This patient was on an oxytocin infusion for long periods of time during her labor. After a trauma or within 1 hr of childbirth tissue plasminogen activator increases drastically. Tissue plasminogen activator causes plasminogen to be converted to plasmin which is a fibrinolytic enzyme.[2] All of these factors greatly increased this patients' risk of developing PPH.

Anesthetic considerations for PPH are similar to a massive hemorrhage treatment in the OR but it is important to know the key differences that occur in obstetrics. According to the American Academy of Family Physicians, Advanced Life Support in Obstetrics recommends treatment for poor uterine tone consist of oxytocin 20 to 40 units IV, carboprost 250 mcg IM every 15 minutes with 2 mg total, methylergonovine 0.2 mg IM every 2 to 4 hours, and misoprostol 600 to 800 mcg sublingually.[4] The patient in this case received oxytocin, carboprost, and methylergonovine.

The World Health Organization recommends the use of tranexamic acid within three hours of birth for women who have been diagnosed with PPH. (WHO 2017 TXA guidelines)[3] Tranexamic acid prevents the breakdown of fibrin clots and fibrinogen by inhibiting the activation of

plasminogen.[2] Tranexamic acid should be administered as 1 g in 10 mL infused over 10 minutes. After 30 minutes, if bleeding persists, a second dose of tranexamic acid 1 gm IV may be administered.[3] A second tranexamic dose may also be administered if bleeding restarts within 24 hours of first dose completion. The World Maternal Antifibrinolytic (WOMAN) trial has found that the administration of tranexamic acid to women with PPH decreased the number of deathes due to bleeding.[2] (the article states that systemic review of clinical trials showed that TXA decrease blood loss in surgery)The study also showed that tranexamic acid should be given alongside of uterotonics rather than waiting a prolonged time to see if they fail to work. Blood products should be given as they would for a massive hemorrhage with acknowledgement that fibrinogen depletion happens faster than any other clotting factors in PPH.[1] Plasma and PRBCs should be given in a 1:1 ratio and for every six units of PRBCs one unit of platelets should be given.[5] PRBCs should be given as 1 mL of PRBCs for every 2 mL of blood lost and fresh frozen plasma should be administered as 10 to 20 mL/kg.[6]

New advances have been found with the use of tranexamic acid to reduce the risk of death in PPH. Anesthesia professionals play a critical role in the management of obstetric patients during a PPH emergency. Knowledge of the critical importance of initiating tranexamic acid within three hours of birth for PPH will provide for better success in this patient population.

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Perioperative Multimodal Analgesia in Buprenorphine-Naloxone Patients

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Keywords: perioperative pain management, Suboxone, buprenorphine-naloxone, chronic opioid, multimodal analgesia

Due to the expanding public health crisis of opioid addiction, misuse, and overdose, there is a parallel increase in patients on opioid addiction therapy (e.g., buprenorphine-naloxone) undergoing surgery and anesthesia.[1] Buprenorphine, the primary treatment for chronic opioid disorders, is prescribed to over three million people.[2,3] This poses a unique challenge for anesthesia practitioners to manage pain throughout the perioperative period due to the pharmacological properties of buprenorphine-naloxone. The literature suggests diligent preoperative anesthetic planning, patient education, and maximizing multimodal analgesia including a N-methyl-D-aspartate (NMDA) antagonist such as ketamine, in place of traditional opioid-dominant care.[2,4–6]

Case Report

A 54-year-old, 175 cm, 68 kg Caucasian male presented for elective laparoscopic cholecystectomy under general anesthesia. His medical history was significant for gastroesophageal reflux disease, intervertebral disc disease, chronic back pain, arthritis, cholelithiasis and opioid use disorder. Previous surgeries included an inguinal hernia repair without any personal or family history of anesthesia complications. Home medications consisted of pantoprazole, buprenorphine-naloxone (last dose yesterday), ondansetron, zolpidem, and medical marijuana. The patient had no known drug allergies and admitted to the usage of the following: alcohol occasionally, current everyday tobacco smoker including two packs per day for 35 years, amphetamines and marijuana with last intake yesterday, and cocaine with last usage one week ago. Physical examination was remarkable only for blood shot eyes and hyperexcitable behavioral findings including pressured speech, hyperactive movements, and in general, being fidgety. Despite his use of cocaine and amphetamines, his electrocardiogram demonstrated sinus rhythm without additional conduction abnormalities. A recent urinalysis elicited cannabinoids, amphetamines, and cocaine metabolites. The patient was premedicated with IV midazolam 2 mg and transferred to the operating room (OR).

Upon arrival to the OR, the patient was transferred onto the operating table and standard noninvasive monitors were applied. Pre-oxygenation began via facemask at 10 L/min for three minutes prior to intravenous (IV) induction with fentanyl 50 mcg, lidocaine 40 mg, propofol 200 mg, and rocuronium 50 mg. An atraumatic endotracheal intubation was achieved without difficulty and IV dexamethasone 4 mg and cefazolin 2 g were administered prior to incision.

Anesthetic depth was maintained with an inspired sevoflurane concentration of 2%. Pain management throughout the case consisted of IV fentanyl boluses of 25-50 mcg for a total of 250 mcg of fentanyl when anesthetic management was considered light; when respiratory rate increased above 18/min along with an increased blood pressure or heart rate from baseline

parameters. At the procedure's conclusion, the rocuronium paralytic was antagonized with sugammadex 200 mg IV, the patient was extubated successfully, and was transferred safely to the postoperative anesthesia care unit (PACU). During the 2-hour PACU course, the patient complained of pain ranging from 7 to 8 out of 10 on the numeric rating scale (NRS) despite the total administration of oral oxycontin 20 mg, and IV hydromorphone 4 mg, fentanyl 150 mcg, ketorolac 30 mg, and acetaminophen 1 g. The patient continued to complain of severe pain and was admitted to manage his ongoing discomfort. After standing orders for buprenorphine, ketorolac, and acetaminophen were administered, the patient reached an adequate level of pain management, reporting a NRS score of 4 or 5 out of 10. He was discharged home on post-op day two with his preoperative medication regimen.

Discussion

Buprenorphine-naloxone, a derivative of a morphine alkaloid called thebaine, was approved in 2002 by the Food and Drug Administration for the treatment and maintenance of opioid dependence and addiction.[5] Buprenorphine-naloxone is a semi-synthetic mu receptor agonist-antagonist with potent kappa/delta receptor antagonist effects.[5,6] It is highly lipophilic causing slow dissociation from mu-opioid receptors resulting in a half-life of 37 hours, and a potency 30 times that of morphine.[5,6] Due to its high affinity at the mu receptor, ceiling effect from the partial agonist activity and long half-life, buprenorphine-naloxone competitively prevents binding of clinical doses of full opioid agonists at mu receptor sites thereby inhibiting the opioid analgesic actions. This leads to ineffective postoperative pain control and associated adverse events.[4–6]

Due to the growing number of patients on buprenorphine-naloxone (Suboxone) related to chronic opioid disorders, it is imperative for anesthesia providers to develop appropriate anesthetic plans for this critical patient population. Adequate pain management, one of the primary goals in the chronic opioid disorder patient, is essential to improve patient outcomes and satisfaction scores, effectively manage post-operative pain, and reduce healthcare costs.[2] One conventional recommendation in the literature includes administering increased doses of high mu activity opioids such as fentanyl, morphine, and hydromorphone in order to compete with buprenorphine at mu receptor sites and potentially provide desired analgesia.[2,4,5] If utilizing high-dose pure opioid agonist interventions, it is imperative to recognize the uncertainty and highly variable response to opioids.[5] However, opioid-focused anesthesia treatment poses a higher risk for adverse events, such as uncontrolled post-operative pain management, respiratory depression, an increase in hospital stay and healthcare costs, hyperalgesia, and an increase chance for relapse.[4,5] Unfortunately, as seen by the case presentation, the high-dose mu activity opioid approach was unpredictable and caused detrimental effects to the patient including unsatisfactory pain relief and an increased length of hospitalization.

Therefore, conforming to the recommendations from the current literature, the following interventions are crucial for optimal pain management: diligent preoperative anesthetic planning, reviewing pharmacology, and maximizing multimodal analgesia compared to traditional opioid-dominant care.[4] To start, a thorough pre-operative discussion with the patient is imperative to the success of the anesthetic and includes assessment of the history of chronic opioid use, last dosage of buprenorphine-naloxone, fears of relapse, the extent of anticipated peri-operative pain and the

post-operative pain management plan with continuation of opioid disorder medications.[1,4,5] Best practice guidelines for perioperative management of this patient population include non-opioid adjuvants for low postoperative opioid requirements with continuation of buprenorphine-naloxone, or utilizing non-opioid adjuvants in conjunction with high-affinity pure mu-opioid receptor agonist therapy for surgeries with higher postoperative opioid requirements.[5]

The literature demonstrates that the combination of multimodal analgesia and non-opioid adjuvants including ketamine should be utilized as the primary anesthetic management in non-elective surgery or continued use of buprenorphine-naloxone therapy throughout the peri-operative period.[1–4,7,8] The multimodal analgesia management includes local anesthetics, regional anesthesia, NMDA receptor antagonists, alpha-2 agonists, NSAIDs, and acetaminophen.[1,2,4–6] Multimodal analgesia has shown effectiveness in decreasing opioid consumption and improved pain relief.[1]

The use of peri-operative NSAIDs have been shown to decrease opioid requirements by 20 to 30%.[2] Perioperative IV acetaminophen specifically decreases pain scores compared to placebo trials.[2] Alpha-2 agonists and NMDA receptor antagonists have been shown to decrease acute post-operative pain and the progression to chronic pain.[1] Peri-operative ketamine administration has demonstrated a reduction in opioid consumption by 40%, and decreases the incidence of postoperative nausea and vomiting, hemodynamic compromise, hyperalgesia, and the risk for chronic postsurgical pain.[7,8] Due to NMDA receptor blockade, central sensitization is diminished and descending inhibition is enhanced, creating a favorable adjunct for chronic pain conditions whose mechanisms derive from those interactions.[7] Since the NMDA receptor mediates both hyperalgesia and tolerance, ketamine is an advantageous adjunct to multimodal analgesia to allow more effective pain control for chronic opioid disorder patients.[8] Multimodal anesthesia demonstrates more effective pain management by blocking receptors peripherally and centrally in the buprenorphine-naloxone patient population.[1]

In conclusion, research evidence supports current guidelines for the use of multimodal analgesia techniques versus opioid-dominant anesthesia by fostering more effective pain management, while also decreasing adverse events such as relapse and hyperalgesia from increased opioid consumption in patients on buprenorphine-naloxone. As discussed in this case, the literature supports increased doses of opioid agonists like fentanyl as an anesthetic alternative to pain management, however this mode of analgesia carries an increased risk for adverse events and less efficacy than multimodal analgesia.[2,5] As the case presentation demonstrates the patient's post-operative pain was uncontrolled due to the pharmacology of buprenorphine-naloxone, leading to an increased length of stay and healthcare costs. Best practice strategy for the patient population utilizing buprenorphine-naloxone includes implementation of multimodal analgesia techniques including NSAIDs, IV low-dose ketamine, nerve blocks and local infiltration of long acting local anesthetics. The multimodal analgesia approach should be recognized as part of the primary anesthetic plan for the patient with chronic opioid disorder.

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Ventilatory Management of Obese Patients during Pneumoperitoneum

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Keywords: obese, lung protective ventilation, barotrauma, post-operative pulmonary complications, pneumoperitoneum

Abdominal insufflation with gas is utilized in both robotic and laparoscopic procedures,[1,2] which creates a pneumoperitoneum that complicates anesthetic management.[2] The cephalad displacement of the diaphragm from increased abdominal pressure (IAP) is often compounded by Trendelenburg positioning.[2] Postoperative pulmonary complications (PPCs) after pneumoperitoneum are a common occurrence in the high-risk population of obese and morbidly obese (OAMO) patients, defined as body mass index (BMI) of greater than 30 and 40 kg/m^2 respectively.[3] Optimal mechanical ventilation modes and settings are explored and serve as a guide for ideal ventilatory management in this surgical population.[3,4]

Case Report

A 47-year-old, 143 kg, 175 cm, male with a BMI of 46 kg/m^2 presented from a skilled nursing facility to the Emergency Department with concern for Fournier's gangrene. The patient was scheduled for an emergency debridement, was returned to the operating room (OR) ten subsequent times over the course of one month for repeated debridement procedures. The patient's trachea was intubated orally for the initial procedure, and he was unable to meet criteria for tracheal extubation until six days after the initial surgery. Ten days after admission, the patient returned to the OR for his eighth procedure, a new laparoscopic diverting end colostomy and repeat washout and debridement of the wound.

The patient's medical history was significant for morbid obesity, obstructive sleep apnea, hypertension, current tobacco use with a 24 pack-year smoking history, multiple sclerosis, and a chronic stage three sacral ulcer. The preoperative assessment revealed low exercise tolerance and non-pitting peripheral edema. Physical assessment demonstrated a Mallampati Class III airway, thyromental distance of 5.5 cm, full cervical spine and thyromental joint mobility, and full beard. Vital signs were within normal limits.

The patient was transported to the OR and adequately preoxygenated with O_2 15 L/min via anesthesia face mask. Anesthesia was induced intravenously with fentanyl 25 mcg, propofol 150 mg, rocuronium 60 mg, and ketamine 15 mg. An initial attempt at direct laryngoscopy was unsuccessful and mask ventilation was required due to rapid oxygen desaturation. Upon the second attempt the trachea was successfully intubated utilizing a Macintosh 4 laryngoscope and 8.0 mm endotracheal tube.

Anesthesia was maintained with 1.8% sevoflurane inspired concentration in a mixture of air 1 L/min and O_2 1 L/min, and intermittent boluses of rocuronium to achieve 0 to 1 twitches using train-of-four monitoring. Ventilation was controlled with pressure control ventilation with volume guarantee (PCV-VG) mode. Initial ventilator settings were: tidal volume (V_T) 500 mL, respiratory rate (RR) 12/min, positive end expiratory pressure (PEEP) 7 cm H_2O, inspiratory expiratory ratio (I:E) 1:2, and fraction of inspired oxygen (FiO_2) 0.6, with a peak inspiratory pressure (PIP) of 21 cm H_2O. The patient was positioned in Trendelenburg and the abdomen was insufflated with carbon dioxide (CO_2). Three minutes after pneumoperitoneum, PIP increased from 23 to 33 cm H_2O and SpO_2 decreased from 99 to 95%. At this time, despite an increase of V_T to 600 mL, the patient's inspired V_T remained around 525 mL, most likely attributed to the set PIP limit of 35 cm H_2O. The following changes were made over a period of 20 minutes: RR increased to 18/min, PEEP increased from 7 to 8 cm H_2O, and I:E ratio reduced to 1:1.5. No change in PIP of more than 1 to 2 cm H_2O was appreciated for 20 minutes after these adjustments were initiated.

The patient's SpO_2 continued to decline, provoking suspicion of atelectasis. Forty minutes after incision, the patients recorded SpO_2 was 93% and $ETCO_2$ was 34 mm Hg with exhaled V_T 536 mL, PIP 31 cm H_2O, and FiO_2 0.54. The FiO_2 was temporarily increased to 1.0, and a lung recruitment maneuver was performed 44 minutes after incision, delivering a breath over the course of 10 seconds at a pressure of 40 cm H_2O. One hour after incision the PIP decreased from 33 cm H_2O to 25 cm H_2O and was maintained between 25 to 29 cm H_2O for the remainder of the

case. The trachea was successfully extubated, and the patient was transported safely to the post anesthesia care unit. No complications were noted in the immediate post-operative period.

Discussion

A decrease in functional residual capacity (FRC) and greater susceptibility to early airway closure is observed in the OAMO populations.[5] Additionally, there is a positive correlation between BMI and the extent of atelectasis and pulmonary shunt.[5] Obesity, abdominal insufflation, and steep Trendelenburg all contribute to high airway opening pressures (AOP).[5,6] The most significant contributing factor is changes in chest wall elastance from distribution of increased IAP.[1,6] Elastance, or elastic resistance, is the reciprocal of compliance. Consequently, an increase in elastance leads to a decrease in compliance.[5] Individual factors that increase pulmonary elastance have a compounding effect in decreasing pulmonary compliance, further contributing to early airway closure.[5,6]

Postoperative pulmonary complications are correlated with increased morbidity and mortality.[3] Perioperative barotrauma, volutrauma, and ventilator-induced lung injury (VILI) are identified as contributing factors.[3,5] Barotrauma and volutrauma correlate with plateau pressures greater than 30 cm H_2O and PIP greater than 40 cm H_2O.[6] Ventilator-induced lung injury can occur from the cyclic collapse and re-expansion of alveoli.[4,5] The OAMO populations are at high risk for early airway closure, atelectasis, and thus PPCs.[3,4,5]

A review of recent literature cited common themes among the surgical population of OAMO patients. In a comparison of PCV to volume control ventilation (VCV), patients receiving VCV required higher minute ventilation to maintain adequate gas exchange.[7] Patients in the PCV group exhibited lower PIP, but did not always achieve adequate V_T.[7] Pressure control ventilation does, however, allowed for a more homogenous distribution of ventilation due to the decelerating flow pattern.[2,7] Ideally, a combination mode of PCV-VG should be used to allow for consistent ventilation while achieving set V_T, without increasing airway pressures.[2,7]

Xie et al.[3] compared RR, V_T, and I:E in OAMO patients, to achieve optimal lung-protective ventilation (LPV) during pneumoperitoneum in the Trendelenburg position.[3] Patients were split into three groups, and each variable was analyzed in association with effects on $ETCO_2$, PIP, and mean airway pressure.[3] The results suggest the ideal combination for LPV is RR 9, V_T 8 ml/kg, and I:E 1:2.[3] This is consistent with Liu et al.[4] findings that V_T 7ml/kg ideal body weight (IBW) compared to 10 ml/kg IBW resulted in less PPCs and improved oxygenation. I:E can have a significant effect on airway pressures, atelectasis, and gas exchange.[7] The findings of two separate studies, Gad et al.[2] and Zhang and Zhu[7] indicate that inverse ratio ventilation (IRV), defined as I:E of 2:1, is superior to both equal ratio ventilation (ERV) and traditional ratio ventilation, defined as I:E of 1:1 and 1:2 respectively. With IRV, airway pressures were reduced, oxygenation and dynamic compliance were improved, and the release of inflammatory cytokines was decreased.[7]

The largest discrepancy in literature was regarding the level of PEEP and utilization of alveolar recruitment maneuvers (ARMs). In OAMO patients who demonstrate airway closure after induction, ARMs utilizing 40 cm H_2O every 30 minutes were not enough to eliminate atelectasis

during laparoscopic surgery, but did improve pulmonary compliance and oxygenation.[5,6] ARMs with 55 cm H_2O every 20 minutes may better treat atelectasis, but only when followed by PEEP of 10 cm H_2O.[5,6] In non-obese patients, ARMs of 30 cm H_2O every 30 minutes during laparoscopy reduced PPCs.[4] The OAMO group is predisposed to early airway closure while the non-obese group is not, indicating the need for a distinctive approach in OAMO patients.[6]

The effectiveness of perioperative ventilation management aimed at preventing PPCs relies in part on the method used for preoxygenation.[6] Utilizing continuous positive airway pressure (CPAP) during preoxygenation for OAMO patients reduces atelectasis formation and increases the safe apnea window.[6] To avoid VILI, it is most beneficial to prevent alveolar collapse early.[4,5,6]

The cumulative time this patient was supported with mechanical ventilation during his hospital stay denotes a concern for preexisting VILI, atelectasis, barotrauma, and volutrauma.[6,7,8] The major foci of the anesthesia team were PPC reduction, adequate ventilation, and maintaining stable hemodynamics. Based on the measurements of PIP, $ETCO_2$, V_T, and SpO_2 over the course of the case, the risk of barotrauma and volutrauma were mitigated, but at the expense of atelectasis.[2,3,5,6,] The delay in tracheal intubation likely contributed to increased atelectasis and pulmonary shunt.[5,6] The use of CPAP during preoxygenation may have circumvented the need to mask ventilate after initial laryngoscopy, and reduced the level of atelectasis present for the duration of the case.[6] Consistent ARMs at a pressure of 55 cm H_2O every 20-30 minutes followed by a PEEP of 10 cm H_2O after pneumoperitoneum initiation, may have also assisted with atelectasis management.[5,6] The adjustment made to the I:E ratio may have been more beneficial if IRV was used as opposed to the selected setting of 1:1.5.[2,3]

During the perioperative period, safe and adequate ventilation was difficult to attain for this critically ill patient. The anesthesia practitioner must recognize that OMAO populations are at risk for early airway closure and that they often benefit from preventative steps and aggressive management of atelectasis.

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Effects of Anesthesia on Breast Cancer Metastasis and Recurrence

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Keywords: regional anesthesia, breast cancer, opioids, metastasis, recurrence

The combination of tumor manipulation, anesthetic technique, and neuroendocrine responses to surgical interventions make cancer proliferation highly susceptible.[1] Surgical removal of tumors allows for the propagation of cancer cells by physical dislodgement into the bloodstream.[1] During surgery, opioids are a mainstay to attenuate laryngeal reflexes for intubation, minimize surgical stimulation, and provide pain control. A recent study found a 4-times higher recurrence-free rate in patients who received paravertebral blocks compared to opioid intravenous patient-controlled analgesia.[2] As healthcare providers, we need to be cognizant of the implications of opioids on cancer progression.

Case Report

A 43-year-old, 62.1 kg, 167.74 cm, Caucasian female presented for oncoplastic reconstruction and right breast reduction for symmetry. The patient had recently undergone right breast papilloma excision and completed neoadjuvant chemotherapy. Her medical history was significant for Hashimoto's hypothyroidism. Her current medication regimen consisted of gabapentin, levothyroxine, vitamin D supplement, and fexofenadine. Allergies consisted of trastuzumab, which caused throat swelling resolved by diphenhydramine, famotidine, and solumedrol. The patient's surgical history included a right breast papilloma excision and a chest port placement. The patient reported no prior complications with anesthesia. A complete metabolic panel, complete blood count, and urine pregnancy test were obtained. All laboratory

values were unremarkable, and the urine pregnancy test result was negative. The patient reported no oral intake for greater than 8 hours. A 20-gauge peripheral intravenous (IV) catheter was inserted into the patient's left hand. A continuous infusion of lactated ringers (1L) was initiated.

After informed consent was obtained, the patient was placed in a sitting position, and the patient's blood pressure, cardiac rhythm, heart rate, continuous pulse oximetry, and level of consciousness were continuously monitored. The patient received midazolam 2 mg and ketamine 10 mg IV. The pain services team performed an ultrasound-guided single-shot paravertebral block and administered bupivacaine 0.5% (15 mL) bilaterally for intraoperative and postoperative pain management. No evidence of hemodynamic changes, pain or paresthesia on injection, or aspiration of blood were noted during the paravertebral nerve block. The patient tolerated the procedure well.

Once in the operating room, noninvasive blood pressure, pulse oximeter, and electrocardiogram monitors were applied. Preoxygenation was initiated with O_2 at 6 L/min via facemask. General anesthesia was induced with lidocaine 100 mg, propofol 170 mg, and rocuronium 50 mg IV. Once induced into general anesthesia, mask ventilation with 100% oxygen was initiated and the patient's eyes were protected. Direct laryngoscopy was performed with a size three MacIntosh blade. A grade I view was achieved and a 6.5 mm endotracheal tube (ETT) was advanced through the glottic opening and secured at 21 cm at the teeth. Chest rise and condensation in the ETT were noted, bilateral breath sounds were auscultated evenly, and positive end-tidal carbon dioxide ($ETCO_2$) tracing was observed. Pressure control volume guaranteed ventilation was utilized with 425 ml tidal volume (TV), 10 breaths per minute (bpm), and 5 mmHg positive end expiratory pressure (PEEP). General anesthesia was maintained through total intravenous anesthesia (TIVA) consisting of a propofol infusion at 150 mcg/kg/min.

At the conclusion of the case, the patient received ondansetron 4 mg IV for antiemetic prophylaxis. After spontaneous ventilation efforts were noted, the ventilator's mode was set to pressure support ventilation. The patient's neuromuscular blockade was evaluated using a train of four (TOF) which indicated 4/4 twitches. Sugammadex 60 mg IV was administered to antagonize the rocuronium, and the TIVA infusion was discontinued. Once the patient was noted to have adequate TV and respiratory rate (RR), the ventilator was set to a manual spontaneous mode. After following commands and demonstrating a regular RR and an adequate TV (300 mL), the oropharynx was thoroughly suctioned, and the patient's trachea was extubated without incident. A nasal cannula set at 2 L of oxygen flow was applied and the patient was transported to the post-anesthesia care unit (PACU). Upon arrival in PACU, the patient complained of 9/10 pain and was treated with fentanyl 50 mcg IV, and meperidine 12.5 mg IV was administered for shivering. The patient was discharged home once adequate pain control was achieved.

Discussion

Worldwide, there are an estimated 9 million new cancer cases diagnosed each year with a mortality of 4.5 million.[1] Research showed that opioids have been implicated in angiogenesis and immunosuppression promoting the potential for metastasis and recurrence of cancer.[1] Certain opioid-free anesthetics, such as regional techniques, have shown to attenuate cellular immunity.[1] Anesthesia providers need to be aware of the implications of anesthetic agents on

cancer recurrence, particularly during surgical excision of a tumor(s). A patient's most vulnerable time for micro-metastasis formation and cancer proliferation is during excision. This discussion will focus on the effects of opioids and regional anesthesia on breast cancer recurrence and metastasis formation.

Surgery and other factors, such as surgical stress, pain, hypothermia, and anesthetic technique, suppress the body's immune system by activation of the hypothalamus-pituitary axis and sympathetic nervous system.[1,3,4] By definition, cancer is composed of an unregulated proliferation of cells.[1] As proliferation progresses into tumor formation, cancer cells release vascular endothelial growth factor and prostaglandin E_2, which promotes the growth of new blood vessels.[1] In time, cancer invades the endothelial layer of blood vessels allowing cancer cells to spread to various locations around the body. Multiple cellular defense systems exist to eliminate cancer cells particularly cytotoxic T cells, natural killer (NK) cells, NK-T cells, macrophages, and dendritic cells.[1,4,5] Surgical removal of tumor cells results in physical disruption of tumors and dislodgement of cells into the bloodstream. Dislodged tumor cells can remain in circulation for an unknown length of time.[4] One study of breast cancer patients in remission found that 59% had circulating tumor cells 7 to 22 years after mastectomy.[4]

Recent research implicates opioids in cancer proliferation, recurrence, and metastasis due to their pro-tumor effects and suppression of NK cell activity.[1,2] Morphine stimulates mu-opioid receptors located in the vascular endothelium leading to angiogenesis, inhibition of apoptosis, and promotion of tumor progression.[1,4] In addition to promoting the creation of new blood vessels, opioids also weaken vascular endothelial cell membranes allowing an increase in cancer cell efflux into the bloodstream.[1] Based on the overall dose and blood concentrations, opioids can trigger or suppress tumor growth with higher blood concentrations promoting tumor growth and intermittent injections resulting in tumor suppression.[1] In a retrospective study of 129 breast cancer patients, those who received paravertebral blocks for pain management remained cancer-free 4-times longer than those who received intravenous patient-controlled analgesia.[2] Additionally, one study found that the administration of methylnaltrexone, a peripheral mu-opioid receptor antagonist, inhibited cancer growth by 80%.[4]

A common hypothesis is that regional anesthesia helps to preserve the body's natural defense mechanisms due to decreasing surgical stress, reducing opioid consumption, and minimizing dosages of general anesthetics.[6] Local anesthetics employed as regional or neuraxial techniques alone, or in combination with general anesthesia, preserve T and NK cell activity, avoid stimulating the neuroendocrine stress response, and have cytotoxic activity in in vitro studies.[1,2] Regional and neuraxial anesthetics reduce opioid use and doses of other general anesthetic agents, thereby reducing the negative effects.[1] One meta-analysis of five studies found paravertebral blocks reduce postoperative pain scores and total opioid consumption by up to 72%.[7] Due to the vasodilating effects of regional anesthetics, lymphatic drainage is similarly decreased resulting in less spread of cancer cells and a reduced risk of metastasis.[1] Another study found a 94% survival rate in patients who received paravertebral blocks compared to 77% in those who received general anesthesia alone.[1,8] Due to their cytotoxic effects, local anesthetics cause cell death via necrosis and apoptosis.[4] Lidocaine and bupivacaine's apoptotic effect reduces proliferation, invasion, and migration of breast cancer cells.[4] However, a recent randomized control (RCT) study and meta-analysis composed of larger sample sizes have

synthesized opposing results. A meta-analysis studying regional versus general anesthesia for breast cancer resection involving 2,132 women demonstrated after 36 months, both groups experienced a 10% recurrence rate.[9] Lastly, one study found breast cancer recurrence following mastectomy similar between perineural ropivacaine and perineural saline groups, 11.5% and 7.1% respectively.[6]

The patient mentioned in this case report received general anesthesia with a paravertebral block. Although research is limited, regional anesthetic techniques help to; minimize the overall opioid administered, reduce the total dose of general anesthetics, maintain immune function, and avoid stimulating the neuroendocrine stress response.[1,3] In retrospect, this patient could have benefited from a denser block to ideally minimize the use of opioids entirely.

Current literature shows many limitations exist. Many of the studies were small sample sizes, animal studies, and retrospective in nature. The lack of compelling evidence does not warrant a change in current practice. Further research comprised of RCTs, with large sample sizes, needs to be studied in order to establish the best practice for reducing cancer recurrence and metastasis. These current research findings allow anesthesia providers to understand the impacts of certain anesthetic agents and the potential effects of each on cancer recurrence and metastasis.

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Management of Hypertension During Carotid Body Tumor Resection

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Keywords: Carotid Body Tumor, Resection, Anesthesia, Hypertension

Carotid body tumors (CBTs) are rare neoplasms from chemoreceptor cells located at the carotid artery bifurcation.[1-3] Although slow-growing in nature, these tumors can have devastating effects on an individual if left untreated.[2-4] Surgical resection of CBTs is the treatment of choice to avoid potential cranial nerve (CN) damage and malignancy.[1-6] Anesthetic management of these patients during resection can be difficult, requiring strict hemodynamic control. This case report discusses the care of a patient with intraoperative and postoperative hypertension associated with CBT resection.

Case Report

A 65-year-old female presented with an 8-month history of a right-sided neck mass just below the angle of the mandible. The patient reported a feeling of fullness in her right neck, and pain with neck movement and mass palpation. Past medical history included gastroesophageal reflux disease, asthma, obstructive sleep apnea, and hypertension. Past surgical history was not significant. The patient was compliant with her home medications: albuterol 2.5 mg/3mL (0.083%) nebulizer solution 2 puffs daily, amlodipine 7.5 mg, lisinopril 10 mg, hydrochlorothiazide 12.5 mg, and omeprazole 20 mg QD. The patient reported allergies to prednisone and aspirin.

Electrocardiogram revealed normal sinus rhythm with a left-sided bundle branch block. Computed tomography (CT) angiography with contrast revealed a 3x4x5 cm vascular mass spanning between the right external and internal carotid arteries (ICA), with almost complete encompassment of the ICA. These findings were suggestive of a CBT with a differential diagnosis of schwannoma or neurofibroma. On the day before CBT resection surgery, the patient underwent successful angiography and embolization of four arteries feeding the CBT.

In the operating room, standard noninvasive monitors were applied to the patient. Heart rate and rhythm, oxygen saturation, and blood pressure were all within normal limits (WNL) prior to induction. General anesthesia was induced via intravenous (IV) administration of midazolam 2 mg, fentanyl 100 mcg, lidocaine 40 mg, propofol 200 mg, and succinylcholine 100 mg. An endotracheal tube was inserted into the trachea and secured. The patient was mechanically ventilated without complication. Continuous blood pressure monitoring was achieved via catheterization of the left radial artery. General anesthesia was maintained with a propofol infusion at 100 mcg/kg/min and a remifentanil infusion at 0.2 mcg/kg/min. Hemodynamic control was maintained with a phenylephrine infusion titrated to goal mean arterial pressure (MAP) of 75-85 mmHg. Preoperative imaging indicated a potential for ICA resection; therefore, the right upper thigh was sterilely prepped and draped in the event that a saphenous vein graft was required. The patient was placed in supine position with neck extended and head turned to the left to facilitate surgical exposure.

During resection of the CBT, bradycardia was noted and resolved with immediate cessation of surgical stimulation, administration of glycopyrrolate 0.2 mg IV, and infiltration of the stimulated area with local anesthetic by the surgeon. After CBT resection, sudden onset hypertension with a MAP of 110 mmHg was observed and treated with cessation of the phenylephrine infusion and fentanyl 50 mcg IV administration. However, the patient remained hypertensive. Two boluses of nitroglycerine 20 mcg IV were administered 5 minutes apart, reducing the MAP to 90 mmHg. Two additional boluses of fentanyl 50 mcg IV administered 5 minutes apart reduced the MAP to 80 mmHg. The patient remained hemodynamically stable without further intervention while the surgeon closed the incision. Hydromorphone 0.4 mg IV was administered 30 minutes prior to extubation to provide analgesia and prevent hemodynamic instability during emergence from anesthesia and tracheal extubation. Mild to moderate airway edema was noted prior to extubation. An endotracheal cuff leak test was performed, and the anesthesia team confirmed that it was safe to proceed with extubation. The patient emerged from general anesthesia and the trachea was extubated without complication. Vital signs during and immediately following emergence and tracheal extubation were WNL.

Upon arrival in the post-anesthesia care unit (PACU), standard monitors were applied, and hypertension was again noted via arterial line tracing with a MAP of 100 mmHg. Three doses of labetalol 5mg IV were administered 5 minutes apart, decreasing the patient's MAP to 80 mmHg. The blood pressure remained WNL for the remainder of the hospital stay. The patient was discharged without further complications on postoperative day two.

Discussion

Carotid body tumors arise from carotid body chemoreceptor cells, located at the bifurcation of the common carotid artery.[3] These slow-growing tumors are most commonly seen in women between forty and sixty years of age.[2,4-6] CBTs are most often characterized as paragangliomas and can be associated with pheochromocytomas.[3,6] While CBTs are rare, their potentially malignant nature, risk of catecholamine secretion, and proximity to major vessels and cranial nerves necessitates surgical resection.[1-6]

Patients may present with a palpable lateral neck mass, as was seen in this patient.[2-6] The tumor can compress the vagus, superior laryngeal, hypoglossal, accessory, and glossopharyngeal nerves leading to dysphagia and hoarseness.[1-5] CBTs can also compress major vessels of the neck, resulting in lightheadedness and syncope.[2-5] Diagnosis is made via ultrasound, CT angiography, or magnetic resonance imaging (MRI) angiography.[1,2,4,5] Imaging helps classify the tumor and identify its involvement with adjacent structures.[3] Considering the potential for association with pheochromocytoma and tumoral catecholamine secretion, urine metanephrine and vanillylmandelic acid measurements should be assessed preoperatively.[1-3,5,6] Urinalysis was not indicated in this patient due to absence of hypertension, tachycardia, or sweating, which are all suggestive of increased catecholamine secretion.[1]

The risk of intraoperative bleeding from the highly vascular tumor can be reduced by preoperative embolization of vessels feeding the CBT, as was performed in this patient.[4,7] Synthetic or saphenous vein grafting may be required if the CBT resection includes part of the

carotid arteries.[3,4,7] Shamblin et al. first classified carotid body tumors in 1971, with type III tumors being far more difficult to resect than type I and II tumors due to their deep infiltration of vital vessels.[3] Although the patient did not have a documented Shamblin classification, the almost complete encompassment of the ICA would label her tumor as type II.[3] Unlike type III tumors, type II tumors rarely require vessel grafting.[3] The surgeon concluded that carotid vessel surgical intervention would most likely not occur due to the superficial nature of the tumor's attachment to the ICA.[3,5] Therefore, preparing the right upper thigh for saphenous vein grafting was a precautionary forethought.

Carotid body tumor removal is a high-risk surgery, and its anesthetic management is inherently challenging. Although peripheral nerve blocks offer advantages over general anesthesia, they are not recommended for surgeries involving CBTs.[5] A cervical plexus block is ideal for other types of carotid artery surgery.[5,8] Still, the risk for hematoma or inadvertent intravascular injection is too high with CBT surgery due to the tumor's extensive vasculature.[5] The literature does not identify a preferred agent for the induction and maintenance of general anesthesia; therefore, any method that promotes hemodynamic stability is acceptable. Due to potential need for intraoperative nerve monitoring, remifentanil and propofol were utilized for maintenance of anesthesia in this case.

Bradyarrhythmias, asystole, and hypotension can be seen during tumor resection as a result of carotid sinus baroreceptor stimulation.[2,5,8] If the immediate cessation of the stimulus does not reestablish hemodynamic stability, glycopyrrolate 0.2 mg or atropine 0.4-1 mg IV are indicated for correction.[1,2,7] After hemodynamic stability is achieved, the surgeon should infiltrate local anesthetic in the area surrounding the carotid sinus to prevent subsequent events.[1] Postoperative hypertension is common with carotid endarterectomy surgery caused by carotid sinus baroreceptor dysfunction, which usually resolves within 24 hours postoperatively.[8] Although the carotid artery was not opened during this case, baroreceptor dysfunction may explain the patient's persistent hypertension given the proximity of the surgical site to the carotid sinus. Additional complications for CBT resection include nerve damage during tumor resection, increasing the patient's respiratory complication risk.[1,2,4,5] Surgical site edema adjacent to the airway may also cause partial airway obstruction, necessitating extreme caution during extubation.

A literature review revealed that similar cases utilized central venous pressure (CVP) monitoring and cerebral oxygen monitoring during CBT resection.[2,5] For this case, bispectral index monitoring was employed throughout the duration of anesthetic administration due to the use of total IV maintenance anesthesia. CVP and cerebral oxygen monitoring would have been necessary if the carotid artery was opened and clamped during the surgery; however, neither occurred during this case. The use of intraoperative nitroglycerine and postoperative adrenergic antagonists were appropriate, given the patient's persistent hypertension.[1,2,5] However, hydralazine or volatile agents could have also been employed intraoperatively to aid in hemodynamic control given their vasodilatory effects.[8]

Carotid body tumor resections pose many challenges to the anesthesia practitioner. Preoperative imaging assesses the ingress of a CBT into adjacent structures.[1,2,4,5] Type II and III tumors are associated with a higher risk for increased intraoperative bleeding and the need for artery

grafting.[3,5] Intraoperative bradyarrhythmias must be quickly communicated to the surgeon and treated with glycopyrrolate or atropine.[1,2,7] Hypertension can be treated with nitroglycerine, adrenergic antagonists, hydralazine, or titration of volatile anesthetics.[1,2,5,8] With vigilant monitoring and appropriate anesthetic intervention, patients can safely undergo CBT resection surgery with positive outcomes.

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Case Study of a Patient with a Cerebrospinal Fluid Leak

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Keywords: Cerebrospinal fluid leak, anesthesia, functional endoscopic sinus surgery, intrathecal fluorescein

Cerebrospinal fluid (CSF) leaks result from a communication between the subarachnoid space and the sinonasal tract.[1,2] CSF rhinorrhea can occur following endoscopic sinus surgery, neurosurgical procedures, skull-based trauma, or have a spontaneous etiology.[1,2] Spontaneous CSF leaks occur in patients with increased intracranial pressure (ICP), benign intracranial

hypertension (BIH), obesity, and uncontrolled hypertension.[1,2] Functional endoscopic sinus surgery (FESS) is the intervention of choice to repair CSF leaks.[1,2] Due to the open nasal cavity, increased bacteria, and highly vascular area, these procedures require delicate anesthetic management.[3-6]

Case Report

A 59-year-old male presented for endoscopic repair of CSF leak and removal of skull base tumor with insertion of a lumbar drain and instillation of fluorescein. The patient initially presented with clear rhinorrhea and intermittent headaches. Diagnosis of a skull base tumor and CSF leak was made via an MRI scan. Medical history was significant for hypertension, hyperlipidemia, and obstructive sleep apnea. Comorbidities were well managed with daily lisinopril and atorvastatin. All medications were held on the day of surgery. He weighed 120 kg with a body mass index of 40 kg/m^2. He had no drug allergies or past anesthesia history. All laboratory values and preoperative vital signs were within normal limits. He had a normal airway examination with a Mallampati score of 2 and a thyromental and interincisor distance of 3 fingerbreadths. The patient was alert and oriented, with no current concerns or active CSF leakage.

The anesthetic plan was devised, taking precautions to avoid bag mask ventilation and reduce the risk of pneumocephalus. He had an uncomplicated intravenous (IV) rapid sequence induction with midazolam 2 mg, fentanyl 150 mg, lidocaine 100 mg, rocuronium 10 mg, and succinylcholine 200 mg. Induction was followed by video laryngoscope endotracheal tube intubation, and mechanical ventilation was initiated. After intubation, a radial arterial line and a second IV were placed. A lumbar drain was placed by a neurosurgeon, and fluorescein was administered prior to the FESS procedure. Dexamethasone 10 mg and diphenhydramine 50 mg IV were administered per the neurosurgeon's request to combat inflammation and histamine release. Anesthesia was maintained with a propofol infusion at 100 mcg/kg/min, remifentanil at 0.2 mg/kg/min, phenylephrine 0.2 mcg/kg/min for a target mean arterial pressure (MAP) of 70 mm Hg. Intermittent doses of rocuronium 30 mg were administered to maintain a train of four count of less than or equal to one twitch, for a total of 120 mg.

He received a total of 2,300 mL of lactated Ringers solution throughout the seven-hour procedure. Approximately 30 minutes prior to emergence, ondansetron 4 mg IV was given for postoperative nausea and vomiting prophylaxis, and acetaminophen 1,000 mg IV was administered for post-operative analgesia. Neuromuscular block was antagonized with sugammadex 400 mg IV. Stable vital signs were maintained for the duration of the surgery. The procedure was completed without surgical or anesthesia complications. Upon extubation, the patient became hypertensive, and labetalol 10 mg IV was administered. He was transported directly from the operating room (OR) to the intensive care unit (ICU) for close monitoring with lumbar drain management and was discharged to home four days postoperatively with no sequelae.

Discussion

Cerebrospinal fluid rhinorrhea is the leakage of CSF from the subarachnoid space into the paranasal sinuses and the nasal cavity.[1,2,7,8] Causes of the leakage can be classified as traumatic, congenital, neoplastic, iatrogenic injury, and spontaneous.[2,7,8] Spontaneous CSF rhinorrhea has been linked to elevated ICP, BIH, obesity, and uncontrolled hypertension.[1,2] CSF leaks can go undetected for a prolonged period of time and pose a significant risk to the patient. Intracranial infections can occur as a result of the CSF leak, significantly increasing a patient's morbidity due to exposure of the subarachnoid space due to the open nasal cavity.[1,2] Patients can present with headaches, visual and balance disturbances, nausea and vomiting, rhinorrhea, nasal congestion, neurological deficits, or symptomatic meningitis.[1,2]

Upon discovery of a spontaneous CSF leak, the patient is referred to and managed by an ear, nose, and throat (ENT) surgeon. Official diagnosis requires a two-step process: confirmation of the leak, and localization of the leak.[1] The most accurate test for confirming a CSF leak is a beta-2 transferrin test. The test, which is noninvasive, collects a sample of nasal rhinorrhea to evaluate for the presence of the glycoprotein beta-2 transferrin.[1] This glycoprotein is present in CSF but is not detected in nasal secretions or surrounding tissue.[1] Once the leak is confirmed, localization is best completed with a high-resolution computed tomography test.[1,2] Surgery is necessary due to the increased risk of morbidity and mortality with this condition. FESS is considered the gold standard procedure to repair CSF leaks.[2,7,8] FESS presents advantages of avoiding morbidities associated with frontal craniotomy, greater visualization of the skull base defect, and high success rates.[2]

Localization of the CSF leak can prove to be difficult due to the translucent color of the CSF drainage in the nasal cavity, mixed with blood and mucosal secretions. Intrathecal administration of fluorescein sodium, a fluorescent green compound, is routinely used to localize the leak with increased success rates.[7,8] An intrathecal lumbar drain is placed in the OR, pre-induction or post-induction, by the anesthesia professional or neurologist. The lumbar drain is placed at the L3-5 level using strict aseptic technique while the patient is in a lateral decubitus position. Approximately 10 mL of CSF is withdrawn from the drain and mixed with fluorescein 10-25 mg. The mixture is then slowly administered over 10 minutes into the subarachnoid space.[7,8] Instillation of intrathecal fluorescein in high doses or at a rapid speed can lead to central nervous system injury.[7,8] Complications can arise with fluorescein administration, such as generalized tonic-clonic or absence seizures, status epilepticus, coma, paresthesia and paraplegia of the lower limbs, headache, deficits of cranial nerves, and aseptic meningitis.[7,8] All complications are high-risk and need to be managed by the anesthesia professional immediately.[7,8]

Anesthetic management for FESS cases with CSF leak repair requires vigilance and proper planning. Standard noninvasive monitors should be placed on the patient with the addition of an arterial line for close hemodynamic monitoring. Skull base deficits are commonly present; therefore, bag valve mask ventilation should be avoided to decrease the risk of pneumocephalus.[2] Standard rapid sequence intubation should be initiated to avoid bag-mask ventilation. FESS is conducted best using total intravenous anesthesia (TIVA) techniques along with preoperative steroids and topical vasoconstriction.[3-6] Providing anesthesia to optimize surgical visualization is essential during FESS.

Intraoperative hemostasis is a critical factor in FESS and directly relates to the quality of surgical intervention.[4,5] Bleeding in excess can compromise the safety and efficiency of the procedure.[3-6] Controlled hypotension is used to aid in intraoperative control of bleeding.[5] However, poorly controlled hypotension can result in decreased blood flow to organs, especially those sensitive to fluctuations in perfusion pressure.[3] A TIVA technique is proven to provide better control of hypotension with less bleeding in the operative field.[3,5] Utilization of TIVA with propofol and remifentanil decreases cerebral metabolism and cerebral blood flow is reduced by autoregulation.[5,6] During tracheal intubation and extubation, a TIVA technique provides a lower heart rate and mean arterial pressure.[5,6] Dexmedetomidine, in addition to propofol and remifentanil, is proven to aid in controlling blood pressure and maintaining hemodynamic stability.[6] Dexmedetomidine, used as an adjunct, also reduces the dose of opioids and propofol utilized throughout the procedure, and reduces post-operative nausea and vomiting.[6] A TIVA technique aids in the recovery of conscious and psychomotor functions upon the termination of anesthesia.[3,5,6] Additionally, intraoperative complications are decreased with the use of TIVA and adequately controlled hypotension.[5,6]

Patients with a CSF leak require certain precautions to be taken throughout the operative period. Once identified, precautions to avoid intracranial infection and other common complications need to be implemented immediately. Surgical precautions need to be taken to promote hemostasis and provide a clear surgical field. A TIVA technique utilizing propofol, remifentanil, and dexmedetomidine has proven effective with a decreased rate of complications. The patient in this case did receive TIVA with propofol and remifentanil; however, he may have benefited from the use of dexmedetomidine. Ensuring a smooth induction and emergence is imperative to surgical and patient success.

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Horner's Syndrome Following Labor Epidural Placement

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Keywords: Horner's syndrome, ptosis, miosis, anhidrosis, stellate ganglion block, labor epidural, labor analgesia, local anesthetic

This case discusses a seldomly reported side effect of local anesthetics via epidural administration. While typically a benign event, Horner's syndrome has been noted to cause serious complications. It is believed to have an incidence of 0.5% in the setting of labor epidurals.[6] Although uncommon, occurrence of this syndrome can be a frightening experience for a patient, especially a laboring mother.

Case Report

A 30-year-old female presented to a tertiary care facility for induction of labor at 41 weeks, 3 days gestation. She was a gravida 2, para 1, with history of an uncomplicated pregnancy. Her first pregnancy and delivery with an epidural were uncomplicated. Upon request, anesthesia was consulted for labor analgesia. Evaluation of the patient was unremarkable, and she reported no other past medical history. She denied any known drug allergies. The patient was 162.6 cm with a BMI of 32 kg/m^2. Following standard procedure, the student nurse anesthetist inserted a lumbar epidural on the first attempt in the L3-L4 vertebral interspace without complication. The precepting certified registered nurse anesthetist performed an elective dural puncture. Catheter aspiration for cerebral spinal fluid or blood, and test dose (3 mL lidocaine 1.5% with epinephrine 1:200,000) administration revealed negative findings. A 6 mL bolus of the pre-mixed pump solution (bupivacaine 0.0125% with fentanyl 2 mcg/mL) with the remaining 2 mL of test dose solution was then administered into the epidural space. An epidural infusion was initiated at 10 mL/hr. Timely relief from contractions was reported, vital signs were stable, and a bilateral T8 sensory block level was noted prior to the anesthesia providers leaving the birthing suite.

Twenty-nine minutes following loading dose administration, anesthesia was notified that the patient reported a feeling of heaviness in the right arm and right eye. Assessment of the patient revealed right-sided unilateral ptosis (eyelid drooping). Despite reported right arm weakness,

bilateral upper extremity grip strength was equal. The patient denied shortness of breath or the presence of sweating. Sensory block height was bilaterally at the T7 dermatome. The patient's SpO_2 remained greater than 95% and supplemental O_2 was not administered. The epidural infusion was temporarily turned off, and patient evaluation was insignificant for other abnormalities. Maternal blood pressure and heart rate remained stable and fetal heart tones were reassuring. The patient's unease dissipated after being educated regarding her symptoms and the likely associated cause. Although the patient initially expressed concern for having a stroke, she was relieved to find the diagnosis to be a quick and self-resolving episode of Horner's syndrome (HS). Beyond the cessation of epidural infusion, no further intervention was provided. Complete resolution of symptoms occurred within 30 minutes. At this point, the epidural infusion was restarted at a slightly decreased rate of 8 mL/hr, providing satisfactory labor analgesia until the birth of a healthy infant 2 hours later. Follow-up assessment the next morning revealed no neurologic deficits and the patient denied return of symptoms. Mother and baby were discharged home the next day.

Discussion

The superior branch of the stellate ganglia provides sympathetic innervation of the iris, ciliary muscle of the eye, and some of the blood vessels in the head.[1,2] Inadvertent blockade of these fibers from local anesthetic administration results in unilateral miosis, ptosis, and anhidrosis, the classic triad of HS.[1,2] Pregnancy-related changes, like engorged epidural veins and narrowed epidural space, are reported to be responsible for the increased likelihood of HS following placement of an epidural for labor analgesia.[3,4]

While believed to be rare, HS may be an underreported event due to its transient and non-harmful nature.[5,6] It is most commonly seen with regional blocks in the thoracic or cervical area but has been reported with lumbar epidurals as well.[3] Although typically a benign complication, HS has an incidence of 0.5% with labor epidurals.[6] A systematic review by Chambers found 63 reported episodes of HS with labor epidurals from 1972 through 2017.[5] No underlying theme was found linking incidence of HS to epidural management via bolus, infusion or varying local anesthetic preferences.[5] Although it is difficult to determine if the elective dural puncture was connected with this case, Smith et al. reports that unintended subdural injection can be a contributor to HS.[3] In light of this, there was no contraindication for an elective dural puncture in this case.

Although typically a benign event, HS is an undesirable event a mother may experience when seeking analgesia with a labor epidural.[2,5] Occurrence of such a complication can not only be frightening to the mother and distracting from the labor process, but may also result in cessation of local anesthetic administration. This temporarily negates the benefit of the requested epidural that was intended to subdue labor pains. Recovery is often rapid, and recurrence after restarting the epidural infusion is rare.[3,5] One case report did discuss the reoccurrence of HS three times in the same patient.[6] A subdural catheter was believed to be the culprit in this case. Although reports are limited, hypotension is thought to occur in roughly 13% of cases.[5] The authors of a systematic review found that 74% of symptom onset occurred within 1 hour of initial epidural bolus and the median time to resolution of symptoms occurred within 2 hours.[5] Median epidural administration volume prior to onset of symptoms was 18 mL.[5]

Contemporary literature findings align with the events of this case. While published case reports tend to discuss more severe episodes of HS, the onset in this case was identified soon enough that the patient did not suffer from adverse effects such as hypotension and shortness of breath.[3] Due to the certified registered nurse anesthetist's experience and knowledge, the patient was spared from a cerebral vascular accident work-up. However, it was still an alarming and disrupting event for the laboring patient to experience.

Management of care following HS focuses on an early diagnosis.[2] While imaging may be performed, HS diagnosis typically occurs through physical examination.[3] A broad differential diagnosis, including cerebral vascular accident, must be considered in the presence of HS symptoms.[3] In many reports, resolution of symptoms occurred before imaging could be obtained.[5] Initial management involves assessment of airway, breathing, and circulation, as well as fetal-well-being.[5] Each of these factors were evaluated in this case and the patient and fetus remained stable throughout. In the presence of maternal hypotension, hemodynamic support with fluids and vasopressors should be administered as indicated.[5]
It is imperative to assess epidural sensory and motor block level related to the possibility of subdural or intrathecal catheter migration.[5] The epidural infusion should either be decreased or paused until resolution of symptoms occurs.[5] Continue to monitor maternal hemodynamics and fetal heart tones while providing reassurance to the mother.[5] A delay in diagnosis involves the risk of prolonged hypotension, cardiovascular collapse, permanent neurologic damage, and fetal distress.[2,3,4] The need for surgical repair of permanently droopy eyelids has been reported as well.[4] Evidence has shown that early diagnosis and prompt management decreases the likelihood of patient harm, such as permanent ptosis secondary to HS.[2,4] Aligning with literature recommendations, all of the aforementioned factors were investigated in the case, the epidural was temporarily paused until symptom resolution, and no permanent patient harm was observed.

Anesthesia providers and obstetric nurses should be familiar with the signs and symptoms of HS in order to provide timely intervention and resolution of symptoms. It is essential to remain vigilant even for subtle symptoms as the onset of symptoms may be masked by labor.

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Thoracic Endovascular Aortic Aneurysm Repair and Spinal Cord Protection

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Keywords: Thoracic aortic aneurysm, thoracic endovascular aortic repair, spinal cord ischemia, intracranial pressure, cerebral spinal fluid drain

This case discusses cerebral spinal fluid drainage during thoracic endovascular aortic aneurysm repair. Although rare, spinal cord ischemia is a serious complication of thoracic endovascular aortic aneurysm repair and a variety of intraoperative strategies may be employed to mitigate this risk.

Case Report

An 80-year-old female presented to a tertiary care facility with new onset of chest and abdominal pain. Computed tomography angiography revealed a 5.1 cm fusiform thoracic aortic aneurysm (TAA) without rupture extending from the subclavian artery bifurcation to just superior to the diaphragmatic hiatus. Medical history included a stable 3.5 cm abdominal aortic aneurysm, essential hypertension, cholelithiasis, metastatic breast cancer, daily tobacco use, chronic obstructive pulmonary disase, and obesity. She had no known drug allergies and home medications included aspirin, metoprolol and losartan. An esmolol infusion was initiated to maintain a systolic blood pressure under 130 mm Hg and the patient was scheduled for an urgent thoracic endovascular aortic aneurysm repair (TEVAR) with left carotid to subclavian bypass grafting.

Preanesthetic evaluation revealed several concerning cardiovascular and pulmonary findings. An echocardiogram from 2 years prior revealed moderate concentric left ventricular hypertrophy with normal ejection fraction and moderate pulmonary hypertention. The airway examination revealed a Mallampatti III classification. Preoperative laboratory work showed slight anemia, but was otherwise unremarkable. No neurological deficits were noted. A lumbar spinal catheter was placed preoperatively at the L4-L5 vertebral interspace to allow for intracranial pressure (ICP) measurement and cerebral spinal fluid drainage (CSFD). Successful placement was achieved on the first attempt and no complications were noted.

The intraoperative course was uncomplicated. Following securement of the airway, a right radial arterial line and central venous catheter were placed under ultrasound guidance. The surgeon

performed a left carotid subclavian bypass via a supraclavicular incision. Intravenous heparin was adminsitered just prior to carotid artery clamping. Following successful grafting, the right common femoral artery was accessed for TEVAR. Stents were deployed from the celiac trunk to the subclavian artery under radiographic mapping. Breath holds facilitated aortic visualization. Intermittent CSFD was performed to maintain an ICP of 10 mm Hg. An intravenous norepinephrine infusion was titrated to maintain a systolic blood pressure greater than 100 mm Hg. Prior to closure, intravenous protamine was administered. Estimated blood loss was 100 mL and the patient received 2 L of crystalloid intraoperatively.

Emergence from anesthesia was uneventful. The patient showed reasurring neurological signs by moving all extremities to command in the post anesthesia recovery unit. The patient was admitted to the intensive care unit for close hemodynamic monitoring and for continued ICP monitoring and drainage. The spinal catheter was removed on postoperative day two in the absence of neurological deficits. The patient discharged to a skilled nursing facility on postoperative day six.

Discussion

Spinal cord ischemia (SCI) is a serious complication following TEVAR.[1-6] Hypoperfusion to the spinal cord via the anterior spinal arteries can precipitate transient or permanent neurologic damage causing paresthesia and paralysis.[1] Additionally, arterial occlusion during TEVAR may precipitate an increase in CSF pressure that may further mitigate spinal cord perfusion pressure.[2] The incidence of SCI following TEVAR ranges from 2.5 – 8%.[3] Risk factors include history of abdominal aortic aneurysm repair, left subclavian artery coverage without bypass grafting,[4] an aneurysm spanning multiple spinal segments,[5] advanced age, intraoperative hypotension, aortic rupture and emergency surgery.[1] This case met several well-documented procedural and patient risk factors for SCI. As SCI following TEVAR poses potentially devastating health outcomes, prevention modalities were implemented during this case.

There are a variety of spinal cord protection strategies available to mitigate the risk of SCI during TEVAR. The most recent guidelines by the European Society of Vascular Surgery recommend integrating therapeutic hypothermia and augmenting intraoperative blood pressures to promote spinal cord protection during thoracoabdominal aortic aneurysm repair.[3] Therapeutic hypothermia can be utilized to decrease cerebral metabolic oxygen demand and maintaining normotension promotes collateral spinal cord perfusion. These recommendations, however, are not specific to TEVAR. Early spinal cord ischemia may also be detected via intraoperative evoked potential (EP) monitoring.[1] Decreased amplitude and increased latency on EP waveforms may indicate SCI.[1,4] This strategy, however, has low specificity and sensitivity for SCI as malfunctioning peripheral nerves and perfusion abnormalities may dampen waveforms.[4] Finally, a recent meta-analysis reported CSFD may decrease SCI in TEVAR.[2] Physiologically, as aortic pressure decreases, CSF pressure increases; thus, draining CSF lowers intrathecal pressure and augments spinal cord perfusion.[2] Subclavian to carotid bypass grafting, preoperative CSFD placement, and blood pressure augmentation were strategies utilized during this case to mitigate SCI risk.

Retrospective evidence and moderate prospective trials report conflicting evidence regarding the use of CSFD during TEVAR as an effective intervention to prevent SCI. [1-6] While many studies support CSFD use, no formal guidelines exist and protocols on CSFD for TEVAR vary significantly by facility.[2] Most studies reported CSFD implementation preoperatively to maintain an ICP of 10-12 mm Hg, with no more than 10 mL of CSF drained per hour.[1,6] Similar hemodynamic goals were achieved during this case to maintain adequate spinal cord perfusion. Retrospective work by Hanna et al demonstrated no decreased risk for SCI when CSFD was implemented among high risk TEVAR patients.[7] Other retrospective work supported CSFD in reducing SCI, but this relationship was not statistically significant.[1] Studies included in the Malloy et al meta-analysis demonstrated a connection between increasing segmental artery coverage and increased CSFD volume and SCI occurrence.[5] Demonstrating increased risk for SCI with larger aneurysm spread may prove useful in developing protocols surrounding CSFD for SCI prevention.

In light of the evidence gap surrounding CSFD and SCI prevention during TEVAR, the risks and benefits to CSFD implementation must be weighed. The most common risk associated with the use of CSFD reported in retrospective research was drain failure.[1,6] A large systematic review found that mild side effects to CSFD such as back pain and spinal headache were as high as 23%.[2] Serious complications of CSFD such as subdural hemorrhage, intracranial hypertension, entrapped drain, infection and paraplegia were rare at 0.4%, 0.4%, 0.3%, 0.1% and 0.1% respectively.[2] In this case the CSFD was removed on postoperative day two and no adverse side effects were noted. The benefits for CSFD outweighed the potential risks in this high-risk case.

As new literature emerges, a comprehensive approach to SCI prevention during TEVAR may yield the most benefit to patients. Retrospective research by Scali et al recommends a bundled approach to preventing SCI during TEVAR to minimize SCI by 10% to 19% in normal and high-risk groups respectively.[8] This bundled approach included preoperative placement of CSFD, intraoperative blood transfusion to maintain serum hemoglobin at 10 g/dL, augmented intraoperative mean arterial blood pressure to at least 90 mm Hg, permissive intraoperative hypothermia to 32ºC, and several intraoperative drugs administered during endograph deployment: naloxone, mannitol and steroids.[8] The only modality described in this study that was employed during the case report included CSFD. In hindsight, permissive hypothermia and more robust blood pressure augmentation may have provided added protection against SCI; however, SCI was not observed in the case, indicating that adequate protection strategies may have been employed. Though the current level of evidence is low, considering multimodal prevention strategies may help mitigate SCI following TEVAR.

To conclude, while reasonable evidence supports several strategies to mitigate SCI, there is still much to be explored surrounding SCI prevention during TEVAR. While this case followed the recommendations of current literature, much literature surrounding CSFD is inconsistent and low-level evidence. Ultimately, prospective research is needed to inform clear guidelines on SCI prevention during TEVAR for anesthesia practice improvement.

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Anesthetic Management for a Patient with Charcot-Marie-Tooth Disease

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Keywords: Charcot-Marie-Tooth, CMT, neuromuscular disease, peripheral nerve block

Charcot-Marie-Tooth disease (CMT) is the most common hereditary peripheral neuropathy,[1-3] with an estimated prevalence of 1:2500 individuals.[4-6] Characterized by progressive, distal to proximal neuropathy,[7,8] CMT leads to loss of sensation, weakness, muscle atrophy and skeletal deformities.[1-8] Consequently, CMT patients frequently require orthopedic surgery.[1,5,6] Though general, neuraxial, and peripheral regional anesthesia have all been used successfully in patients with CMT,[1-3,5-8] specific anesthetic techniques have rarely been experimentally evaluated, and disagreement exists over the best management of these patients. This case study describes the use of general anesthesia and peripheral nerve block in a patient with CMT undergoing orthopedic reconstruction.

Case Report

A 31-year-old male patient presented for right foot reconstruction and repair of rearfoot varus, forefoot valgus, pes cavus, and hammertoe deformities secondary to type 1 CMT (CMT1). He was ambulatory but limited by chronic bilateral foot pain, and had failed conservative treatment with orthotics and ankle-foot orthosis braces. Other comorbidities were obesity, depression, insomnia, migraine headaches and tobacco dependence. His medication regime included duloxetine, oxycodone, sumatriptan and medicinal cannabis.

The patient's physical exam was notable for obesity and bilateral foot deformities. Strength and sensation were diminished to both feet. His cardiac functional status was greater than four metabolic equivalents.

Prior to surgery, the patient received saphenous and sciatic peripheral nerve blocks (PNB). For these procedures, standard noninvasive monitors were applied, and he was sedated with intravenous midazolam 2 mg and ketamine 20 mg. Using aseptic technique, the adductor canal and saphenous nerve were visualized with ultrasound and 0.2% ropivacaine 12 mL was incrementally injected perineurally after negative aspiration. Next, the sciatic nerve was visualized with ultrasound just cephalad to the popliteal crease. Nerve stimulation was concurrently utilized, and the patient had great toe twitch when the nerve stimulator was set to 0.5 mA that resolved when the current was decreased to 0.2 mA. Subsequently, 0.35% ropivacaine 20 mL with dexamethasone 4 mg was incrementally injected perineurally after negative aspiration.

Upon transfer to the operating suite, standard noninvasive monitors were reapplied, and the patient was preoxygenated with O_2 10 L/min via facemask. Hydromorphone 1 mg and lidocaine 50 mg were administered intravenously. After achieving an exhaled oxygen concentration of 80 percent, general anesthesia was induced with propofol 200 mg and ketamine 30 mg. Neuromuscular blockade was initiated with rocuronium 50 mg and after 2 minutes of mask ventilation the trachea was intubated under direct laryngoscopy. Ventilation was mechanically assisted with a mixture of air 0.7 L/min and O_2 0.3 L/min and the patient was allowed to gradually resume breathing spontaneously. General anesthesia was maintained with sevoflurane 1.5-2% expired concentration and a propofol infusion at 25 mcg/kg/min.

Anesthesia for the 7-hour surgery was uneventful. A lower leg tourniquet was used twice, with a total tourniquet time of 239 minutes. Ketamine and hydromorphone were administered periodically for tourniquet pain, with a total dose of 100 mg and 4 mg respectively. As the surgical site was dressed, the propofol infusion and anesthetic gases were discontinued. When the patient followed commands, the trachea was extubated. He was transferred to the post anesthesia care unit where he required fentanyl 100 mcg and hydromorphone 1 mg to control his pain. As planned, he was admitted to the hospital for two nights for pain management and intravenous antibiotics.

Discussion

Charcot-Marie-Tooth is the clinical manifestation of a heterogenous group of hereditary peripheral nerve diseases. Dozens of genes have been implicated as the cause of over 70 subtypes of the disorder; however, over 90% of patients have mutations in one of five genes resulting in three primary types: CMT1, CMT2, and CMTX.[4] The patient in this case study presented with CMT1 which is a primary demyelinating disorder and accounts for approximately half of all cases.[4] Other subtypes affect the nerve axon (CMT2), or Schwann cells (CMTX).[4] Disease course and severity of symptoms can vary reflecting the assortment of genetic causes but in the most common forms of CMT disease progression is quite homogeneous.[4] Neurogenic muscle weakness and wasting typically starts in the first or second decade and progresses in a distal to proximal fashion.[5,7,8] Diagnosis may be made based on phenotype, inheritance pattern, and nerve conduction studies or through genetic testing. The patient in this case had maternal familial history of CMT and exhibited the typical timing and progression of the disease.

The mainstay treatment for CMT is symptomatic drugs, orthopedic splints, physical therapy, and surgery, though new therapies such as focal mechanical vibration, gene silencing, and novel drug combinations appear promising in clinical trials.[4] The patient in this case is undergoing surgery due to disease progression despite treatment with orthopedic devices, and physical therapy. He takes opiates for chronic pain. Therefore, he was deemed an excellent candidate for PNB as it is an effective way to achieve postoperative analgesia while limiting the complications associated with opioid consumption.[6]

Though special considerations are necessary, PNB has been safely used in patients with CMT.[1,6] Theoretical susceptibility to nerve injury may be increased since myelin is decreased or absent, but nerve injury from exposure to local anesthetic has not been described.[1] Nevertheless, using lower doses of local anesthetic and minimizing needle manipulation is advocated.[1] The typical electrophysiological finding in CMT is decreased motor conduction velocity.[6] Accordingly, nerve stimulation has been reported to be unreliable and may not elicit a response.[1] Ultrasound guidance is recommended for placement of PNB in CMT patients,[1] but anesthesia practitioners should be aware of potential anatomical abnormalities. In CMT, the fascicles of peripheral nerves may be enlarged, or concentric arrays of myelin may give nerves an onion bulb appearance.[4] This case study patient did not have unusual anatomy and his response to nerve stimulation was typical.

Among patients with CMT, a higher-than-normal degree of variability may exist in the analgesia derived from PNB.[1] In case reports where high doses of local anesthetic were used, there are reports of substantially prolonged block.[1] Concerns about a prolonged block plus the theoretically increased susceptibility to local anesthetic toxicity contributed to the local anesthetic dosing choice for the patient in this case study. The safety and efficacy of a perineural catheter has been described in CMT patients,[6] and would be an excellent option for the patient in this case study allowing for the precise titration of local anesthetic.

General anesthetic considerations in CMT deal primarily with the safety and efficacy of neuromuscular blockade.[3,5,7,8] Since CMT is a denervating condition there is a possibility of upregulation of the acetylcholine receptor on the postsynaptic motor endplate leading to

hyperkalemia in the presence of succinylcholine. This fear has been shown to be unfounded as currently there are no reports of hyperkalemia after succinylcholine administration in CMT patients.[3,7] Upregulation of the postsynaptic neuron could lead to resistance to nondepolarizing neuromuscular blocking agents but this has not been described.[3] In some case reports, anesthesia providers have expressed concern about prolonged paralysis and respiratory depression in patients with severe CMT,[3,5,7,8] but this phenomenon has been infrequently reported.[3] Due to the pathology of CMT, a prolongation of neuromuscular blockade is more likely to be observed at distal sites, and therefore, anesthesia practitioners are advised to use the corrugator supercilii muscle to judge return of diaphragmatic function.[3,7]

Concerns about succinylcholine or volatile anesthetics triggering malignant hyperthermia (MH) abound in the CMT case reports.[3,5,7,8] However, there is no evidence to suggest that CMT patients are at increased risk of MH.[3,7,8] Though the disease presents a clinical picture similar to many myopathies, it is a neuropathic not myopathic condition, and there is no theoretical reason CMT patients would be at unique risk for MH.

Due to the anticipated long duration of the surgery described in this case study, a general anesthetic was delivered. The patient responded typically to sevoflurane and rocuronium. He received rocuronium 50 mg and was intubated easily two minutes after neuromuscular blocker administration. He began spontaneously breathing 38 minutes after the rocuronium dose. The patient received no further neuromuscular blockade and did not receive any reversal agent. Upon extubation, he had no signs of respiratory distress.

Charcot-Marie-Tooth disease is a common hereditary neuropathy that poses numerous theoretical anesthetic challenges. Upon reviewing the contemporary descriptive research literature, it appears most CMT patients can be successfully managed using standard techniques. Nevertheless, anesthesia practitioners should remain vigilant when caring for CMT patients as the anesthetic implications of the numerous rare subtypes of the condition may not yet have been described.

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Perioperative Pain Management for a Patient on Chronic Methadone

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Keywords: chronic pain, perioperative pain management, methadone, multimodal analgesia, exploratory laparotomy

Pain management for patients with chronic pain and opioid dependence can be a challenging undertaking. Patients with chronic pain require complex pain management strategies while balancing the adverse effects of opioids, withdrawals, and patient comorbidities. Currently, there are no guidelines for the management of postoperative pain of patients with chronic opioid use.[1] The preoperative assessment of a patient's history, physical status, medication history, and surgical considerations are imperative for determining a plan for postoperative pain management. It is paramount that anesthesia practitioners and the multidisciplinary healthcare team collaborate on pain management strategies in this unique population.

Case Report

A 35-year-old, 89 kg, 170 cm Caucasian male presented for exploratory laparotomy and enterostomy closure. The patient had undergone previous terminal ileal resection with divided loop ileostomy for small bowel obstruction. Medical history was significant for Crohn's disease and past medical history of substance use disorder, anxiety, and depression. The patient's medication list included methadone 90 mg daily. His allergies and drug sensitivities were to codeine, buprenorphine-naloxone, prednisone, morphine, and sulfa antibiotics.

In the preoperative phase, the patient received midazolam 2 mg intravenously (IV). Upon arrival to the operating room, standard noninvasive monitors were placed. The patient was then placed in the sitting position for a subarachnoid block to provide intraoperative and postoperative analgesia management. His back was prepped and draped using sterile technique. Single-injection spinal anesthesia was performed at the L4-5 interspace using a 25-gauge, 3.5 inch pencil-point needle. Hypobaric bupivacaine 0.25%-2 mL and morphine 250 mcg was injected into the intrathecal space. Due to the possible complexity and length of the surgery, the patient received a general anesthetic. Patient was assisted to the supine position for induction of general

anesthesia. Intravenous induction included fentanyl 50 mcg, lidocaine 90 mg, propofol 280 mg, and rocuronium 50 mg. General anesthesia was maintained with sevoflurane titrated to an end-tidal of 1.5-1.9%. Multimodal analgesia included dexamethasone 10 mg, ketamine 40 mg, and magnesium sulfate 2 g. Additional narcotics administered during the case included fentanyl 150 mcg and hydromorphone 1 mg. The approximate 120-minute surgical time from incision to closure was routine.

Prior to emergence, the patient received ondansetron 4 mg and fentanyl 100 mcg. Neuromuscular blockade was antagonized with sugammadex 180 mg IV and the patient was extubated when he met criteria for extubation. Shortly after extubation, the patient appeared to be in severe pain demonstrated by moaning, grimacing, and guarding his abdomen. Once he arrived to the PACU, the patient became more alert and oriented. He stated his pain was 10/10 in his abdomen, which was unrelieved by the fentanyl administration. Incremental doses of narcotic were administered and monitored by the anesthesia provider. The patient received a total of hydromorphone 10 mg, fentanyl 850 mcg, ketamine 180 mg, and midazolam 2 mg IV in the PACU.

After consulting with the surgeon, a rescue thoracic epidural was placed for postoperative pain management. The patient was placed in the sitting position and his back was prepped and draped using sterile technique. Using the T10-11 interspace, 3 mL of 1% lidocaine was administered to localize the skin. A 25G Touhy needle was then inserted into the interspinous ligament. Loss of resistance was achieved at 7 cm and the epidural catheter was threaded into the epidural space. A test dose of 1.5% lidocaine with 1:200,000 epinephrine 3 mL was administered with negative signs for intravenous and intrathecal placement. The patient was then returned to the supine position and lidocaine 2%-5 mL was administered for rescue analgesia, followed by a second dose 10 minutes later. The patient stated his pain was tolerable and the pain level decreased to 8/10. A post-anesthesia care visit was conducted in PACU approximately 2 hours after the epidural placement. After discussion with the patient and bedside nurse, it was discovered that the patient had not taken his morning methadone dose as he had described to the preoperative nurse.

Discussion

According to the Centers for Disease Control and Prevention, 191 million opioid prescriptions were dispensed in the United States in 2017.[2] With a large population using opioids chronically, this provides a challenge for perioperative pain management in this population. It is essential to understand the anesthesia implications for patients taking chronic opioids, such as methadone.

Methadone is a long-acting full opioid agonist commonly prescribed for the treatment of substance use disorder. It is a racemic mixture of two enantiomers, D isomer (S-methadone) and L isomer (R-methadone).[3] The R-methadone produces the opioid agonist effect.[3] It has multiple receptor activity, including μ- and δ-opioid agonism, N-methyl-D-aspartate (NMDA) antagonism, and serotonin reuptake blockade.[3] Other unique properties of methadone are the lack of neurotoxic or active metabolite.[3] The elimination half-life is variable, averaging approximately 27 hours, but may vary from 8 to 80 hours.[3] Interestingly, the biphasic elimination phases of methadone correlate with periods of analgesia and periods of prevention of withdrawal symptoms.[3] The alpha elimination phase lasts 8 to 12 hours and correlate with analgesic effect;

the beta elimination phase ranges from 30 to 60 hours and correlates with the potential for prevention of withdrawal symptoms.[3] Methadone is generally prescribed as a single daily dose with 60 to 100 mg being more effective in retaining people in treatment.[4] Understanding the pharmacodynamics and pharmacokinetics of methadone is an essential component to the perioperative strategies of pain management in patients taking chronic opioids.

Patients are commonly instructed to continue their prescribed methadone regimen on the day of surgery. However, the extent of education for this patient was not known. In this case report, the patient misinformed the preoperative staff and the anesthesia team that he took his morning dose of methadone. The patient later confided in PACU that his last dose was the day prior. The approximate lapse of time was 48 hours, which potentially disrupted the pharmacologic steady state of methadone. The patient may have benefited from the prevention of withdrawal symptoms, while no longer experiencing the analgesic effects of methadone. Chronic use of methadone may lead to hyperalgesia postoperatively, requiring significant amounts of analgesia rescue.[9] Patient education was provided regarding the importance of continuing his daily methadone. It was emphasized how crucial an accurate depiction of home medication use is in developing an effective anesthetic plan of care.

Because there are no current guidelines for the management of postoperative pain for chronic opioid users, management strategies heavily rely on the expertise of the anesthesia practitioner. Despite perioperative strategies to address postoperative management for this patient by administering intrathecal morphine and intraoperative multimodal analgesic agents, the patient experienced excruciating pain postoperatively. Premedication strategies could have been considered preoperatively to include gabapentin, celecoxib, and acetaminophen. Gabapentin, a gabapentinoid, has been shown to decrease postoperative opioid consumption.[1] Celecoxib, a selective COX-2 non-steroidal anti-inflammatory, is an effective oral analgesic premedication with a long duration of action.[1] Acetaminophen has the potential to reduce opioid consumption postoperatively.[1] While the patient did not show signs of pain intraoperatively (heart rate and respiratory rate were within normal limits), additional intraoperative multimodal analgesic agents should have been considered. The Anesthesia Patient Safety Foundation recommends intraoperative non-opioid pharmacologic agents to optimize multimodal analgesia strategies to reduce opioid consumption. Pharmacologic agents include dexmedetomidine 0.5-1 mcg/kg slow IV bolus followed by an IV infusion of 0.2-1.7 mcg/kg/hr, lidocaine 1.5 mg/kg IV bolus then IV infusion 1-2 mg/kg/hr, and acetaminophen 1000 mg IV 6 hours after oral dose, and ketorolac 15-30 mg IV.[5]

Pain management strategies for exploratory laparotomy were considered. A combination of IV analgesia, intrathecal morphine, patient-controlled epidural analgesia, and transversus abdominis plane (TAP) block are reasonable options for abdominal surgery.[6-8] Intrathecal morphine has been reported to decrease postoperative 24-hour pain scores and reduce opioid requirement up to 48 hours.[6] When compared to IV analgesia, epidural analgesia provided better pain relief with movement; however, pain difference at rest was minimal.[7] Limited studies exist comparing TAP blocks with other analgesic strategies. Randomized control trials and observational studies reported no decrease in postoperative pain scores or opioid use with the addition of TAP blocks.[8] A possible explanation may be due to the extent of the surgery and variation in the surgical

incision.[8] The research evidence suggests a preoperative thoracic epidural may have been an ideal pain management strategy for our patient.

In summary, patients presenting for surgery with a history of chronic pain may require complex pain management considerations. Because there are no established guidelines, a thorough assessment in the preoperative, intraoperative, and postoperative phase is crucial. Early preoperative formulation of multimodal analgesia management strategies should be considered to manage and minimize postoperative pain.

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Exploratory Laparotomy in a Patient with Antiphospholipid Syndrome

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Keywords: Antiphospholipid syndrome, catastrophic antiphospholipid syndrome, anticardiolipin antibodies

Antiphospholipid syndrome (APS) is a rare thrombophilic autoimmune disorder which results in vascular thrombosis and obstetric morbidity.[1] Anesthesia professionals must balance the risk of perioperative thrombosis induced by tissue injury and venous stasis against the likelihood of significant bleeding due to prophylactic anticoagulation. Despite the challenging nature of anesthetic management, few studies exist to guide perioperative care.[2,3] This report details the case of a patient with APS presenting with a high-grade small bowel obstruction, whose surgical course was complicated by septic shock and intraperitoneal hemorrhage. Recent recommendations for perioperative management of patients with APS undergoing non-cardiac surgery are discussed.

Case Report

A 63-year old, 154 cm, 68 kg female presented to the emergency department with severe abdominal pain and multiple episodes of non-bloody emesis. The patient's past medical history was significant for bilateral pulmonary emboli, deep vein thromboses of the right lower extremity, and small bowel obstruction. The patient's extensive surgical history included small bowel anastomosis, partial colectomy, and inferior vena cava and common and external iliac vein stents. The patient tested positive for serum anticardiolipin immunoglobulin M antibodies. The patient's home medications included rivaroxaban 20 mg and acetylsalicylic acid (ASA) 81 mg.

On admission, the patient's labs were significant for prothrombin time (PT) 21 seconds, activated partial thromboplastin time (aPTT) 44.3 seconds, international normalized ratio (INR) 1.8, lactic acid 2.4 mmol/L, and hemoglobin 13.1 mg/dL. Computed tomography revealed a high-grade bowel obstruction. The patient was taken to the operating room (OR) for exploratory laparoscopy and small bowel resection. During trocar insertion, the bowel was perforated, and the procedure was converted to laparotomy. The abdomen was left open and a negative pressure wound therapy dressing applied. The patient remained intubated and was transferred to intensive care. Enoxaparin 30 mg was given twice a day.

On postoperative day (POD) one, the patient developed signs of septic shock. Lactic acid increased to 3.1 mmol/L and the patient required continuous norepinephrine and vasopressin infusions to maintain mean arterial pressure > 65 mmHg. On POD two, the patient's hemoglobin dropped to 6.5 mg/dL. The patient was transfused with two units packed red blood cells (PRBCs) and two units fresh frozen plasma (FFP). Enoxaparin 15 mg was administered subcutaneously on POD two and held for 24 hours prior to surgery.

The patient returned to the OR on POD three to identify the source of bleeding and for possible wound closure. Chest x-ray showed basilar infiltrates. Transthoracic echocardiogram revealed an ejection fraction of 60%. The patient's hemoglobin increased from 6.9 mg/dL to 7.9 mg/dL after infusion of one unit PRBCs. When assessed by anesthesia, the patient's vital signs were as follows: blood pressure 113/51 mm Hg, HR 55/min, SpO_2 100% on 70% FiO_2. The patient was receiving continuous infusions of norepinephrine 0.1 mcg/kg/min and vasopressin 0.04 units/min. Two units PRBCs were placed on hold.

Standard monitoring was initiated upon entry to the OR. Arterial blood pressure and central venous pressure were monitored continuously. The patient received midazolam 2 mg and propofol 20 mg while the endotracheal tube was connected to the anesthesia circuit. General anesthesia was maintained with isoflurane 1% expired concentration in a mixture of O_2 1 L/min and air 1 L/min. After induction 100 mL bilious fluid was aspirated from a nasogastric tube. The patient received fentanyl 50 mcg, rocuronium 50 mg, cefazolin 2 g, ondansetron 4 mg, and dexamethasone 8 mg intravenously. The source of bleeding was located and sutured, and the patient's abdomen was closed. Norepinephrine and vasopressin were discontinued due to the patient's stable hemodynamics. The patient was given 5% albumin 250 mL and normal saline 1 liter through a fluid warmer. The patient was given a total of fentanyl 200 mcg throughout the case. The patient was transferred intubated to intensive care and was later discharged home.

Discussion

Antiphospholipid syndrome occurs when antibodies target plasma proteins that bind to phospholipid surfaces, resulting in inflammation, vasculopathy, and thrombosis.[5] APS is diagnosed when vascular thrombosis or pregnancy morbidity occur in the presence of serum antiphospholipid antibodies.[6] Thrombotic APS presents with venous, arterial, or microvascular thromboses. Obstetric APS results in pregnancy complications such as pre-eclampsia and fetal demise. Catastrophic APS is a life-threatening form of APS in which microvascular thrombi cause multiorgan failure.[2] Clinical manifestations of APS can also include cardiac, neurologic, renal, and hematologic sequelae.[5,6]

Medical management of APS is directed at prevention of thrombosis or obstetric complications through anticoagulation. Primary thromboprophylaxis is aimed at risk factor modifications.[2] Secondary thromboprophylaxis targets patients with a history of thrombosis or pregnancy complications.[2,6] Warfarin is the recommended first-line treatment. For patients with previous venous thromboses, a target INR of 2-3 is suggested. An INR of 3-4—or INR of 2-3 plus low-dose ASA—is recommended for patients with a history of arterial thromboses.[7]

Perioperative care of patients with APS similarly focuses on the prevention of thromboembolic events and obstetric morbidity. Surgical exposure of tissue factor and postoperative immobility increase the risk for thrombus formation.[6] Oral anticoagulants should be bridged with therapeutic dosing of unfractionated heparin—titrated to aPTT 1.5-2 times normal—or low molecular weight heparin (LMWH)—1 mg/kg twice a day or 1.5 mg/kg once a day—five to seven days prior to surgery.[2,6] Unfractionated heparin should be held 4-6 hours prior to surgery, while LMWH should be held 24 hours prior to surgery. The last dose of LMWH should be half the daily

total.[2,4,6] Some recent publications have suggested that low-dose ASA should be continued through the perioperative period.[6]

Preoperative assessment of patients with APS should include a chest x-ray, electrocardiogram, complete blood count, basic metabolic panel, and coagulation profile. Elevated aPTT values are expected due to the consumptive coagulopathy created by antiphospholipid antibodies and indicate a risk for thrombosis, rather than hemorrhage.[6,8] Since antiphospholipid antibodies can artificially elevate aPTT, anti-Xa assays are recommended to assess effectiveness of unfractionated heparin. Elevated PT is also expected due to oral anticoagulation or the syndrome itself, and should only be corrected if INR > 2.0.[6]

Intraoperative management of patients with APS focuses on prevention of thrombosis, careful monitoring, and treatment of severe bleeding. Physical measures to prevent thromboembolism include anti-embolism stockings, sequential compression devices, and adequate hydration.[3,6] Aggressive warming reduces viscosity and opposes thrombus formation. Avoiding limb tourniquets, intravascular manipulation, frequent pneumatic blood pressure cuff cycling, and tourniquets for drawing blood reduces venous stasis and the risk for thrombosis.[6] Close monitoring of patient hemodynamics with arterial and central lines are suggested. The use of thromboelastograms has also been suggested to guide pharmacologic management.[8]

Patients with APS are at risk for increased surgical bleeding. Emergency surgery in patients with APS presents a particularly challenging situation. Oral vitamin K 1-2 mg or a slow infusion of FFP is recommended to achieve an INR $\leq$ 1.5 for procedures with a high bleeding risk. For procedures with a low bleeding risk, anticoagulants do not need to be discontinued.[2,6] Significant bleeding should be treated with high-dose corticosteroids and intravenous immunoglobulins. Platelet transfusions should be avoided unless bleeding is life-threatening.[6]

Neuraxial techniques can be performed safely in parturients with APS. Epidural or spinal placement may be performed 4-5 hours and 24 hours following administration of unfractionated heparin and therapeutic LMWH, respectively. Low-dose ASA does not need to be held. In the patient receiving both low-dose ASA and a second anticoagulant, neuraxial anesthesia should be approached with caution due to an increased risk of bleeding.[2]

Postoperatively, warfarin or other oral anticoagulants should be resumed the evening of surgery and LMWH within 24 hours. After spinal placement or epidural catheter removal, unfractionated heparin and therapeutic LWMH may be resumed after 2 and 24 hours, respectively. Anticoagulation may be delayed 48-72 hours in the case of surgical procedures with a high risk for bleeding.[2,6] LMWH and unfractionated heparin should be discontinued when INR is therapeutic.[6] Early mobilization following surgery is essential to prevent deep vein thrombosis.[3]

The patient described in this report received enoxaparin 30 mg twice a day. Despite the significant bleeding she experienced, this prophylactic dose may have put her at increased risk for thrombosis. Given the patient's history of previous venous thromboses, a therapeutic dose of enoxaparin 70 mg twice a day is most consistent with recent APS anticoagulation guidelines.[6,7] The patient's lovenox dose was increased to 70 mg twice a day later in her hospital stay. These guidelines also highlight the limited evidence for the safe use of direct oral anticoagulants in

APS.[1] Thus, warfarin may be a safer choice for this patient than rivaroxaban. The patient was later diagnosed with primary adrenal insufficiency, which can occur with APS due to adrenal infarct or hemorrhage. This diagnosis was not known at the time of surgery and a stress dose of hydrocortisone was not given. With careful management and appropriate anticoagulation, anesthesia professionals can provide safe and effective care to patients with APS.

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Sugammadex Induced Bradycardia and Asystole

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Keywords: Sugammadex, bradycardia, asystole, adverse effect, neuromuscular antagonism

Sugammadex is indicated for antagonism of nondepolarizing neuromuscular blocking agents (NMBA) of aminosteroid type, specifically for rocuronium bromide and vecuronium bromide. Its efficacy in antagonizing rocuronium and vecuronium is improved when compared to the

combination of neostigmine and glycopyrrolate. Additionally, reported adverse effects are fewer than the adverse effects from the combination of neostigmine and glycopyrrolate. Sugammadex minimizes residual neuromuscular blockade, the need for postoperative reintubation, and overall adverse effects.[1] Bradycardia and asystole are rare complications but have been reported.[2-7] This case study reports a patient experiencing bradycardia and asystole following sugammadex administration.

Case Report

A 32-year-old male patient (164 kg, 175 cm, BMI 53.6 kg/m^2) was scheduled for a spinal cord implant due to chronic back pain. His past medical history was significant for shortness of breath, obstructive sleep apnea, obesity, pre-diabetes, depression, anxiety, palpitations, syncope, chronic low back pain, and tobacco smoking. Vital signs in the preoperative area were as follows: blood pressure (BP) 118/81 mm Hg, heart rate (HR) 90/min, respiratory rate (RR) 18/min, SpO_2 93% (room air), and temperature 36.7°C (oral). The patient stated he had episodes of syncope many years ago with no recent episodes. When asked about documented heart palpitations, he stated that they were related to his anxiety. He reported no previous anesthesia complications for himself or his family.

The patient received intravenous (IV) midazolam 2 mg in the preoperative area and was transferred to the operating room. Standard noninvasive monitors were placed, and the patient was pre-oxygenated with 8 L/min O_2 via a circuit mask. General anesthesia was induced with the following IV medications: lidocaine 100 mg, propofol 300 mg, ketamine 50 mg, and succinylcholine 200 mg. The trachea was intubated successfully on the first attempt without complications. The patient was immediately placed in the prone position with eyes free of pressure. Rocuronium 30 mg IV was administered after recovery from succinylcholine, and 3 additional doses of rocuronium 10 mg IV were administered during the procedure for a total of 60 mg. General anesthesia was maintained with sevoflurane 1.9% to 2.6% expired concentration in a mixture of O_2 2 L/min and air 1 L/min.

The patient was hemodynamically stable throughout the procedure with the following vital signs: BP 110-150/60-90 mm Hg, HR 70-90/min, RR 12-18/min, SpO_2 97-100%, temperature 36°C (esophageal), and $EtCO_2$ 35-40 mm Hg. The electrocardiogram showed a normal sinus rhythm throughout the surgery. Fentanyl 200 mcg IV was administered in divided doses during the procedure for pain control. Phenylephrine 200 mcg IV was administered in divided doses for blood pressure management without a significant change in the heart rate. At the end of the 90-minute procedure, the patient was placed in a supine position before sugammadex was administered. Train of four (TOF) count monitoring showed 4 out of 4 with tetanic fade. Sugammadex 320 mg (2 mg/kg) IV was administered over 1 minute, as recommended by the manufacturer.

Immediately following the sugammadex administration, the patient became bradycardic with the heart rate decreasing from 75/min to 30/min within 15 seconds. Glycopyrrolate 0.4 mg IV was immediately administered, and the patient's heart rate recovered to 70/min for several seconds. However, bradycardia reoccurred immediately, followed by asystole for approximately 6 seconds. While the anesthesia practitioner requested the code cart, the heart rate spontaneously

recovered within seconds of occurrence; neither atropine nor chest compressions were initiated. The patient maintained spontaneous ventilation effort during the short episodes of bradycardia and asystole. Antagonism effectiveness of sugammadex was assessed with 4 out of 4 TOF count and sustained tetany. The patient was spontaneously and adequately ventilating with tidal volume 500-600 mL, RR 16-20/min, $EtCO_2$ 40-50 mm Hg, and vital signs were stable. He was extubated and transferred to the post-anesthesia care unit (PACU). He remained in the PACU under observation and was hemodynamically stable with no further bradycardic episodes. The patient was discharged home 4 hours later.

Discussion

Sugammadex is a modified gamma-cyclodextrin. It is indicated for the antagonism of rocuronium and vecuronium. Sugammadex encapsulates rocuronium and vecuronium into its lipophilic inner structure, resulting in the inactivation of these two aminosteroids. Potential adverse effects of sugammadex include hypersensitivity, bradycardia, cardiovascular collapse, interaction with steroids, coagulopathy, and neuronal damage. The bradycardic response is dose-dependent.[1]

Profound bradycardia and sustained hypotension have been reported by Choi and colleagues after sugammadex was administered to antagonize rocuronium.[2] The patient was an 80-year-old, 75 kg male and was scheduled for laparoscopic cholecystectomy. Sugammadex 200 mg (2.7 mg/kg) IV was administered for a TOF count of 0. The patient's BP and HR before the administration of sugammadex were 90/50 mm Hg and 60/min. HR decreased to 29/min 2 minutes post-administration of sugammadex while BP did not change. The HR spontaneously recovered within 10 seconds. At this time, TOF stimulation demonstrated 4 twitches, and the TOF ratio reached 0.2 and remained at this value after 5 minutes. An additional dose of sugammadex 200 mg IV was administered. Bradycardia and hypotension occurred 30 seconds later: HR 21-30/min, BP 60/40 mm Hg. Atropine 0.5 mg IV was administered, and HR improved to 60/min but decreased to 21/min after 30 seconds, while hypotension persisted. Several subsequent episodes of bradycardia occurred with persistent hypotension. During this time, multiple doses of ephedrine 10-20 mg IV and phenylephrine 50-100 mcg IV were administered. After 5 minutes, the patient's HR was stable at 70/min, but hypotension persisted with BP 80/40 mm Hg. The patient was transferred to the intensive care unit for BP management.

Bhavani reported two cases of bradycardia and asystole after sugammadex was administered to antagonize rocuronium.[3] For the first patient, sugammadex 300 mg (4.2 mg/kg) IV was administered to antagonize rocuronium for a TOF count of 2 twitches, and the patient was immediately extubated. Approximately 2 minutes after the sugammadex administration, the patient's HR dropped to 25/min followed by asystole. The trachea was reintubated while chest compressions were initiated, and epinephrine 1 mg IV was administered every 3 minutes. The patient recovered after 5 cycles of cardiopulmonary resuscitation (CPR). For the second patient sugammadex, 200 mg (2.3 mg/kg) IV was administered to antagonize rocuronium for a TOF of 4 twitches, and the patient was subsequently extubated. One minute later, the patient developed bradycardia (HR 30/min) followed by asystole. The trachea was reintubated, CPR was initiated, and epinephrine IV was administered. The patient recovered after 5 cycles of CPR.[3]

In the case report by Oliveira and colleagues, sugammadex 2 mg/kg IV was administered to antagonize rocuronium for a TOF count of 2 twitches. Bradycardia (HR 30/min) developed 30 seconds post-administration of sugammadex and immediately progressed to asystole. Advanced cardiovascular life support was started. The patient recovered after 1 minute.[4]

In addition, Sanoja and Toth reported bradycardia and asystole after sugammadex 2.4 mg/kg IV was administered to antagonize vecuronium. Within 1 minute following the administration of sugammadex, bradycardia (HR 35/min) developed and immediately followed by asystole. CPR was initiated, and epinephrine 1 mg IV was administered. The patient recovered after several cycles of CPR and epinephrine administration.[5]

Death following hypotension, bradycardia, and asystole has been reported after sugammadex (2.9 mg/kg) was administered for rocuronium antagonism. Bradycardia and hypotension occurred within seconds after the sugammadex administration. Glycopyrrolate 0.4 mg IV and ephedrine 10 mg IV were administered with no effect, and the patient progressed to asystole. Chest compressions were initiated with multiple doses of epinephrine IV administration. The patent did not recover, and the efforts were terminated after 110 minutes.[6]

Yoshida and colleagues reported atropine-resistant bradycardia after an administration of sugammadex (2.5 mg/kg) to antagonize rocuronium. The patient's HR decreased from 87/min to 36/min over 3 minutes, followed by hypotension (BP 41/20 mm Hg). Atropine 0.5 mg IV was promptly administered, but HR and BP did not recover. Epinephrine 0.5 mg IV was administered 2 minutes after the administration of atropine, and the patient's HR and BP recovered to 130/min and 100/54 mm Hg.[7]

According to the manufacturer's guideline, severe bradycardia and asystole are rare adverse effects.[8] In the current case report, the patient's heart rate recovered after glycopyrrolate was administered, and the second episode of bradycardia recovered spontaneously without interventions. Lessons learned from this case report and previous case reports regarding severe bradycardia and asystole from sugammadex administration include the following: position the patient supine with access to the airway before administering sugammadex; administer the minimum recommended dose of sugammadex according to the manufacturer's recommendation;[8] have emergency medications such as glycopyrrolate, atropine, ephedrine, and epinephrine ready to be administered if needed; administer sugammadex slowly over at least 1 minute as recommended by the manufacturer;[8] recognize that the highest risk of sugammadex-induced bradycardia is within the first 3 minutes post-administration.[2-7]

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Bone Cement Implantation Syndrome

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Keywords: Bone cement implantation syndrome, hemiarthroplasty, polymethyl methacrylate

Polymethyl methacrylate (PMMA), used during arthroplasty procedures, is associated with bone cement implantation syndrome (BCIS): hypoxia, hemodynamic instability, and loss of consciousness during prosthesis insertion.[1] BCIS can occur during any cemented procedure but occurs most frequently during hip hemiarthroplasty (HA). In a single center study from 2008 to 2019, of 3,294 patients who underwent joint arthroplasty, BCIS occurred in 26% of patients but was highest in hip HA (31%).[2] Severe BCIS is experienced more often in hip HA and is associated with increased 30-day mortality.[2] With an increased aging population and as hip fractures continue to rise, anesthetists may experience patients with BCIS with increasing frequency.[3]

Case Report

A 92-year-old female presented to the emergency department (ED) after suffering a mechanical fall at home. An x-ray of her left hip obtained in the ED revealed a subcapital femoral neck fracture with mild foreshortening and varus angulation. Head and neck imaging were negative for intracranial bleed or fracture.

The patient's past medical history included chronic atrial fibrillation (AF) not on anticoagulation, myocardial infarction with percutaneous intervention to the right coronary artery five years prior, carotid artery stenosis, status-post carotid stent placement, cerebral vascular accident, and hypertension. Home medications were aspirin, lisinopril, magnesium, mirtazapine, and

torsemide. Her transthoracic echocardiogram from one year prior demonstrated a left ventricular ejection fraction (EF) of 40%-45% with basal inferior akinesis, right ventricular dysfunction with a right ventricular systolic pressure of 60 mm Hg, and severe mitral and tricuspid regurgitation. Chest x-ray on current admission showed prominent interstitial markings consistent with chronic lung disease or pulmonary edema.

Her Revised Cardiac Risk Index was 3/6, reflecting a 15% risk for major postoperative cardiac complication. Cardiology was consulted and established that the patient was in mild congestive heart failure, requiring diuresis with intravenous furosemide prior to surgical intervention. On hospital admission day two, following adequate diuresis, cardiology cleared the patient for surgery.

On the morning of surgery, she received furosemide 80 mg IV. Laboratory results were notable for hemoglobin of 9.9g/dL and hematocrit of 31.7%. All other values were within normal limits. On physical exam, she was alert and oriented, had S1/S2 heart sounds with a systolic murmur, and fine crackles in bilateral lung bases. The patient's baseline blood pressure was 123/75mmHg.

Upon entering the operating room (OR), standard noninvasive monitors were applied. Initial vital signs were within normal limits; the cardiac rhythm was AF. Following fentanyl 50 mcg and propofol 50 mg IV, a spinal was performed in the left lateral position with bupivacaine 0.5% 2 mL. The patient was placed in the right lateral position, and a propofol infusion was initiated at 20 mcg/kg/min. The patient's blood pressure was 82/47mm Hg which was treated with phenylephrine 200 mcg IV bolus. The blood pressure improved to 91/51mmHg but decreased again to 73/60 mm Hg, and a phenylephrine infusion of 0.5 mcg/kg/min was initiated for sustained improvement. The patient remained sedated and spontaneously breathing O_2 at 6 L/min, delivered via a simple face mask.

Approximately five minutes following cementation, the patient's heart rate decreased from 86 to 49 beats/min over 2 minutes. Glycopyrrolate 0.2 mg IV was administered with no effect. The heart rate continued to drop to 30 beats/min. Atropine 0.4 mg IV was administered. Heart rate remained unchanged at 30-40 beats/min and blood pressure dropped to 46/31 mmHg with no $ETCO_2$ detected. Pulses were assessed and found to be absent; cardiopulmonary resuscitation (CPR) was initiated. The surgical team was notified, and the patient was repositioned to supine. The patient was intubated with a 7.0 mm endotracheal tube. Wound closure was expedited. Following two minutes of CPR, administration of epinephrine 0.3 mg, and vasopressin 2 units IV, recovery of spontaneous circulation was achieved. Blood pressure was 142/92 mmHg and heart rate 120/min. A right radial arterial line was inserted. The patient was transferred to the intensive care unit mechanically ventilated and hemodynamically stable without vasopressor or inotropic support. The patient was successfully extubated that same evening without neurological deficit.

Discussion

This patient's cardiac arrest was attributed to BCIS, defined as "hypoxia, hypotension or both, and/or unexpected loss of consciousness occurring around the time of cementation, prosthesis

insertion, reduction of the joint or, occasionally, limb tourniquet deflation in a patient undergoing cemented bone surgery."[1] BCIS varies in severity from mild hypoxia and hypotension to fulminant cardiac arrest and is graded based on presentation (Table 1).[1] Thirty-day mortality after experiencing grade 3 BCIS is 88%.[4]

Table 1. BCIS Grades and Presentation

BCIS Grade	Presentation
1	Moderate hypoxia and hypotension (SpO_2 < 94%; > 20% fall in BP)
2	Severe hypoxia and hypotension (SpO_2 < 88%; > 40% fall in BP)
3	Cardiopulmonary arrest requiring CPR

In 2014, using the BCIS definition and severity grades, Olsen et al. evaluated the incidence of BCIS and risk factors for its development in patients undergoing HA. Their retrospective analysis of 1016 patients revealed that the overall incidence of BCIS was 28%.[4] Individually, the incidence of grades 1, 2, and 3 were 21%, 5.1%, and 1.7%, respectively.[4] Independent risk factors for developing grades 2-3 were ASA grade III-IV, a history of chronic obstructive pulmonary disease, and diuretic and warfarin therapy.[4] Other risk factors identified for BCIS include older adults, male gender, severe cardiopulmonary disease, pulmonary hypertension, osteoporosis, bony metastasis, hip fracture (especially pathological), and excessive cementation pressure.[3]

This patient experienced grade 3 BCIS; hemodynamic instability requiring cardiopulmonary resuscitation (CPR). She first experienced bradycardia, hypotension, and reduction in $ETCO_2$ (grade 2), quickly progressing to grade 3. This patient was sedated; therefore, loss of consciousness was unable to be assessed. Other signs of BCIS noted in the literature include bronchospasm, dysrhythmia, and thrombocytopenia, but none were evident in this patient.[3]

The etiology of BCIS remains poorly understood, but many theories exist. Monomer-induced vasodilation leading to hypotension has been demonstrated but not well supported as the plasma level of PMMA monomer is negligible.[1] The most accepted explanation is the embolic model. On transesophageal echocardiography, emboli have been detected following cementation. Post-mortem exams of intraoperative death during cementation have revealed marrow, fat, bone, and PMMA emboli in the lungs, brain, kidney, and myocardium.[1,3]

Emboli are formed from increased intramedullary pressure when PMMA is applied. The exothermic reaction from cement preparation further increases intramedullary pressure, trapping air and debris, which are forced into circulation. [1,3] Emboli, combined with the release of inflammatory mediators, cause ventilation/perfusion mismatch, hypoxemia, increased pulmonary vascular resistance (PVR), right ventricular dysfunction, and septal shift. [1,3,7]

Most cemented patients experience some degree of emboli; however, the extent to which they are compromised varies.[1,3] This patient's reduced EF, chronic AF, and severe mitral regurgitation resulted in increased left atrial pressure and pulmonary overload. On echocardiogram, her RVSP was 60 mm Hg, signifying an increase in right ventricular afterload.

Upon cementation, her right ventricle was likely unable to tolerate additional increases in PVR, leading to a further reduction in her already compromised cardiac output and cardiac arrest.

Treatment for BCIS is supportive with an emphasis on managing right heart failure. Initial goals are securing the airway, delivering FiO_2 1.0, and maintaining hemodynamic stability.[1,3] Anticholinergics may be given preventively or as a rescue for bradycardia.[3] Direct alpha agonists such as epinephrine and norepinephrine should be administered for hypotension and anesthetic levels reduced until stable.[3] Dobutamine or milrinone should be considered if continued hemodynamic support is needed.[3] The patient was initially administered anticholinergics without effect; therefore, CPR was initiated and the airway secured with an endotracheal tube. Hemodynamic stability was achieved following administration of epinephrine and vasopressin.

Currently, there is no superiority of spinal versus general anesthesia in preventing perioperative mortality associated with HA.[3,5] Anesthetic recommendations for preventing BCIS include avoiding nitrous oxide, minimizing volatile anesthetics, maintaining normovolemia and normotension, avoiding anemia, and administration of FiO_2 1.0 during cementation.[1,3] Inhaled prostaglandins may mitigate increases in PVR.[6] Colloid infusion at the time of cementation has also been shown to mitigate BCIS risk.[8] High-risk patients should be identified early, and invasive monitoring should be considered for patients with two or more risk factors. This patient may have benefitted from the institution of invasive blood pressure monitoring. The patient had many risk factors associated with BCIS. These included an ASA score of 4, advanced age, cardiopulmonary disease, preexisting pulmonary hypertension, diuretic therapy, and hip fracture.

Communication with the OR team is essential, and risk of BCIS should be discussed among the team preoperatively.[3] This patient was draped with an open incision in the lateral position. Cooperation among the team facilitated the supination of the patient, initiation of CPR, and expedited surgical closure.

In conclusion, a 92-year-old woman with significant cardiac history underwent a left HA and suffered grade 3 BCIS. This patient had many risk factors for developing BCIS. After failing to respond to anticholinergics, CPR was initiated with the spontaneous return of circulation. Although no specific anesthetic technique has been identified for preventing BCIS, it may be mitigated by identifying risk factors preoperatively and adequate preparation for managing hemodynamic instability. Communication and cooperation with the OR staff are essential for maintaining safe patient care should BCIS ensue.

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Enhanced Recovery After Surgery Protocols with Thoracic Surgery

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Keywords: enhanced recovery after surgery protocol (ERAS), thoracic surgery, multimodal pain management, thoracic epidural, intercostal nerve block

Enhanced recovery after surgery protocols (ERAS) were initially integrated into colorectal surgery in the 1990's.[1] Now they are becoming integrated into many clinical subspecialties, including thoracic surgery. ERAS protocols focus on patient education and self-health promotion throughout the operative experience, ultimately promoting a quick postoperative return to baseline function.[1-3] They standardize care through evidenced-based practice, collaborating a multidisciplinary team that is patient centered. [1,3] ERAS protocols focus on preoperative patient optimization, intraoperative temperature management, euvolemia, avoidance of invasive tubes, venous embolism, pain and postoperative nausea and vomiting, which facilitates early mobilization, nutrition, and recovery.[1,3] Implementing ERAS protocols in thoracic surgery has been proven to reduce the length of hospital stay and patient complications by 30-50%.[1,3]

Case Report

A 59-year-old, 63 kg, 163 cm female presented for a right upper lobectomy for a malignant neoplasm. Extensive preoperative testing was completed, including a transthoracic echocardiogram and pulmonary function tests. Smoking cessation was achieved eight weeks prior to surgery and physical activity was optimized, walking three miles daily. On the morning

of surgery, the patient last drank clear liquids 3 hours before arrival to the hospital. Preoperatively, the patient was administered acetaminophen 975 mg, gabapentin 100 mg, and oxycodone 10mg orally in the surgical admissions care unit. Two large bore intravenous catheters were placed in the holding area. Midazolam 2 mg was administered intravenously prior to the transfer to the operating room. The patient was induced with lidocaine 60 mg, fentanyl 100 mcg, and propofol 120 mg. Rocuronium 40 mg was administered after confirmation of ventilation and then a left sided 37 French double lumen VivaSight -DL tube (TM Ambu Inc.) was inserted using video laryngoscopy. Ventilation was established with a tidal volume of 6 mL/kg and the respiratory rate was titrated between 12 - 16/min to maintain an end tidal carbon dioxide reading of about 35 mm Hg. Dexamethasone 8 mg IV was administered for postoperative nausea and vomiting prophylaxis and to decrease postoperative pain and opioid consumption. Sevoflurane 1.7 - 2.1% expired concentration was titrated to effect. A left radial arterial line and urinary catheter were placed. The patient was then placed in the left lateral decubitus position, the nondependent lung was deflated, and one-lung ventilation ensued without issue. Vital signs remained stable throughout induction and initiation of one lung ventilation.

Prior to incision, magnesium sulfate (30 mg/kg) was administered as a one-time bolus dose. In addition, a Ketamine bolus (0.5 mg/kg of ideal body weight) was administered, and an infusion was initiated (0.005 mg/kg/min) based on ideal body weight. Intravenous fluids, opioids, and benzodiazepines were minimized throughout the procedure. Pulse pressure variation was monitored to maintain euvolemia. Video-assisted thoracic surgery (VATS) was initiated, however, the procedure quickly converted to an open thoracotomy related to the size of mass. The surgery lasted about 6 hours. Liposomal Bupivacaine was infiltrated into the intercostal spaces by the surgeon. Two-lung ventilation was resumed with stable hemodynamics and the patient was placed on a spontaneous ventilation mode. The Ketamine infusion was discontinued with surgical closure and a total of 2 mg hydromorphone was incrementally administered with the return of spontaneous respirations. Ketorolac 30 mg IV was administered intravenously. A single chest tube was placed to water seal. The patient was extubated at the end of the procedure and transferred to the ICU on a facemask with O_2 8 L/min. The patient denied pain and nausea. The total time in the operating room was about 8 hours. The next morning the patient's pain was well managed on a PCA pump of hydromorphone, allowing for optimal mobility. The patient complained of increased sputum production, however, vital signs remained stable, the chest tube output was low, the urinary catheter had been removed, and the patient was mobile and completing the assigned pulmonary toileting.

Discussion

Inappropriate pain management can poorly impact postoperative mobility and nutrition. In severe cases, it can lead to chronic persistent postoperative pain.[2] This type of pain persists for months after surgery greatly impairing functional status, leading to increased postoperative complications.[4]

According to ERAS protocols, comprehensive patient education regarding pain management and expectation should begin preoperatively.[1,3] An expectation is created, which allows the patient to become their own advocate in postoperative healing. The patient above was provided with a thorough preoperative education about ERAS and how it applied to the operative course.

Compliance with preoperative nutrition and activity requirements were achieved, including smoking cessation. Upon arrival to the pre-holding surgical area, the patient had a thorough understanding of the operative course and plan for opioid sparing multimodal analgesia. The patient understood the goals of early postoperative mobilization and nutrition.

An open thoracotomy with chest tube placement is extremely painful. ERAS protocols recommend multimodal pain management, avoidance of opioids, regional anesthesia, and initiation of oral medications early.[2] By treating pain at a variety of receptors, the stress response is inhibited.[2] Acceptable choices for pain medications include "acetaminophen, NSAIDs, NMDA receptor antagonists, anticonvulsants, beta blockers, alpha-2 agonists, glucocorticoids, opioids, central neuraxial techniques, surgical site infiltration, and regional anesthesia."[2] Tylenol, gabapentin, and oxycodone were administered preoperatively, initiating the multimodal approach. Celebrex was not used in this case, however, it's a favorable NSAID choice in surgery because of its COX2 inhibition and preservation of the COX 1 pathway.[2] Fentanyl was used to blunt the sympathetic nervous system response to intubation. After induction, 8 mg of dexamethasone was administered. Decadron has been shown to decrease postoperative pain by decreasing the production of proinflammatory mediators.[2,3] It additionally works as an antiemetic, of which the mechanism of action is unknown. However, research has shown that 4 mg of Decadron produces similar effects as 8 mg.[5] An inhalational agent was used as the primary anesthetic, however, an alternative approach with short acting total intravenous anesthetics, such as propofol and remifentanil infusions, maintaining a BIS at 40-60 could also be used.[1,6] Liposomal Bupivacaine was infiltrated into the intercostal spaces by the surgeon. The advantage of an intercostal block includes "direct visualization during administration, procedural ease, and single injections".[2] The literature reveals a disparity regarding the intercostal nerve block compared to epidural analgesia. A survey of thoracic anesthesiologists found that "93% of providers preferred epidural anesthesia for open thoracotomies versus 41% with VATS lobectomy", however, patient outcomes were not represented.[2] Another institution cited a "standard infiltration of ropivacaine at intercostal spaces 4, 5, and 6 under direct vision" and manages pain post operatively with intravenous Tylenol and Ketorolac.[4] Interestingly, another institution compared a liposomal bupivacaine intercostal block to an epidural infusion in open thoracotomies.[3] The intercostal nerve block was linked to "decreased length of hospital stays, intensive care unit admissions, and pulmonary and cardiac complications compared the epidural."[3]

Ketamine and Magnesium sulfate are NMDA antagonists that, when given perioperatively at subanesthetic doses, can decrease intraoperative and postoperative opioid consumption by impairing central sensitization.[3,7,8] In doing so, adverse side effects of opioids, like nausea and vomiting, are mitigated. Ketamine may cause emergence delirium, however, one study compared perioperative subanesthetic Ketamine to placebo and found no significant difference in delirium, hallucinations, or nightmares 24 hours postoperatively.[7] Another study showed that administration of a Magnesium Sulfate bolus followed by a continuous infusion decreased the need for neuromuscular blocking agents which lead to improved postoperative pulmonary function tests and the additive benefit of decreased opioid consumption.[8]

The multimodal pain management approach works synergistically, decreasing opioid requirements. This decreases opioid adverse effects, such as nausea and vomiting, urinary

retention, and respiratory depression, thus allowing for early post-operative mobility and nutrition. [2] Tramadol is recommended as first line treatment because it is a weak opiate and has less abuse potential.[2,6] If treatment with tramadol is unsuccessful, hydromorphone is suggested.[6]

Post-operative day one, the patient was on an IV PCA of hydromorphone, was mobile, taking oral nutrition, and compliant with pulmonary toilet. Alternatives for postoperative pain include a combination of IV Tylenol every 8 hours for 24 hours, oral Tylenol, Ketorolac 15 mg, Ibuprofen, Gabapentin, Tramadol, and low dose Hydromorphone, individualized for patient specific considerations.[6] The patient complained of minimal appetite, so alternatives for postoperative pain management could have been employed to facilitate comfortable oral nutrition, thus optimizing recovery.

Compliance with ERAS protocols have been associated with improved clinical outcomes in thoracic surgery.[6] Areas for improvement include standardized order sets to help assure protocol compliance and obtaining measures of patient experience. By surveying patients on their view of pain control, provided education, and team collaboration, we can evaluate the ERAS protocols circumferentially by including patient satisfaction.[3]

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Arteriovenous Malformation of the Mandible

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Keywords: Arteriovenous malformation (AVM), mandibular reconstruction, embolization, anesthetic management, hemorrhage

Arteriovenous malformations (AVMs) are rare blood vessel growths with direct artery-to-vein connections creating high blood flow malformations. Arteriovenous malformations that arise in the mandible are extremely rare and potentially fatal. They can present in a variety of ways, including bone lesions, slow-growing masses, mild gingival bleeding, and severe hemorrhage.[1,2] The gold standard treatment for AVMs of the mandible involves endovascular embolization to decrease bleeding risk, followed by resection and reconstruction of the mandible.[2,3] This case study focuses on the anesthetic management of a patient with an AVM of the mandible and the risk factors commonly associated with this patient population.

Case Report

A 15-year-old, 163 cm, 53 kg male presented for an AVM of the mandible repair including open reduction internal fixation (ORIF) of the lower jaw, tracheostomy, nerve repair and mandible reconstruction with fibular free flap. The patient had no significant past medical history. Surgical history consisted of general anesthesia for four endovascular embolization procedures done in preparation for the current surgery. Airway assessment included Mallampati class III, inter-incisor gap of 3 cm, thyromental distance of 7 cm, mandibular protrusion test class I, and normal atlanto-occipital joint mobility. The patient's lab values included a hemoglobin level of 15.3 gm/dL and a hematocrit of 45.8%.

The patient was premedicated with midazolam 2 mg intravenously and taken to the operating room. After 3 minutes of preoxygenation with O_2 10 L/min, the patient was intravascularly induced with fentanyl 100 mcg, lidocaine 100 mg, propofol 200 mg, and rocuronium 50 mg. A Glidescope (Verathon Inc., Bothell, WA) was used for intubation and a size 7.0 mm endotracheal tube (ETT) was placed at 22 cm at the teeth. Tube placement was confirmed with $EtCO_2$ and auscultation of bilateral breath sounds. The patient was mechanically ventilated on volume control mode with a tidal volume (V_t) of 480 ml and a positive end-expiratory pressure (PEEP) of 4 cmH_20. General anesthesia was maintained with sevoflurane at 2.4-2.8% expired concentration in a mixture of air 1L/min and O_2 1L/min. The 20-guage intravenous catheter used to induce the patient was placed preoperatively. In the operating room, a 20-gauge arterial catheter was placed in the right radial artery and a 16-gauge intravenous catheter was placed in the right forearm.

Upon completion of the tracheotomy, the ETT was removed under the guidance of the surgeon. A 6.0 mm cuffed tracheostomy tube was placed and placement was confirmed with $EtCO_2$ and auscultation of bilateral breath sounds. General anesthesia was maintained on the previous settings. Intermittent boluses of fentanyl 25 mcg were administered to maintain analgesia using

increased heart rate and blood pressure as the trigger. A total of 200 mcg was administered throughout the case.

One hour into the case, the patient became hypotensive with a blood pressure of 84/55. After two 40 mcg boluses of phenylephrine, a phenylephrine infusion was started at 100 mcg/min and titrated to maintain a mean arterial pressure greater than 65 mmHg. A 1L bolus of lactated ringers was given over 1 hour. After four hours, the estimated blood loss was 500 ml. A 250 ml bolus of 5% albumin was given and a point-of-care blood analyzer was used to determine hematocrit and hemoglobin. The lab values were a hemoglobin level of 9.9 gm/dL and a hematocrit of 29%. Six hours into the procedure, the estimated blood loss was 900 ml. Two units of packed red blood cells were requested from the blood bank and administered. Thirty minutes after administration, the point-of-care blood analyzer was used again to determine the patient's hematocrit and hemoglobin. The lab values were a hemoglobin of 10.3 gm/dL and a hematocrit of 31%. Total EBL for the procedure was 1200 ml and the total fluids given were two units of PRBCs, 3200 ml of crystalloids, and 250 ml of 5% albumin.

At the end of the 8-hour surgery, the patient was transferred to the pediatric intensive care unit (PICU) with the tracheostomy tube in place. Intermittent intravenous boluses of propofol 20 mg were given during transport. Upon arrival to the PICU, the patient was comfortable and vital signs were stable. Postoperative recovery was uneventful and the patient was discharged home 13 days after surgery.

Discussion

The patient had noticed left mandibular swelling and medial shifting of the teeth one year prior to surgery. The tumor had been slowly growing until a recent increase in size, including new onset of pain. After being seen by interventional radiology, it was determined that the patient had a large, high-flow AVM originating from the left inferior alveolar artery and the submental and alveolar branches of the left facial artery. The arteries involved drained into large varicose veins and continued to the left facial, left external jugular, and left internal jugular veins.

Arteriovenous malformations lack capillaries and consequently, these highly vascular areas are unable to autoregulate, which can ultimately lead to severe hemorrhage and death in otherwise healthy patients.[1-3] Most AVMs occur in the skin, with few affecting bones or visceral organs. However, nearly 50% of all AVMs that have bone involvement arise in the skull and maxillofacial region.[1] These lesions of the mandible are often found due to excessive bleeding after dental procedures. It is estimated that 10-15% of patients with an AVM of the mandible will die if hemorrhage occurs.[2] Although risk of intraoperative hemorrhage can be reduced with preoperative embolization, it is still the most significant complication.[2] The goal of embolization is to destroy malformation feeder vessels preventing blood flow to the AVM.[3] It can be used as a nonsurgical intervention for smaller malformations or as an adjunct with surgery to decrease bleeding of larger lesions.[2,3] Different techniques include approaching lesions from the venous and/or arterial side and injecting sclerosing agents or radiation.[3] This patient had four arterial approach embolization procedures prior to surgery and blood loss during surgery was still substantial enough to require blood products and significant fluid replacement. Thus, the anesthesia practitioner should be prepared for significant blood loss during these procedures.

Preparation should include readily available plasma expanders, fluid warmer, and blood products that are type and crossed preoperatively.

Arteriovenous malformations are the result of errors in embryonic development and often do not present until childhood or adolescence.[3] Hormonal changes that accompany puberty and pregnancy can stimulate mass growth which can shift oropharyngeal structures, decrease mouth opening, and effect mandibular protrusion.[1-3] A thorough airway assessment is important with these patients to determine difficulty of airway, ventilation, and intubation. Advanced airway equipment should also be considered while formulating an airway management plan. Having a fiberoptic scope in the operating room and quick access to difficult airway equipment, such as a laryngeal mask airway and/or a tracheal tube introducer is prudent. The tumor growth and medial shift of this patient's teeth caused a decrease in thyromental space which impeded tongue displacement. A Glidescope (Verathon Inc., Bothell, WA) was chosen for intubation due to this difficult airway concern.

Nerve damage is a common risk with a variety of surgeries, including AVM of the mandible.[3] Electromyography (EMG) is used to monitor cranial nerve motor function during surgery by measuring changes in electrophysiologic function.[4] Electromyography can be used to stimulate motor neurons while monitoring the muscles innervated by that nerve or passively by monitoring nerve stimulation caused by manipulation of the nerve.[5] Paralytic agents are contraindicated during EMGs to maintain neuron function, therefore no paralytics were used with this patient after the initial induction dose of rocuronium 50mg. Duration should be considered when choosing a neuromuscular blocker and a neuromuscular antagonist may be required for reversal if the surgeon requires EMG promptly. Anesthesia practitioners should be prepared to monitor recovery of neuromuscular function and have reversal available. In this case, enough time passed between induction and EMG during neck dissection and reversal was not required.

This case, involving a relatively rare AVM, demonstrates the common anesthetic concerns discussed in literature regarding this surgery. When caring for a patient undergoing surgery for a mandibular AVM, anesthesia practitioners need to recognize the increased risk for bleeding by closely monitoring blood loss and having blood replacement products readily available for transfusion, the necessity of a thorough airway assessment accounting for an increased risk for difficult airways in this patient population, and the limitations of having to avoid paralytic medications as required for EMG. Understanding the pathophysiology of AVMs of the mandible and the surgical process will aid the anesthesia practitioner in delivering the safest anesthetic possible and therefore improving patient outcomes.

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Target Controlled Infusion: Management of the Neurosurgical Patient

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Keywords: target-controlled infusion, neurological surgery, total intravenous anesthesia, propofol, remifentanil

Total intravenous anesthesia (TIVA) is a commonly used technique to provide sedation and general anesthesia. Target-controlled infusion (TCI) is a TIVA technique that utilizes a software model to achieve a target plasma drug concentration. The software uses an algorithm that considers the three-compartment model to determine pharmacokinetic (PK) properties to achieve a target concentration of the drug in the plasma or at the tissue effect-site.[1,2] This case report summarizes a patient presenting for neurological surgery undergoing TIVA with the TCI method in Lima, Peru. Anesthesia implications, considerations, current recommendations, patient outcomes, and complications are reviewed.

Case Report

A 76-year-old male presented to a hospital in Lima, Peru, with acute neurological decline, including slurred speech and dizziness. A computed tomography (CT) scan of the head revealed a bilateral acute on chronic subdural hematoma. It was determined that emergency surgery was necessary to evacuate the hematoma. Baseline vital signs and lab values were within normal limits. The patient's medical history included anemia and chronic renal failure requiring hemodialysis three times per week. Physical examination was unremarkable, and the patient had a Glasgow Coma Score of 15. He was declared a grade III emergency (E) physical status, and general anesthesia with an endotracheal tube utilizing propofol and remifentanil TCI was planned.

Once in the operating suite, standard noninvasive monitors were applied. The patient was pre-oxygenated with O_2 10 L/min via circuit mask and a Bispectral Index Monitor (BIS) was placed to measure the depth of anesthesia by continuous electroencephalogram (EEG) monitoring. The induction of general anesthesia was initiated through the patient's preexisting 18-gauge intravenous (IV) catheter. Lidocaine 40 mg was given and the clinician programmed the TCI

pump for a specific plasma concentration level of propofol and remifentanil. A propofol infusion was initiated with a target plasma concentration of 1 mcg/mL in conjunction with remifentanil target plasma concentration of 3 ng/mL using the Braun Perfusor Space machine utilizing the Schnider model. Maintaining a propofol plasma concentration of 1 mcg/mL is equivalent to an infusion rate of approximately 38 mcg/kg/min. A remifentanil plasma concentration of 3 ng/mL is equivalent to an infusion of approximately 0.125 mcg/kg/min. After the administration of rocuronium 30 mg, an 8.0-mm cuffed endotracheal tube was successfully placed in the trachea and secured at 22 cm at the lips after direct laryngoscopy revealed a grade IIa view. A right radial arterial catheter was inserted for hemodynamic monitoring and intravascular blood sampling for frequent laboratory analysis.

The TCI target concentration of propofol was titrated to a maintenance level of 1.2 mcg/mL, or approximately 46 mcg/kg/min. An additional dose of rocuronium 30 mg was given for paralysis during the hematoma evacuation. The patient's vital signs remained hemodynamically stable, and BIS remained between 46 and 50 for the case's duration. At the closing of the skin, the propofol target concentration was titrated to 0.9 mcg/mL and remifentanil was at 3.5 ng/mL. The infusion rates would now be propofol at 34 mcg/kg/min and remifentanil at 0.145 mcg/kg/min, respectively. At the completion of the surgery, the propofol TCI infusion was discontinued, and the patient was awake and extubated within 15 minutes. It was noted on the infusion pump that wake-up time with the propofol would be 15 minutes if the infusion were halted at that exact time. At the time of extubation, the remifentanil TCI infusion was discontinued. The total dosage of medications given during the duration of the case was: propofol 502 mg and remifentanil 1,315 mcg.

Discussion

This case report demonstrated the successful use of the TCI method of TIVA in a patient undergoing neurological surgery. The TCI method is commonly used in neurological surgery because of the favorable cerebrovascular effects, reduction in the perioperative stress response, rapid recovery, decreased postoperative nausea and vomiting, and a decrease in the acute systemic inflammatory response.[3]

Target-controlled infusion was first introduced in 1996 to deliver TIVA through a computer software system and has been utilized in 96 countries, including most of Europe and Asia; however, it is not routinely seen in the United States.[4] TCI utilizes mathematical calculations of PK based upon a three-compartment model. The three-compartments are the central compartment, which is primarily plasma (V_1), well perfused-tissue including muscle (V_2), and mainly tissue fat stores (V_3). The computer software was developed using data from studies of plasma concentrations collected in patients after receiving bolus doses and computer-controlled infusions of target drugs.[6] TCI software models determine a drug distribution and allow anesthesia professionals to choose both bolus and continuous doses of anesthetics to achieve either a user-selected plasma or effect-site drug concentration.[5, 7] TCI is not a fully automated software system. The anesthetist determines the initial rate, and the selected mode will bolus the anesthesia medication to achieve a user-selected plasma or effect-site concentration. The anesthetist may bolus an additional dose of the medication based on the intuition of the anesthetist and the patient's hemodynamic profile. Following the bolus, the software then adjusts

the basal rate to achieve the user-selected or effect-site concentration.[8] At the conclusion of a procedure, TCI machines apply PK calculations to provide reliable estimates of time to emergence from anesthesia.

The TCI software has two commonly used and approved modalities: Marsh and Schnider, which are named after the software developers. In both the Marsh and Schnider modes, the clinician may select either an effect-site concentration or plasma concentration. The mode and concentration model chosen determines the algorithm used, which will affect the bolus dosing and infusion rates delivered to the patient. Both Marsh and Schnider also utilize age, sex, height, and weight as controlled variables for PK calculations of the drug for plasma effect.[3] The Marsh model uses total body weight as the influencing parameter with a 15.9 L central compartment for the PK calculations with fixed constants for redistribution rate and compartment equilibration rate. The Schnider model is considered more complex with a 4.2 L central compartment (V_1), and drug clearance is dependent on age, sex, total body weight, lean body mass, and height. V_1 and V_3 are fixed while V_2 is determined by the patient's age and decreases as the patient ages.[1, 7] The Schnider model, when targeting the effect-site, uses the patient's age as the influencing parameter to adjust the dose and rates.[7] The size difference in the central compartments creates an alteration in the estimated blood and effect site concentration for the first 10 minutes of beginning the TCI pump. After 10 minutes, the alteration is less substantial. The Marsh mode is used best to target plasma and Schinder is best used to target effect site.[8] In this case report, the Schnider model of TCI was chosen for the elderly patient, due to the fast distribution of the drug, reduced induction dose, and the age-adjusted dose and rate.[1, 7]

The most frequently used drugs in TCI and manual controlled infusion (MCI) methods of TIVA are remifentanil and propofol.[8] Propofol is an anesthetic drug best known for its short-acting, lipophilic properties. Reducing cerebral blood volume and intracranial pressure, as well as preserving autoregulation and vascular reactivity, are advantages of using propofol for the neurosurgical patient. Remifentanil, an opioid Mu agonist, has beneficial neuroprotective effects, including suppressing cell death by the lowering expression of tumor necrosis factor-alpha and tumor necrosis factor receptor-1.[3] In addition, there is no effect on cerebral perfusion pressure or intracranial pressure with the use of remifentanil.

Although TCI and MCI use the same anesthetic drugs, the modalities are different. For the MCI method of delivery, the anesthetist manually calculates the bolus and infusion dosages of the anesthetic drugs based upon the patient’s age, weight, and anticipated clearance of the drug. The anesthetist will make multiple adjustments to the dosages and infusion rate based on the depth of anesthesia and the patient status.[6] MCI does not use a formalized PK calculation to determine dosages or basal rates but instead uses clinical monitoring and anesthetist intuition and knowledge of pharmacology and physiology of the anesthetic drugs.

There were significant differences between the two modalities in a randomized clinical study comparing MCI versus TCI models. Lugo et. al., showed results that suggested that both MCI and TCI provided a safe and effective anesthetic with an anticipated and prompt recovery of the patient in the postoperative period. However, when utilizing TCI, induction of anesthesia is more rapidly achieved with maintained hemodynamic stability. Results also suggest that TCI allowed for a reduction in overall propofol usage.[8] Furthermore, emergence from anesthesia, defined as

eye-opening and orientation, was significantly shorter in a TCI patient versus MCI. The MCI technique utilized a larger propofol volume which resulted in increased hemodynamic instability and prolonged emergence.[6]

There are unsolved differences and problems associated with the TCI system such as the plasma-effect site disequilibrium and adequate measures to describe the IV anesthetic concentration appropriately. Plasma-effect site disequilibrium occurs when plasma concentration is selected because there is a significant delay in the drug effects stability. When targeting the effect site, therapeutic concentrations of the drug are achieved at a much faster rate, however with an incidence of hemodynamic variability. Adequate measures to describe IV anesthetic concentrations appropriately have also been an issue because there is not a minimum alveolar concentration (MAC) equivalent for IV drugs as there is for volatile anesthetics.[10]

In summary, this case scenario of a patient undergoing neurological surgery in Lima, Peru demonstrates a positive outcome with a fast emergence and hemodynamic stability of the patient after receiving TIVA with the TCI method. TCI and MCI TIVA both deliver safe and effective anesthetics. The TCI method allows for a precise calculation of the drug being delivered based on effect-site or plasma concentration. It allows the anesthetist more control over the depth of anesthesia and hemodynamic stability of the patient, ultimately reducing the consumption of anesthetic drugs and improving anesthetic outcomes.

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Cervical Spine Precautions in a Difficult Airway and Bloody Airway

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Keywords: Difficult Airway, Cervical Spine Precautions, Airway Management

Blunt trauma adult patients are at 2-5% risk of cervical spine trauma, with 14% of these being unstable. As many as 10% of blunt trauma patients with proven cervical spine injury need emergent intubation within 30 minutes of arrival in the emergency department (ED). Complications of intubating trauma patients are reported at 9.3%, with 3.2% of complications resulting from oxygen desaturation less than 85%.[1]

Case Report

A 90 year-old, 90 kg, 170 cm, male presented for a re-exploration of possible loose hardware at C1-C2. The patient had a past medical history of coronary artery disease with 7 stents, hypertension, diabetes mellitus, multiple transient ischemic attacks with no residual deficits, and atrial fibrillation. Past surgical history significant for transoral odontoidectomy with hardware placement at C1-C2 three weeks before this encounter. The patient was admitted to the intensive care unit (ICU) for confusion, falls, and atrial fibrillation with rapid ventricular response, which had since resolved.

A cervical spine x-ray showed questionable loose hardware at C1-C2. Computerized tomography showed a retropharyngeal abscess, scheduled to be drained by the Ear, Nose, Throat (ENT) service in the operating room (OR) once re-exploration of the hardware was completed. Home medications included apixaban, clopidogrel, aspirin, metoprolol, lisinopril, metformin, and regular insulin. The patient had not taken any oral anticoagulant or antiplatelet medications in 10 days and all other medications were held on the day of surgery. Pertinent laboratory results included hemoglobin 11.6 g/dL, hematocrit 36%, 247,000 platelets /µl, and coagulation within normal limits.

Physical examination findings included a Mallampati class IV airway, a semi-rigid cervical collar in place, edentulous mouth, coarse lung sounds, and S1, S2 heart sounds with a systolic murmur.

The patient was transported from the ICU to the OR. He was pre-oxygenated for 5 minutes and induced with propofol 50 mg and remifentanil 150mcg. Fiberoptic intubation was attempted for approximately 90 seconds. At this point, the patient began to desaturate down to a SpO_2 of 85%. An oropharyngeal airway was placed and two-person mask ventilation was attempted, but an adequate seal was difficult due to his cervical collar. A size 4 laryngeal mask airway (LMA) was then placed and ventilation was confirmed with positive $EtCO_2$. Copious amounts of blood began to flow from his nasal cavity and oral cavity. There was no clear reason for sudden hemorrhage and ENT service was paged. A decision was then made to place an endotracheal tube (ETT) using an airway exchange catheter through the LMA with a fiberoptic bronchoscope for visualization. A 6.0 ETT was successfully placed and the patient was maintained on sevoflurane 1% inspired concentration with O_2 at 2L/min on pressure control ventilation for the duration of the case. Following airway securement, an arterial line was placed in his left radial artery.

The ENT service performed an endoscopy of the oropharynx and nasopharynx but did not find an obvious source of the bleeding. An intact retropharyngeal abscess was then drained. The hardware re-exploration was canceled and the patient was uneventfully transported to the ICU. Estimated blood loss was 500mL with the previous odontoidectomy surgical site as the suspected source of the hemorrhage. Chest x-rays were performed every 24 hours for 4 subsequent days, which showed no acute cardiopulmonary conditions. The patient had successful hardware exploration surgery 4 days after this event.

Discussion

This case describes an anticipated difficult airway compounded by unanticipated blood in the airway and a retropharyngeal abscess. The patient was wearing a cervical collar due to a presumed unstable cervical spine from loose hardware present at C1-C2. When securing the airway in a patient with presumed or confirmed cervical spine instability, the primary goal is to minimize cervical spine movement and prevent secondary cervical spine injury. There are several methods for maintaining cervical immobility and securing the airway. Most research on this topic is based on animal or cadaveric models and there is no definitive conclusion on which method is best. This discussion will focus on three primary topics: cervical spine immobilization techniques, preferred intubation techniques when a patient has suspected or confirmed cervical spine injury, and airway adjuncts as rescue methods when the patient has suspected or confirmed cervical spine injury.

The gold standard for cervical immobilization is the combined use of a backboard, collar, sandbags, and tape or straps. This can limit movement to 5% of the normal range of motion. However, this type of immobilization is associated with limited Cormack-Lehane views, with 64% of these patients having grade III or IV views during direct laryngoscopy.[2] Another method for cervical immobilization include semi-rigid collars, such as the Philadelphia collar. These collars have been shown to limit mouth opening, creates cervical displacement during placement, and were not effective in limiting segmental motion in stable or unstable cervical spines.[2]

Manual in-line stabilization (MILS) is the last common cervical immobilization procedure that is seen during collar placement or during intubation. MILS requires the provider to cradle the occiput and mastoid process from the side or head of the bed. MILS avoids the problem of decreased mouth opening, has been shown to limit head extension, and decreases vertebral subluxation and angulation in cadaveric models of C5-C6 transection.[2] Drawbacks of MILS include limiting Cormack-Lehane views and increasing time to intubate.[2,3] If MILS is used with a two-piece collar, it is recommended that the anterior portion is removed and the posterior portion remains in place.[2]

The method of tracheal intubation is not standardized and there are multiple accepted methods for securing the airway. Direct laryngoscopy has been shown to be safe and effective.[2] There is no significant difference between the Macintosh or Miller laryngoscope blades in this population.[2] Direct laryngoscopy produces extension of each vertebral segment; specifically at the occipital-C1 and C1-C2 segments in cadaveric models.[3] Video laryngoscopy has become widely available in the last 10 years and is now a primary tool for airway management. Video laryngoscopy requires less mouth opening and has a more acute angulation, which improves laryngoscopic views compared to direct laryngoscopy, especially in patients wearing cervical collars.[2] Video laryngoscope reduced cervical spine motion by 50% in C2-C5 segments compared to using a Macintosh blade, however motion at the occipit-C1, C1-C2, and C5-thoracic segments remained similar.[4,5] Limitations with video laryngoscope include difficult to access in emergent situations, blood in the airway obscuring camera use, and provider comfort.[2,6] Finally, fiberoptic intubation is accepted and can be approached in the awake patient or the asleep patient. It is the preferred choice to produce the least motion in the upper cervical spine. Advantages include visualization of structures below the level of the vocal folds, visual verification of ETT placement, identifying subglottic pathology, and facilitating pulmonary toilet. Disadvantages include provider comfort and inexperience, visualization hindered from secretions, blood, or debris; and ETT hang-up on airway structures.[7] Awake fiberoptic intubation is the preferred technique in a patient who is hemodynamically stable and cooperative.[3] It is beneficial for frequent neurological examinations which can occur before and after the airway is secured or during surgical positioning.[2]

There are a few airway adjuncts that can be used as both primary and rescue airway management in this population. LMA's can be used as conduit for intubation as well as a rescue method in failure to intubate or ventilate scenarios. Their use is controversial due to increased cervical spine displacement relative to intubation, but other studies have shown no significant differences.[2] The lighted-optical stylets have shown to reduce motion across all segments compared to direct laryngoscopy and decrease time to intubation compared to fiberoptic bronchoscopic intubation. Lighted stylets should not be used as a first-line technique in patients with anticipated difficult airways or inexperienced providers.[3] Blind nasal intubation was popular in the late 1980's and is still an option today, but the availability of video laryngoscope and fiberoptic bronchoscope has made this technique a rescue maneuver during failed intubation.[2] A surgical cricothyrotomy was once advocated for by Advanced Trauma Life Support in this population as a primary maneuver to minimize cervical displacement, but this technique was not well studied and not always done.[2]

This case study presented a patient with cervical spine immobility, anticipated difficult airway, and unanticipated bloody airway. In retrospect, the anesthetic plan for intubation was conservative. Removing the anterior portion of the cervical collar and having a provider maintain MILS may have yielded a different outcome during mask ventilation and intubation. Airway management is not standardized in this patient population and anesthetic plans should be individualized on a case-by-case basis.

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Oculocardiac Reflex during Pediatric Strabismus Surgery

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Keywords: Oculocardiac reflex, trigemino-cardiac reflex, strabismus repair, pediatrics, general anesthesia

Strabismus repair corrects visual axes alignment abnormalities by surgically manipulating the 6 extraocular muscles that control eye movement.[1] The oculocardiac reflex (OCR) was first recognized in 1908 as a greater than 20% decrease in heart rate from baseline after manipulation of the eye and has a documented incidence rate of 14% to 90% during strabismus surgery.[1,2] The OCR consists of 2 phases, including initial bradycardia, when traction is applied to the

extraocular muscle (EOM), followed by a tachycardia after traction is released.[1] The effects of the OCR can be detrimental; therefore, it is essential to understand its management.

Case Report

A 7-year-old, 124 cm, 22.4 kg, Hispanic male presented for an elective right strabismus repair under general anesthesia in the ambulatory surgery department. The patient's past medical history included febrile seizures as an infant. His previous surgeries included a hernia repair with no known complications. The patient was taking no home medications and had no known drug allergies. A physical examination revealed right eye monocular exotropia, a standard mouth opening with a Mallampati Classification I airway, no loose teeth, and a full range-of-motion of his neck. After the informed consent for general anesthesia was obtained from the parents, oral midazolam 10 mg was administered.

Approximately 25 minutes after the administration of midazolam, the patient was transferred to the operating room. At this time, the patient appeared sleepy yet cooperative, and a pulse oximeter was placed on the left foot. The patient was induced by inhalational induction with sevoflurane 7% inspired concentration and O_2 8 L/min in the supine position. Following inhalational induction, standard monitors were applied. Additionally, a precordial stethoscope was used to monitor the patient's respirations. A peripheral intravenous (IV) line was inserted in the dorsum of the left hand. The patient received fentanyl 20 mcg IV, propofol 100 mg IV, and a maintenance infusion of lactated ringers. The patient was ventilated by mask with sevoflurane 3.7% inspired concentration and O_2 8 L/min. A size 2 laryngeal mask airway (LMA) was inserted. The patient was manually ventilated until spontaneous ventilation resumed, and then respirations were assisted with pressure-support ventilation. General anesthesia was maintained with sevoflurance 2.2% expired concentration and O_2 2 L/min. The patient's post-induction blood pressure was 90/50 mm Hg, heart rate ranged from 107 to 115/min, SpO_2 100%, and respiratory rate 24/min.

At this time, the operating table was turned 180 degrees. The right side of the patient's face was prepped and draped in a sterile fashion by the surgeon. Antibiotics were not indicated for this procedure. Dexamethasone 4 mg IV and ondansetron 2 mg IV were administered for postoperative nausea and vomiting (PONV) prophylaxis. The surgeon placed a lid speculum between the upper and lower lids of the right eye. The surgeon first manipulated the lateral rectus muscle uneventfully. As the surgeon began to isolate the medial rectus muscle, the patient's heart rate rapidly decreased to 70/min. The surgeon was informed immediately of the decrease in the patient's heart rate. The surgeon released tension on the medial rectus muscle, and the patient's heart rate stabilized at 95-110/min. The incidence of decreased heart rate lasted less than one minute. Weight-appropriate dosage of atropine, glycopyrrolate, and epinephrine were prepared, but not administered. The surgeon proceeded cautiously and minimized tension on the medial rectus muscle.

At the conclusion of the surgery, bupivacaine was placed in the sub-tenon space, and the surgeon applied maxitrol ointment. The sevoflurane was titrated until it was discontinued and the patient maintained spontaneous ventilation. Ketorolac 10 mg IV was administered for analgesia. Once adequate tidal volumes and respiratory rate were achieved, the LMA was removed, and the

oropharynx was suctioned. The patient was positioned in the left lateral decubitus position with O_2 6 L/min via open face mask. The patient was transferred to the pediatric room in the post-anesthesia care unit with no signs of pain, PONV, or emergence delirium.

Discussion

Strabismus repair is one of the most common ocular surgical procedures in the pediatric population.[1] The OCR is a parasympathetic response caused by manipulation or traction of the EOMs or eye compression, leading to bradycardia or dysrhythmias.[3] The effects of the OCR may lead to cardiac arrest at an occurrence of 1:2,200 strabismus surgery cases.[3] The afferent limb of the OCR arc is the ophthalmic branch of the trigeminal nerve (cranial nerve V), and the efferent limb of the reflex arc is the vagus nerve (cranial nerve X), which is responsible for decreasing both heart rate and contractility.[2,3] The occurrence rate of the OCR is higher in young patients who have increased vagal tone when compared to adult patients.[2] The OCR may occur multiple times with varying presentations after repeated manipulations of the EOMs.[3] The most common manifestation of the OCR is sinus bradycardia; however, atrioventricular block, ventricular fibrillation, and asystole have been documented, which can lead to sudden death.[2]

There is conflicting evidence related to whether or not traction on medial rectus muscle during resection causes an increased risk of the OCR.[2,3] For patients having surgery on 2 EOMs, there is a higher frequency of OCR during manipulation of the first muscle, compared to the second muscle.[3] If bradycardia or dysthymias occur during strabismus surgery, the first step the anesthesia practitioner should take is to communicate with the surgeon.[4] Surgical stimulation should cease, and the patient's anesthetic depth and oxygenation should be reassessed.[4] If the heart rate does not immediately return to basline, atropine 0.02 mg/kg should be administered IV.[4]

Researchers have focused on the effects of different anesthetic agents on the occurrence of the OCR. Various strategies have been explored to decrease the incidence of OCR by the administration of retrobulbar blocks, anticholinergics, and inhalational agents, none of which significantly impact the rate of prevention.[1] Premedication with atropine 0.02 mg/kg IV or glycopyrrolate 0.01 mg/kg IV, to block the muscarinic receptors of the heart, and retrobulbar xylocaine hydrochloride, to block the ciliary ganglion, have been shown to decrease OCR, but not consistently.[1,4] To mitigate the potential for cardiac arrest and sudden death, atropine can be administered before the OCR occurs or after if there is prolonged bradycardia.[1]

Several researchers have reported a lower occurrence of the OCR when using sevoflurane or desflurane as opposed to using propofol or remifentanil for maintence of general anesthesia.[1,2] Furthermore, there is evidence suggesting increased depth of anesthesia and bispectral index (BIS) values less than 50 decrease the incidence of the OCR.[2] As an adjunct to anesthesia, ketamine has been utilized to reduce the prevalence of the OCR due to its sympathetic nervous system effects that counter the vagal stimulation of the OCR.[1] Preschool-aged children undergoing ophthalmic strabismus procedures with sevoflurane or desflurane have an increased occurrence of emergence agitation and PONV.[5,6] Dexmedetomidine 0.5 to 1 mcg/kg IV administered during induction has been shown to decrease the incidence emergence agitation and PONV, without increasing the incidence of intraoperative OCR.[5,6]

This case study was noteworthy when exploring OCR in the pediatric population. The patient's heart rate immediately decreased by 39% when traction was placed on the medial rectus muscle. After swift communication between the anesthesia practioner and the surgeon, the heart rate increased back to baseline after the surgeon removed traction on the muscle. However, if the heart rate had not responded, atropine would have been considered. Although no exact preventative methods have yet been identified, the treatment of stopping the OCR include removing traction of the EOM, taking pressure off of the eye, administering anticholinergic medication, and then cautiously proceeding with the procedure.[2] Pediatric anesthesia practitioners should pay close attention to the heart rate during high-risk periods of surgical manipulation such as traction, isolation, and resection of the EOMs.

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Labor Epidural with Factor XI Deficiency

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Keywords: factor XI deficiency, neuraxial anesthesia, postpartum hemorrhage

Factor XI (FXI) deficiency is a rare hemophilia with a variable expression that complicates obstetric management due to potentially life-threatening bleeding.[1] Predicting the impact of FXI deficiency on labor and delivery outcomes is challenging due to the lack of correlation between factor activity level and bleeding phenotype.[2] The optimal management of obstetric patients with FXI deficiency is complex and requires careful consideration of risks and benefits of

interventions such as blood component therapy.[3] This case discusses the obstetric anesthetic management of a parturient with FXI deficiency requesting a continuous labor epidural (CLE) for labor and delivery.

Case Report

A 23-year-old, 66 kg, 162 cm multiparous (G3P2A0L2) female presented to the labor and delivery unit for a planned induction of labor at 36 weeks and six days estimated gestational age for a planned vaginal delivery of a singleton fetus. Elective labor induction was scheduled due to an increased risk for postpartum hemorrhage (PPH) related to a patient history of FXI deficiency as evidenced by heavy menstruation and multiple episodes of spontaneous epistaxis. Her first pregnancy resulted in a vacuum-assisted vaginal delivery at 38 weeks where she prophylactically received two units of fresh frozen plasma (FFP). Her second pregnancy resulted in a spontaneous vaginal delivery at 37 weeks complicated by preterm labor at 28 weeks, with five days of inpatient monitoring. She was admitted at 37 weeks and five days for elective induction and received one-unit FFP before her continuous labor epidural placement. During delivery she sustained a labial laceration and subsequent vaginal hematoma. Her estimated blood loss during delivery was 400 mL. She reported no known allergies and denied past surgical history. Aside from FXI deficiency and multiple plasma infusions, the patient's medical history was non-contributory. Her medication regimen included a daily prenatal vitamin and folic acid supplement. Her current pregnancy was complicated by a FXI activity level of 23% at 33 weeks and three days. Hematology was consulted and recommended transfusion of solvent/detergent-treated plasma (SDTP) to at least 40% or greater before epidural placement and delivery. Her factor XI activity level at 35 weeks and five days was 37%.

After an initial assessment, the nursing staff placed bilateral 18-gauge antecubital peripheral intravenous catheters. Pertinent admission laboratory results included: hemoglobin 11.2 g/dL, hematocrit 34.3%, platelets 188K/uL, FXI activity 46%, fibrinogen 361 mg/dL, active partial prothrombin time 30.1 seconds, prothrombin time 12.6 seconds, international normalized ratio 1.0 and type and crossmatching indicated A positive blood type. The obstetric-anesthesia team developed a plan to transfuse four units of SDTP before lumbar epidural catheter placement to reduce the risks associated with the most severe bleeding phenotype.[1,3] She experienced throat irritation during the transfusion of the second unit of SDTP. Her transfusion was stopped, and she received diphenhydramine 25 mg intravenously. The transfusion was restarted 10 minutes later, and she remained asymptomatic for all subsequent infusions of SDTP. Epidural catheterization was successful after six attempts. Multiple attempts were necessary due to poor patient positioning and inability to maintain lumbar spine flexion during epidural catheter placement. Loss of resistance to saline occurred at 5 cm using a 17-gauge Touhy needle. A 19-gauge multi-orifice catheter was inserted to 6 cm in the space and secured at 11 cm at the skin using a transparent dressing. A continuous labor epidural infusion of bupivacaine 1.25 mg/mL with fentanyl 2 mcg/mL at a basal rate of 8 mL/hr, a patient-controlled bolus of 5 mL with a lockout time of 15 minutes was initiated. A bilateral T10 dermatome level was achieved with the patient endorsing satisfactory analgesia.

Labor was augmented with a continuous oxytocin infusion administered per protocol to 4 units per hour before delivery. The obstetrician inserted an intrauterine pressure catheter, and complete

dilation immediately occurred following placement. Tranexamic acid 1 gram was administered intravenously over 10 minutes just before delivery. Spontaneous vaginal delivery of a viable baby girl occurred with less than 500 mL of quantifiable blood loss. The labor nurse discontinued the labor epidural following vaginal laceration repair with the catheter tip intact.

Discussion

Hemostasis is a complex physiologic process that involves a constant balance between factors that cause clotting and bleeding with pathologic derangements occurring from imbalances in either bleeding or clotting.[4] Hemostasis after vascular injury involves: arteriolar vasoconstriction, platelet activation and adhesion, the formation of fibrin clots, and fibrin/platelet contracture with activation of controlled fibrinolysis. Coagulation is initiated by the intrinsic and extrinsic pathways that converge to a common pathway that forms a fibrin clot. The intrinsic pathway is activated when factor XII contacts subendothelial substances exposed during vascular injury and activates FXI. FXI, activated during the intrinsic pathway, plays a vital role in triggering complement, kinin, and fibrinolytic pathways.[2]

Factor XI deficiency is a rare hemophilia that presents challenges to obstetric management due to potential life-threatening bleeding caused by the impact on downstream thrombin production.[1] The indirect inhibition of fibrinolysis through the production of thrombin-activated fibrinolytic inhibitors is a critical role of FXI in hemostasis. The role of FXI in coagulation includes the contact pathway and Factor X, thrombin, and activation of the extrinsic pathway.[5] FXI deficiency is manifested as increased fibrinolysis, leading to unpredictable and potentially severe bleeding episodes during labor.[1]

The bleeding tendencies of individuals afflicted with FXI deficiency do not directly correlate with activity level, and individuals with equivalent levels of FXI activity can have different bleeding severities, and even individuals with a partial deficiency can have a severe bleeding phenotype.[1] Individuals with severe FXI deficiency include homozygous and compound heterozygous carriers with activity levels less than 15%.[2] A mild deficiency in heterozygous carriers ranges from 15 to 70%. The strongest predictor of bleeding is a bleeding history regardless of the FXI level.[1,6] In parturients with FXI deficiency and O type blood, a deficiency in von Willebrand factor confers an elevated bleeding risk.[2]

In women with FXI deficiency, the physiologic hemostatic changes of pregnancy are complicated by variable bleeding tendencies and the potential for PPH.[1,2] These changes necessitate therapies to reduce bleeding risk such as fresh frozen plasma and antifibrinolytic agents administered at the time of delivery or before neuraxial anesthesia administration. Patients with FXI deficiency and a bleeding phenotype have significantly decreased thrombin generation, while patients with severe FXI deficiency without a bleeding phenotype may have normal thrombin generation.[2] A clinical feature of FXI deficient patients is that bleeding diathesis is milder than hemophilia A or B, and severe spontaneous bleeding is rare.[6]

Neuraxial anesthesia has been safely initiated in women with severe factor XI deficiency with antifibrinolytics, FXI concentrate, and without hemostatic prophylaxis.[2] The prevalence of primary PPH in women with FXI deficiency; defined as >500mL blood loss for vaginal delivery

ranges from 10-22% of deliveries, which is significantly higher than the general population at 5-8%.[2] Neuraxial anesthesia has been safely administered in FXI deficiency; however, the risk for spinal hematoma should be considered.[2] Techniques to reduce the risk of a traumatic placement include utilizing experienced providers or using adjuncts to improve first attempt success.

The multidisciplinary team took a concerted approach to reduce the risk associated with coagulopathy and initiate interventions to improve antifibrinolytic activity. The team's consensus was to reevaluate the FXI level upon admission to the labor and delivery unit and correct FXI activity levels to greater than 40% using SDTP.[4] The patient was at increased risk for PPH due to a partial FXI deficiency and a bleeding phenotype. Her elevated risk for bleeding warranted the correction of FXI activity with SDTP before CLE placement.[3] On the day of induction, the FXI activity level was 46% and the team decided to proceed with prophylactic FXI replacement due to the patient's bleeding history.[1] The nursing staff administered four units of SDTP. The reduced incidence of allergic transfusion reactions and equal efficacy of SDTP compared to untreated plasma influenced the team's decision to use SDTP.[7,8] Minimal blood loss following difficult CLE placement and spontaneous vaginal delivery with a laceration is attributed to our team's proactive approach to the correction of the patient's FXI deficiency.

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Anesthesia Management for a Patient with Hemangioma of the Liver

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Keywords: Liver resection, anesthesia, nitroglycerin, liver hemangioma, partial hepatectomy

Providing anesthesia for patients undergoing partial liver resection due to hepatic hemangiomas can result in massive intraoperative hemorrhage.[1] Hepatic hemangiomas are the most common benign tumors of the liver.[2] Patients with hepatic hemangiomas usually present with signs and symptoms that include nausea, vomiting, portal hypertension, and abdominal pain.[2] Surgery is usually indicated for hepatic hemangiomas greater than 4 cm that cause complications including abdominal pain, nausea, poor appetite, portal hypertension, and liver dysfunction.[2] Overall, the liver holds a large amount of blood supply. Bleeding during a liver resection can be significant and lead to intraoperative morbidity and mortality.[1]

Case Report

A 47-year-old, 120 kg male, was scheduled to undergo an open partial hepatectomy for a hepatic hemangioma. The patient presented with a basal metabolic index of 35 kg/m^2. The patient denied any allergies and any previous medical history. His past surgical history included a right knee arthroscopy. The patient denied any previous problems with anesthesia. A preoperative electrocardiogram confirmed sinus rhythm at a rate of 78/min. An ultrasound and computed tomography scan were performed and showed a 7 cm hepatic hemangioma.

Preoperative labs and vitals were within normal limits except slightly elevated total and direct bilirubin levels. A type and crossmatch were completed and 4 units of packed red blood cells were available in the operating room. The preoperative airway assessment showed a Mallampati grade II, thyromental distance of greater than 3 cm, and a mouth opening of 4 cm.

Prior to entering the operating room, the patient received midazolam 2 mg intravenously (IV). Upon entering the operating room, the patient was pre-oxygenated with O_2 10L/min. Standard monitors, as well as bispectral index monitor (BIS), were applied prior to anesthesia induction.

Once the patient was pre-oxygenated greater than three minutes and the end-tidal oxygen concentration was greater than 90%, anesthesia induction was initiated. Fentanyl 100 mcg, lidocaine 100 mg, propofol 200 mg, and rocuronium 50 mg were administered IV. Tracheal intubation was successfully completed via direct laryngoscopy with a MAC 3 blade and a 7.5 mm cuffed endotracheal tube was placed. Placement was verified with positive end-tidal carbon dioxide ($ETCO_2$), chest rise, and bilateral breath sounds. The patient was placed on volume control mechanical ventilation and general anesthesia was maintained using isoflurane to keep BIS between 40-60. The patient was ventilated using the volume control mode, TV 600 mL, RR 10-12/min to keep ETCO2 32-37 mm Hg, and PEEP 5 cm H_2O. After the airway was secured, a right radial arterial line was placed, a right internal jugular central venous line was inserted using ultrasound, and a second 18-gauge IV catheter was placed in the left forearm.

Prior to surgical incision, the patient's mean arterial pressure (MAP) was maintained between 65-70 mm Hg. The patient's central venous pressure (CVP) ranged between 6-8 cm H_2O with the operating table leveled. Baseline arterial blood gas values were within normal limits.

After incision, the patient remained hemodynamically stable. The first bag of IV fluids was limited to less than 500 mL until the designated part of the liver was resected. Prior to resection, a nitroglycerin drip was started at 5 mcg/min and titrated to achieve a CVP less than or equal to 5 cm H_2O. A norepinephrine drip was made and readily available should the patient's MAP fall below 60 mm Hg. After resection of the hepatic hemangioma and the adjacent segment of the liver, the nitroglycerin and norepinephrine drips were titrated down and turned off when the patient was able to maintain a MAP greater than 60 mm Hg. An extra 700 ml of IV crystalloids were administered after the hepatic hemangioma was resected. The surgery lasted a total of 6 hours. The estimated blood loss was 400 mL and the total urine output was 500 mL. Sedation and paralysis were continued and the patient was transferred to the intensive care unit.

Discussion

The liver is a large reservoir of blood supply. Proper anesthetic management of a partial hepatectomy consists of minimizing operative blood loss and transfusion requirements. Blood loss and transfusion requirements are risk factors that are associated with perioperative complications and mortality after partial hepatectomies.[3] Using various methods to reduce blood loss during hepatectomies will improve surgical outcomes and prevent perioperative complications.

Blood loss during hepatectomies is usually secondary to increased pressure from within the inferior vena cava. For this reason, CVP has been used to guide anesthetic fluid management.[3] A central venous catheter is essential in this type of case. Reducing CVP will reduce the resistance the hepatic venous blood flow meets as it travels to the inferior vena cava.[4] Decreasing impedance of outflow will decrease overall hepatic venous volume allowing a decrease in bleeding during resection and providing a better surgical site environment.[4] Multiple methods have been used and studied to support the practice of reducing CVP to decrease blood loss during hepatectomies.

Limiting fluid intake before resections is a simple, non-pharmacologic, method to assist with decreasing CVP. Literature has shown success using a variety of different methods of limiting fluid administration. During the case, fluids were limited to less than 500 mL prior to resection. Maintaining fluid administration at approximately 75 mL/hr has been shown to reduce CVP without adversely affecting kidney function or increasing overall mortality rates.[4] Literature also suggested utilizing a balanced technique of a 500 mL colloid bolus in addition to 80 mL/hr of IVF to achieve a CVP goal of less than 5 cm H_2O.[1] Additional studies have shown success using lactated ringers at 1.5 mL/kg/hr with a nitroglycerin drip.[3] Although the exact amount of fluids a patient should receive prior to resection is not clear, research supports the reduction of fluid intake along with pharmacologic methods to decrease CVP prior to resection.

In addition to fluid restriction, a nitroglycerin drip was used to keep CVP 5 cm H_2O or less while maintaining a MAP greater than 60 mm Hg. A benefit to using nitroglycerin is that it is a potent

vasodilator, has a fast onset and offset, and can reduce portal pressure.[1] Nitroglycerin infusions should be titrated between rates of 0.15-2.4 mcg/kg/min to maintain an appropriate CVP while also ensure a MAP of 60 mm Hg or greater.[3] During the case, nitroglycerin was started at 5 mcg/min and was titrated to achieve the appropriate hemodynamic parameters. A norepinephrine drip was necessary to achieve the MAP goal of greater than 60 mm Hg. The use of nitroglycerin is advised to decrease CVP, however, literature is recently suggesting the addition of vasopressin. Vasopressin has been proven to decrease hepatic and portal blood flow.[3] An infusion of 9.6 units/hour for 5 minutes, followed by 4.8 units/hr for 15 minutes prior to starting the nitroglycerin drip has been recommended.[3] Combined, nitroglycerin and vasopressin will reduce portal and hepatic venous pressure while decreasing the inflow of blood coming to the liver.[3]

Utilizing a high PEEP (10 cm H_2O or greater) increases intra-thoracic pressure and has been known to result in an increased CVP.[5] During the case, a PEEP of 5 cm H_2O was utilized and the CVP was not found to have been impacted. Literature has suggested that the effect of reducing PEEP in the supine position on CVP was not significant.[6] However, studies have found a reduction in PEEP in combination with the reverse-Trendelenburg position has resulted in a significant decrease in CVP values.[6] A substantial change in CVP was only noted when a position change was added to a decrease in PEEP. While supported in the literature, due to a decrease in venous return, reverse-Trendelenburg may not be appropriate when applied specifically to hepatectomies.[6] Reverse-Trendelenburg was not utilized during this specific case and may be difficult to perform while still providing optimal surgical conditions for the surgeon.

Anesthetic management of this case was successful to minimize excessive blood loss and to prevent the need for blood transfusion, which leads to improved postoperative outcomes.[6] Using an anesthetic technique of fluid restriction and nitroglycerin administration until the desired portion of the liver is resected has been supported with research. The use of vasopressin intraoperatively, rather than norepinephrine, is also preferred and considered best practice based on current evidence.[3] Considering vasopressin for this case may have been a better option due to providing a decreased portal vein flow and pressure while preserving cardiac output and intestinal perfusion.[3] Overall, the patient was adequately optimized intraoperatively, blood loss was minimized, and the patient did not require a blood transfusion. Regarding this case, reverse-Trendelenburg could not have been considered in adjunct with a lower PEEP due to the surgeon's positioning preferences for optimal visualization of the liver.

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Clinical Decision Support for the Prevention of Postoperative Nausea and Vomiting

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Keywords: anesthesia information management system, clinical decision support, postoperative nausea and vomiting

Introduction

Electronic health information systems have transformed modern healthcare. The benefits of anesthesia information management systems (AIMS) utilized in the perioperative period include cost effectiveness, enhanced reimbursement, consistent documentation and improved patient safety.[1] Additionally, the information stored in AIMS data can be used for outcomes research to promote quality of care and evidence-based practice. Hypotheses related to medicines and interventions can be studied as they relate to real-time data across large populations. In turn, large data sets can be analyzed to improve the safety of perioperative care and anesthesia delivery.

A subset of AIMS research is specifically concerned with the improvement of clinical decision making. Defined as clinical decision support (CDS) systems, these electronic programs are adjuncts to clinical practice and serve as reminders for perioperative tasks. CDS programs are implemented to uphold patient safety, such as a reminder to measure blood pressure after a five-minute delay in recording, or to re-dose heparin during cardiopulmonary bypass surgery. A recent systematic review supported CDS programs for improved outcomes of timely administration of perioperative antibiotics and overall documentation completeness.[2] Within the anesthesia profession, CDS systems have been implemented in order to decrease postoperative nausea and vomiting (PONV).

PONV remains a leading cause of patient dissatisfaction after surgery and contributes to increased time spent in recovery rooms that is associated with increased hospital admissions and greater length of hospital stays. In essence, PONV translates into more hospital resource allocation and increased healthcare costs. Although rare, PONV can also lead to dire consequences such as aspiration pneumonitis, acute respiratory distress syndrome, and increased

morbidity and mortality. In order to reduce the incidence of PONV and its poor sequelae, there are well established clinical guidelines to identify those at risk thereby allowing the healthcare professional to administer the appropriate interventions.[3] Regrettably, PONV remains a persistent problem in clinical settings and this may be due to poor provider implementation of well-known prophylactic guidelines.[4] Recent research has studied the effects of CDS programs for improvements in PONV prophylaxis and the resultant incidence of PONV.

Methodology

Evidence-based Practice Model

The PICO (population, intervention, comparison, outcome) question developed for this review is as follows: "In adult patients requiring general anesthesia for elective non-cardiac surgery (P), does the use of electronic clinical decision support systems for PONV prophylaxis (I) result in decreased PONV (O) compared to protocols without decision support systems (C)?" The theoretical framework used to organize this review followed the PDSA (plan, do, study, act) model, as research findings will be used for quality improvement.

Search Models

Online research databases including CINAHL and PubMed were utilized to complete this literature review. Keywords used were anesthesia information management systems, clinical decision support, and postoperative nausea and vomiting. Filters included peer reviewed journals, full text, and English language. Articles were gathered based on relevance to the PICO question within the PDSA framework. Articles were excluded that were published prior to 2012. The final literature review involved 8 articles, including a systematic review, a comparative effectiveness study, three prospective cohort analyses, and three case-control trials. The data was organized and evaluated in a research synthesis matrix (see Table below).

Literature Analysis

Clinical Decision Support and PONV prophylaxis

A systematic review by Simpao et al. compiled literature from 2006 to 2015 pertaining to CDS in AIMS research.[2] A total of 25 articles were studied that pertained to the following CDS categories: perioperative antibiotics, PONV prophylaxis, vital sign monitors and alarms, glucose management, blood pressure management, ventilator management, documentation, and resource utilization. Simpao et al. noted strong evidence to support CDS systems for improvements in perioperative antibiotic administration and documentation.[2] However, the results called for more research pertaining to the remaining subjects of interest, including PONV. The lack of evidence was not due to a lack of quality of research design, but rather a lack of quantity of available research.[2] At the time of the review, PONV CDS research was limited to two research groups with positive patients results.

Effectiveness of Improving Clinical Outcomes

Gabel et al. performed a prospective comparative effectiveness study using a novel PONV pathway through an electronic CDS program, along with an educational initiative and personalized feedback, to decrease the incidence of PONV.[5] A total of 40,831 cases met the inclusion criteria of general anesthesia through the use of inhaled anesthetics, age over 12 years

old, and transfer to the post-anesthesia care unit (PACU). A propensity matching score was completed to match the PONV risk factors for the pre- and postintervention periods, which led to final equal cohorts of 18,398 patients. A care-as-usual period was defined as the control data for the year leading up the intervention. An educational initiative was completed during an 8-month interim time between the control and intervention periods. The incidence of PONV for both groups was defined as the administration of any of the following rescue antiemetics in the recovery period: ondansetron, promethazine, haloperidol, diphenhydramine, and metoclopramide. The PONV CDS pathway included a preoperative PONV risk score as well as an intraoperative real-time checklist for prophylactic interventions. During the CDS intervention, weekly personalized emails were sent to providers with PONV statistics pulled from AIMS data. The incidence of PONV decreased from 19.1% (95% confidence interval (CI): 17.9% - 20.2%) before the CDS intervention to 16.9% (95% CI: 15.2% - 18.5%, P = .007).[5] In the high-risk PONV population, the rates of PONV decreased from 29.3% (95% CI: 27.6% - 31.1%) before the CDS intervention to 23.5% (95% CI: 20.5% - 26.5%, P < .001), or a total drop of 5.8% (P < .001).[5] The use of automated feedback showed no significant difference in PONV incidence with little change in system compliance. Adherence to the CDS intervention before email feedback was 85.5% (95% CI: 83.8% - 87.1%) and remained 84.7% (95% CI: 81.0% - 86.9%) after email feedback was initiated .[5] Unlike other CDS research, Gabel et al. created a decision support program for PONV that was approved for use through a nationally recognized electronic health record. This promotes widespread integration and future research. Limitations of the study include a uniquely modified PONV risk scoring system, lack of randomization of the intervention, and a definition of PONV that is restricted to PACU recovery time.

Kappen et al. randomized the delivery of a PONV CDS to anesthesia professionals and found that those exposed to the CDS program delivered more antiemetics to high-risk patients and less antiemetics to low-risk patients.[6] The trial originally included 12,032 elective adult surgical patients who were treated by 79 anesthesiologists. Patients were excluded based on pregnancy, continued mechanical ventilation, or inability to communicate in Dutch or English. After randomization to the PONV CDS, anesthesiologists were excluded that treated less than 50 patients. This led to a final total of 11,613 patients (5,471 intervention, 6,142 control) and 57 anesthesiologists (31 intervention, 26 control). Ultimately, there were no significant differences in PONV incidence between the two groups (intervention 41% vs. care-as-usual 43%).[6] The CDS program automated risk stratification for PONV but did not provide further recommendations of appropriate prophylactic antiemetics. In a following study, Kappen et al. adjusted the CDS program to combine risk stratification with specific treatment recommendations for PONV prophylaxis.[7] After similar inclusion and exclusion criteria, the cohort study consisted of 1,483 elective surgical patients. A subsequent reduction in PONV was observed between the intervention and control groups (intervention 42% vs. care-as-usual 50%).[7] For both studies, PONV was measured over a 24-hour interval and included the administration of a rescue antiemetic, an episode of nausea on a 3-point verbal scale, or an episode of vomiting. The data was collected as 30-minute increments in the PACU and again at the 24-hour mark through visitation or phone call if discharged home. As compared to other studies, the broad definition may explain the larger PONV incidence overall. A limitation to this research is a lack of control for the variable PONV risk between the two groups. This leads to difficulty interpreting the primary outcome of PONV incidence. Next, although the CDS programs were randomized to the providers, there was no way to prevent the cohorts from interacting and likely

limiting true randomization. Even though the follow up study was able to improve PONV rates, the same site and practitioners were involved which may have prompted them to be more aware of PONV prophylaxis at the time. Finally, these studies used a unique AIMS database which limits its applicability to other care settings.

Kappen, et al. completed a third observational study to determine how the automated PONV stratification tool influenced practitioners' decision-making process.[4] The previous anesthesia professionals who were randomized to a novel PONV CDS program (N = 57) were surveyed and a randomized sub-selection of those individuals (N = 8) were interviewed. A total of 53 out of 57 (93%) anesthesia providers from the original trial completed the survey. Anesthesia professionals exposed to the CDS intervention had a more positive perception of PONV prophylaxis than the control group; however, this did not correlate with an increased administration of antiemetics during the cluster-randomized trial.[4] Interview themes were as follows: PONV is not a forefront issue, predicted PONV risk may not change an inherent decision about prophylactic administration, and there are various layers to determining antiemetic measures that cannot be replaced by an automated prediction model, which lacks ability to weigh risks and benefits.[4] A limitation to this study is the sample size and use of the same individuals, which may prevent the findings to be applied to other settings.

With a similar definition of PONV incidence over 24-hours, Kooij, et al. performed a prospective cohort study to decrease the incidence of PONV.[8] Adult patients undergoing elective non-cardiac surgery were included in the study. Exclusion criteria consisted of pregnancy, allergy to anti-emetic medications, and inability to communicate with the patient. The final cohort contained 2,662 patients (1,681 intervention and 981 control). The CDS program intervention consisted of a preoperative risk stratification for PONV and a subsequent reminder to administer prophylaxis intraoperatively. The overall incidence of PONV decreased between the control and intervention groups (27% to 23%, $P = 0.01$), with the greatest decrease for the high-risk population (47% to 30%, $P < .001$).[8] A secondary outcome defined as the amount of prophylactic antiemetics administered increased for the high-risk population and decreased for the low-risk population.[8] In order to further increase guideline adherence, a follow-up study by Kooij et al. requested for a reason for non-adherence at the time of CDS implementation.[9] By requesting a rationale, adherence rates to the CDS program increased.[9] Secondary outcomes related to the reasoning behind poor compliance can be useful for future quality improvement studies. A major limitation of these studies is related to the Hawthorne effect, such that previous studies of similar PONV prophylaxis were completed at the same site with the same practitioners. This could explain the overall low PONV incidence and high adherence rates due to increased awareness among study participants.

Gillmann, et al. performed a retrospective study to analyze adherence rates to PONV guidelines through AIMS data in which a CDS program was not utilized.[10] Cases included adult surgical patients who were followed in the PACU over the span of one year. A total of 5749 out of 10,604 (54%) patients received PONV prophylaxis correctly according to hospital protocol, and 27449 out of 10,604 (23%) of all patients were discharged from the PACU with insufficient PONV prophylaxis that did not comply with hospital guidelines.[10] The retrospective nature of this study limits its conclusions to associations of PONV risk factors that were not explicitly documented in the PACU.

Table. Summary of Literature regarding the use of CDS Programs for PONV Prophylaxis

Author Year	Level of Evidence	Population	Purpose	Findings	Limitations
Simpao, et al. 2016	Systemic Review, Level I	25 CDS research publications from 2006 to 2015	Examine recent CDS research and summarize clinical implementations	Strong evidence for CDS to improve antibiotic administration and documentation completeness	Limited quantity of PONV CDS research
Gabel, et al. 2019	Prospective Comparative Effectiveness Study, Level II	36,796 general anesthesia cases with PONV prophylaxis care as usual vs. electronic CDS	Determine the effectiveness of a new PONV pathway implemented through EPIC software	PONV decreased in CDS group (16.9%) when compared to the control group (19.1%) High-risk PONV population had the greatest reduction (5.8%) in PONV incidence	Narrow PONV definition restricted to recovery room time Lack of randomization Specialized PONV risk scoring system
Kappen, et al. 2014	Prospective Cluster-randomized Trial, Level II	11,613 general anesthesia cases randomized to PONV prophylaxis care as usual (N = 6,142) vs. electronic CDS (N = 5,471)	Evaluate PONV incidence and number of antiemetics administered between control and CDS groups	No significant difference in PONV incidence between control (43%) and intervention groups (41%). CDS group administered more antiemetics to the high-risk population and fewer antiemetics to the low-risk population.	Broad PONV definition over 24-hour period Unique AIMS database
Kappen, et al. 2015	Prospective Cohort Study, Level II	1,483 general anesthesia cases with PONV prophylaxis care as usual (N = 1022) vs. electronic CDS (N = 458)	Evaluate the effectiveness of a CDS program with specific risk-tailored antiemetic interventions	PONV incidence decreased in CDS group (42%) when compared to the control group (50%). Anesthesia practitioners administered more antiemetics per given	Lack of control for PONV variables Potential Hawthorne effect

				risk-factor in the intervention group as compared to the control group.	
Kappen, et al. 2016	Case-Control Observational Study, Level III	Survey of 57 anesthesia practitioners involved in previous study; Randomized sub-selection of cohort (N = 8) chosen for interviews	Understand clinician perception of PONV prophylaxis and a PONV risk-tailored CDS program	CDS group providers had an improved perception of PONV prophylaxis as compared to the control group. Poor CDS perception may relate to provider attitude towards PONV	Small sample size Limited audience
Kooij, et al. 2012	Prospective Cohort Study, Level II	2,662 general anesthesia cases with PONV prophylaxis care as usual (N = 981) vs. electronic CDS (N = 1,681)	Evaluate the effectiveness of an automated reminder of PONV prophylaxis for high-risk patients	PONV incidence for high-risk patients decreased in CDS group (30%) when compared to the control group (47%)	Individualized AIMS database Unique PONV definition
Kooij, et al. 2017	Case-Control Observational Study, Level III	Historical control group from previous study (N = 2594) vs. intervention group in preoperative setting (N = 27,332) and OR/PACU (N = 11,270)	Determine CDS ability to improve clinician compliance to PONV prophylaxis guidelines	Guideline adherence increased in the CDS group for prescribing (89%) and administering PONV prophylaxis (90%) when compared to the control group (82%).	Potential Hawthorne effect
Gillmann, et al. 2017	Retrospective Case-Control Study, Level III	10,604 general anesthesia cases recovered in the PACU with valid AIMS data from 2013 - 2014	Investigate adherence rates to PONV prophylaxis guidelines	Only 54% of cases received PONV prophylaxis per protocol and 23% of cases were discharged with inadequate antiemetics	Lower level of evidence

Conclusion

AIMS systems provide abundant data that can be used for improvements in quality of care. CDS tools provide a way to implement best practices and enhance patient outcomes. In terms of PONV CDS programs, research is limited due to difficulty in design, lack of randomization, trouble defining complex phenomenon for study comparisons, and unknown variables that may influence provider behavior. Existing PONV CDS research is limited to single-center trials with unique AIMS databases. Even with positive patient outcomes, these results are limited to the involved study group. Recently, Gabel, et al. studied a PONV CDS program through a nationally recognized electronic database which may pave the way for future research.[5]

Unfortunately, poor clinical application of PONV prophylaxis remains a large barrier to improved patient experiences, increased patient safety, and decreased healthcare costs. Even when CDS tools are utilized, full implementation by providers is not always maintained. PONV must be viewed as a critical part of patient care that can lead to poor patient outcomes. This sentiment is not routinely shared by all anesthesia professionals who view PONV as merely a side effect of more life-saving measures. This attitude may affect compliance with PONV prophylaxis overall. More research is needed to prove the utility of PONV CDS prevention tools in order to improve compliance with well-known prophylactic measures.

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Mentor: Imke Casey, DNP, CRNA, RN-BC, RHIT

Editorial

I'm pleased to present another large issue with an interesting variety of case reports representing submissions from over a dozen different nurse anesthesia programs for your review! I often receive inquiries about the rate of publication for the ISJNA – I will address that question and provide some additional interesting information about the student journal. Our mission is to encourage and support nurse anesthesia student publication. We accept a variety of submission types covering basic to complex topics. Over the past 10 years, we have averaged 100 submissions per year and a publication rate of about 53%. Our publication rate for 2019 submissions was approximately 60%. We received our highest number of submissions this past year at 126 – so far 50 have been published, and I expect that number to increase. Over 800 student-authored items have been published in the ISJNA since its inception. The ISJNA functions solely by CRNA volunteer support, for which I am eternally grateful. Without this generous support of time and talent, the student journal would not exist!

Sincerely,

Vicki Callan, PhD, CRNA, CHSE
Editor

"***The International Student Journal of Nurse Anesthesia*** **is produced exclusively for publishing the work of nurse anesthesia students. It is intended to be basic and introductory in its content. Its goal is to introduce the student to the world of writing for publication; to improve the practice of nurse anesthesia and the safety of the patients entrusted to our care.**"

INTERNATIONAL STUDENT JOURNAL OF NURSE ANESTHESIA
GUIDE FOR AUTHORS

MISSION STATEMENT

The International Student Journal of Nurse Anesthesia (ISJNA) is produced exclusively for publishing the work of nurse anesthesia students. It is intended to be basic and introductory in its content. Its goal is to introduce the student to the world of writing for publication; to improve the practice of nurse anesthesia and the safety of the patients entrusted to our care.

ITEM PREPARATION & SUBMISSION

Case reports, research abstracts, evidence-based practice (EBP) analysis reports, evidence-based practice project abstracts, and letters to the editor may be submitted. These items must be authored by a student under the guidance of an anesthesia practitioner mentor (CRNA or physician). Case reports must be single-authored, while EBP analysis reports and abstracts may have multiple authors. Submissions may list only one mentor. **Mentors should take an active role** in reviewing the item to ensure appropriate content, writing style, and format prior to submission. The mentor must submit the item for the student and serve as the contact person during the review process. Items submitted to this journal should not be under consideration with another journal. Authors and mentors should critically evaluate the topic and quality of the writing – multiple reviews of the item by the mentor, faculty, and peers (fellow graduate students) prior to submission is recommended. If the topic and written presentation are beyond the introductory publication level we strongly suggest that the article be submitted to a more prestigious publication such as the *AANA Journal*.

The journal is committed to publishing the work of nurse anesthesia students. The review process is always initiated with the following rare exceptions. We are conservative in accepting reports where the patient has expired, realizing that you can do everything right and still have a negative outcome. Submissions that report a case demonstrating failure to meet the standard of care (by any practitioner involved in the case) will not be accepted. Unfortunately, while the experiences in these cases can offer valuable insight, these submissions will not be accepted for review due to potential legal risks to the author, journal, and anyone else involved in evaluating the report.

It is the intent of this journal to publish items while the author is still a student. In order to consistently meet this goal, all submissions must be received by the editor at least **3 months prior** (4-6 months recommended) to the author's date of graduation. Manuscripts must be submitted by the mentor of the student author via e-mail to **INTSJNA@aol.com** as an attachment. The subject line of the e-mail should use the following format: ISJNA Submission_submission type_author last name_mentor last name. The item should be saved in the following format – two-three word descriptor of the article_author's last name_school abbreviation_mentor's last name_date (e.g. PedsPain_Smyth_GU_Pearson_5.19.09)

REVIEW PROCESS

Items submitted for publication are initially reviewed by the chief editor. If the chief editor does not acknowledge receipt of the item within two weeks, please inquire to ensure receipt. Upon receipt, the chief editor will review the submission for compliance with the Guide to Authors. If proper format has not been followed, the item will be returned to the mentor for correction. This is very important as all reviewers serve on a volunteer basis. Their time should be spent ensuring appropriate content, not making format corrections. It is the mentor and author's responsibility to ensure formatting guidelines have been followed prior to submission.

All accepted submissions undergo a formal process of blind review by at least two reviewers. After review, items may be accepted without revision, accepted with revision, or rejected with comments. Once the item has been accepted for review the chief editor will assign a submission number and send a blinded copy to an editor, who will then coordinate a blinded review by two reviewers who are not affiliated with the originating program. Submissions are reviewed using the Track Changes function of Word. The editor will return the item to the chief editor, who will return it to the mentor for appropriate action. **The mentor should guide the author through the revision process. The revised copy must be returned clean (no comments or Track Changes) with the original submission number in the filename and subject line of the email.** Every effort is made to complete the process in an efficient, timely matter. Again, the goal is for all articles submitted by students to be published while the author is still a student. If an item is not ready for publication within 6 months after the student author has graduated it will no longer be eligible for publication. Mentors will be listed as contributing editors for the issue in which the item is published.

PHOTOS

Photos of students for the front cover of the Journal are welcome. Please contact the chief editor at intsjna@aol.com to submit photos for consideration. Only digital photos of high quality will be accepted. If the photo is accepted,

consent forms must be completed and returned by all identifiable individuals in the photo, and the individual who took the photo.

ACADEMIC INTEGRITY

Issues of academic integrity are the responsibility of the author and mentor. Accurate and appropriate acknowledgement of sources is expected. The two most common breaches of academic integrity that have been identified in submissions to this journal are (AMA 11th ed., 5.4.2):

1. Direct plagiarism: verbatim lifting of passages without enclosing the borrowed material in quotation marks and crediting the original author.
2. Paraphrase: restating a phrase or passage, providing the same meaning but in a different form without attribution to the original author.

Please note that changing one or two words in a reference source passage (e.g. 'of' for 'in', or 'classified' for 'categorized') and then citing it as a paraphrase or summary is also not appropriate, and still falls within the definition of direct plagiarism. If plagiarism in any form is identified, review of the item will be suspended and it will be returned to the mentor. Repeated instances of plagiarism will result in rejection of the item.

Plagiarism detection software (Scribbr, TurnItIn, PlagScan, SafeAssign, etc . . .) can be used to analyze the document prior to submission to ensure proper citation and referencing, but is not required.

"Plagiarism is the presentation of someone else's ideas, writings, or statements as one's own. Plagiarism is a serious breach of academic integrity, and anyone who is found to have committed plagiarism will be subject to disciplinary action.

Paraphrase is the act of putting someone else's ideas into one's own words. The use of paraphrase can be an acceptable practice under some circumstances if it is used sparingly and if the original text is properly acknowledged. Unacknowledged paraphrase, like plagiarism, is a serious breach of academic integrity. Any improper use of sources may constitute plagiarism. Every quotation from another source, whether written, spoken, or electronic, must be bound by quotation marks and be properly cited. Mere citation alone is not sufficient when a scholar has used another person's words. Similarly, every paraphrase or summary (a more concise restatement of another's ideas) must be properly cited."

https://sites.google.com/a/georgetown.edu/gsas-graduate-bulletin/vi-academic-integrity-policies-procedures

GENERAL GUIDELINES

Items for publication **must adhere to the *American Medical Association Manual of Style*** (AMA 11th ed., the same guide utilized by the *AANA Journal* and such prominent textbooks as *Nurse Anesthesia* by Nagelhout and Elisha). Section numbers from the online version are provided for easy reference in the AMA Manual of Style throughout this document. The review process will not be initiated on items submitted with incorrect formatting and will be returned to the mentor for revision.

Reference: Christiansen S, Iverson C, Flanagin A, et al. *AMA Manual of Style: A Guide for Authors and Editors.* 11th ed. Oxford University Press; 2020.

Please note the following:

1. Use complete sentences.
2. Acronyms/Initialisms (2.1.5, 10.6, 13.9) - spell out with first use, do not capitalize the words from which the acronym/initialism is derived unless it is a proper noun or official name. If you are using the phrase only once, do not list the acronym/initialism at all. Avoid beginning sentences with acronym/initialisms.
3. Abbreviations (13.0)
4. Use *Index Medicus* journal title abbreviations (3.11.2, http://www.ncbi.nlm.nih.gov/nlmcatalog/journals)
5. Always provide units of measure (17.0). In most cases The International System of Units (SI) is used. Abbreviations for units of measure do not need to be spelled out with first use. Report height in cm, weight in kg, temperature in °C, pressure in mm Hg or cm H_2O. Report heart and respiratory rate as X/min (e.g. the patient's heart rate increased to 145/min). The manual includes a complete list of SI units (17.1 – 17.5).
6. In general, first use of pulmonary/respiratory abbreviations should be expanded, with the following exceptions: O_2, CO_2, PCO_2, $PaCO_2$, PO_2, PaO_2, $EtCO_2$, N_2O. Please use SpO_2 for oxygen saturation as measured by pulse oximetry.
7. Use the nonproprietary (generic) name of drugs (2.1.3, 10.3.5) - avoid proprietary (brand) names. Type generic names in lowercase. When discussing dosages state the name of the drug, *then* the dosage (midazolam 2 mg).
8. Use of descriptive terms for equipment and devices is preferred. If the use of a proprietary name is necessary (for clarity, or if more than one type is being discussed), give the name followed by the manufacturer in parenthesis (e.g. a GlideScope (Verathon Inc.) was used) (14.5.1). Please note, TM and ® symbols are not used per the AMA manual.

9. Infusion rates and gas flow rates:
    a. Use mcg/kg/min or mg/kg/min for infusion rates. In some cases it may be appropriate to report dose or quantity/hr (i.e. insulin, hyperalimentation). If a mixture of drugs is being infused give the concentration of each drug and report the infusion rate in mL/min.
    b. Report gas flow of O_2, N_2O and Air in L/min (not %) and volatile agents in % as inspired or expired concentration (e.g. General anesthesia was maintained with sevoflurane 3% inspired concentration in a mixture of O_2 1 L/min and air 1 L/min.)
10. Only Microsoft Word file formats will be accepted with the following criteria:
    a. Font - 12 point, Times New Roman
    b. Single-spacing (except where indicated), paragraphs separated with a double space (do not indent)
    c. One-inch margins
    d. End the sentence with the period before placing the superscript number for the reference.
    e. Do not use columns, bolds (except where indicated), or unconventional lettering styles or fonts.
    f. Do not use endnote/footnote formats.
11. If referencing software is used (Endnote, Zotero, etc.), any embedded <u>formatting must be removed</u> prior to submission.
12. Remove all hyperlinks within the text.
13. Avoid jargon and slang terms. Use professional, scholarly, scientific language.
    a. *'The patient was reversed'* - Did you physically turn the patient around and point him in the opposite direction? "Neuromuscular blockade was antagonized."
    b. *The patient was put on oxygen.* "Oxygen 2 L/min was administered via face mask."
    c. *The <u>patient</u> was intubated and put on a ventilator*. "The trachea was intubated and mechanical ventilation was initiated.
    d. *An IV drip was started.* "An intravenous infusion was initiated."
    e. Avoid the term "MAC" when referring to a sedation technique - the term sedation (light, moderate, heavy, unconscious) may be used. Since all anesthesia administration is monitored, pharmacologic, rather than reimbursement, terminology should be used.
14. Direct quotes are discouraged for reports of this length – please express in your own words.
15. Use the words "anesthesia professionals" or "anesthesia practitioners" when discussing all persons who administer anesthesia (avoid the reimbursement term "anesthesia providers").
16. Do not include ASA Physical Status unless it is germane to the report.
17. Do not use the phrase "ASA standard monitors were applied". Instead, "standard noninvasive monitors" is acceptable – additional monitoring can be detailed as needed.
18. References
    a. The **<u>AMA Manual of Style must be adhered to</u>** for reference formatting.
    b. All sources should be published within the past 8 years. Seminal works essential to the topic being presented will be considered.
    c. Primary sources are preferred.
    d. **A maximum of one textbook (must be most recent edition available) may be used as reference for case report submissions only**.
    e. All items cited must be from peer-reviewed sources – use of sources found on the internet must be carefully considered in this regard. URLs must be current and take the reader directly to the referenced source.

<u>Heading</u> – for all submission types (Case Report, Abstract, EBPA Report) use the following format.

1. **Title** is bolded, centered, 70 characters (including spaces) or less
2. Author name (academic credentials only) and NAP are centered, normal font
3. *Graduation date and email address* are centered, italicized, and will be removed prior to publication)
4. **Keywords** is left-justified, bolded – list keywords that can be used to identify the report in an internet search

Title
Author Name
Name of Nurse Anesthesia Program
Anticipated date of graduation
E-mail address

Keywords: keyword one, keyword two, etc.

Case Reports - The student author must have had a significant role in the conduct of the case. The total word count should be between 1200 – 1400 words (references not counted). Case reports with greater than 1400 words will be returned to the mentor for revision prior to initiation of the review process. The following template demonstrates the required format for case report submission.

Heading (see above)

A brief introductory paragraph of less than 100 words to focus the reader's attention and interest them to continue reading. This may include historical background, demographics or epidemiology (with appropriate references) of the problem about to be discussed. It is written in the *present tense*. Although it is introductory, the heading word '***Introduction'*** is not used. Be certain to cite references in this section, especially statistics and demographics pertaining to your topic.

Case Report (400-600 words)

This portion discusses the case performed and is written in the *past tense*. Do not justify actions or behaviors in this section; simply report the events as they unfolded. Present the case in an orderly sequence. Some aspects need considerable elaboration and others only a cursory mention. Under most circumstances if findings/actions are normal or not contributory to the case then they should not be described. Events significant to the focus of the report should be discussed in greater detail. The purpose of the case report is to set the stage (and 'hook' the reader) for the heart of your paper which is the discussion and teaching/learning derived from the case.

- Give dosage and schedule only if that information is pertinent to the consequences of the case.
- **Significant** laboratory values, x-rays or other diagnostic testing pertinent to the case. Give the units of measure after the values (eg. Mmol/L or mg/dL).
- Physical examination/pre-anesthesia evaluation - **significant** findings only.
- Anesthetic management (patient preparation, induction, maintenance, emergence, post-operative recovery).

Discussion (600-800 words)

Describe the ***anesthesia*** implications of the focus of the case report citing current literature. Describe the rationale for your actions and risk/benefits of any options you may have had. This section is not merely a pathophysiology review that can be found in textbooks. *Relate the anesthesia literature with the conduct of your case noting how and why your case was the same or different from what is known in the literature.* Photographs are discouraged unless they are essential to the article. Photos with identifiable persons must have a signed consent by the person photographed forwarded to the editor via first class mail. Diagrams must have permission from original author. This is the most important part of the article. In terms of space and word count this should be longer than the case presentation. End the discussion with a summary lesson you learned from the case, perhaps what you would do differently if you had it to do over again.

References

A minimum of 5 references is recommended, with a maximum of 8 allowed. One textbook may be used as a reference – it must be the most recent edition. All references should be no older than 8 years, except for seminal works essential to the topic. This is also an exercise in searching for and evaluating current literature.

Mentor: mentor name, credentials

E-mail address: *(*will be removed prior to publication)

EBP Analysis Reports - Evidence-based practice analysis reports are limited to 3000 words. Please do not include an abstract. The report should provide a critical evaluation of a practice pattern in the form of a clinical question about a specific intervention, population, and outcome. The manuscript should:

1. Articulate the practice issue and generate a concise question for evidence-based analysis. A focused foreground question following either the PICO or SPICE format should be used.
2. Describe the methods of inquiry used in compiling the data.
3. Critically analyze the quality of research reviewed and applicability to different practice settings.
4. Draw logical conclusions regarding appropriate translation of research into practice.

The same general format guidelines apply with the exception of the section headings as below. Textbooks and non-peer reviewed internet sources may not be used, and sources of reference should be less than 8 years old unless they are seminal works specifically related to your topic of inquiry. A maximum of 16 references is allowed.

Heading

Introduction (bold)

Briefly introduce the reader to the practice issue or controversy, describe the scope or significance or problem, and identify the purpose of your analysis. Describe the theoretical, conceptual, or scientific framework that supports your inquiry.

Methods (bold)

Include the format used for formulating the specific question you seek to answer, search terms and methods used, and levels of evidence.

Literature Analysis (bold)
Analyze and critique the literature relevant to your question, determining scientific credibility and limitations of studies reviewed. Your synthesis table is included in this section. Please follow AMA formatting guidelines for your table (4.1.2, 10.2.3). Your review and discussion of the literature should logically lead to support a practice recommendation. Subheadings may be used if desired.
Conclusions (bold)
Summarize the salient points that support the practice recommendation and make research-supported recommendations that should improve the practice issue, while also acknowledging any limitations or weaknesses
[space]
References (bold, 16 maximum)
Mentor: (bold, followed by mentor name and credentials in normal text)
E-mail address: (normal text, will be removed prior to publication)
Evidence Based Practice Project Abstracts - Evidence-based practice project abstracts are limited to 600 words. References do not impact the word count - a maximum of 5 are allowed. Note that the abstract is different from a project proposal. The following format should be used:

Heading

Introduction (bold)
A brief introductory paragraph including purpose (what change is intended) and rationale (why change is needed/evidence to support the change) here.
Design and Methods (bold)
Include population, intervention, and measures
Outcome (bold)
Present results from statistical analysis – do not justify or discuss here.
Conclusion (bold)
Discuss results (implications). Optionally include limitations, suggestions for future projects/research.
References (bold, 5 maximum)
Mentor: (bold, followed by mentor name and credentials in normal text)
E-mail address: (normal text, will be removed prior to publication)
Research Abstracts - Research abstracts are limited to 600 words. References do not impact the word count - a maximum of 5 are allowed. Note that the abstract is different from a research proposal. The following format should be used:

Heading

Introduction (bold)
A brief introductory paragraph including purpose and hypotheses.
Methods (bold)
Include sample and research design
Results (bold)
Present results from statistical analysis – do not justify or discuss here.
Discussion (bold)
Discuss results (implications, limitations, suggestions for future research)
References (bold, 5 maximum)
Mentor: (bold, followed by mentor name and credentials in normal text)
E-mail address: (normal text, will be removed prior to publication)
Letters to the Editor - Students may write letters to the editor topics of interest to other students. Topics may include comments on previously published articles in this journal. Personally offensive, degrading or insulting letters will not be accepted. Suggested alternative approaches to anesthesia management and constructive criticisms are welcome. The length of the letters should not exceed 100 words and must identify the student author and anesthesia program.
AMA MANUAL OF STYLE
The following is brief introduction to the *AMA Manual of Style* reference format along with some links to basic, helpful guides on the internet. The website for the text is http://www.amamanualofstyle.com/oso/public/index.html. It is likely your institution's library has a copy on reserve.

Journal names should be in italics and abbreviated according to the listing in the PubMed Journals Database. PubMed can also be used to perform a search: http://www.ncbi.nlm.nih.gov/pubmed
The International Student Journal of Nurse Anesthesia (ISJNA) is not listed in the PubMed Database. For the purpose of citing the ISJNA *in this Journal* use "**Int Student J Nurse Anesth**" as the abbreviation.
Journals (3.11) - A comma is placed after the first initials until the last author, which has a period. If there are six or less authors **cite all six**. If there are more than six authors **cite only the first three** followed by "et al." Only the first word of the title of the article is capitalized. The first letters of the major words of the journal title are capitalized. There is no space between the year, volume number, issue number, and page numbers. If there is no volume or issue number, use the month. If there is an issue number but no volume number use only the issue number (in parentheses). Page numbers are inclusive - **do not omit digits** (note - some online journals do not use page numbers). Some journals may be available both as hard copies and online. When referencing a journal that has been accessed online, the DOI (digital object identifier) or PMID (PubMed identification number, 3.15.2) should be included (see examples below).

Journal, 6 or fewer authors:
Han B, Liu Y, Zhang X, Wang J. Three-dimensional printing as an aid to airway evaluation after tracheotomy in a patient with laryngeal carcinoma. *BMC Anesthesiol*. 2016;16(6). doi:10.1186/s12871-015-0170-1
Journal, more than 6 authors:
Chen C, Nguyen MD, Bar-Meir E, et al. Effects of vasopressor administration on the outcomes of microsurgical breast reconstruction. *Ann Plast Surg*. 2010;65(1):28-31. PMID: 20548236
Elayi CS, Biasse L, Bai R, et al. Administration of isoproterenol and adenosine to guide supplemental ablation after pulmonary vein antrum isolation. *J Cardiovasc Electrophysiol*. 2013;24(11):1199-1206. doi: 10.1111/jce.12252
Electronic references (3.15) - Only established, peer-reviewed sources may be referenced. Please do not reference brochures, fact sheets, or informational websites where a peer-review process cannot be confirmed. The accessed date may be the only date available. The URL must be functional and take the reader directly to the source of the information cited.
Author (or if no author, the name of the organization responsible for the site). Title. *Name of Website*. Year;vol(issue no.):inclusive pages. Published [date]. Updated [date]. Accessed [date]. URL (with no period following).
Examples:
Kamangar N, McDonnell MS. Pulmonary embolism. *eMedicine*. Updated August 25, 2009. Accessed September 9, 2009. http://www.emedicine.com/med/topic1958.htm
Howlader N, Noone AM, Krapcho M, Garshell J, Miller D, et al. SEER Cancer statistics review, 1975-2012. National Cancer Institute. Published April 2015. Updated November 18, 2015. Accessed February 29, 2016. http://seer.cancer.gov/csr/1975_2012
Textbooks (3.12) - There are two types of books – 1) those that are fully authored by one or more individuals, and 2) those that are edited by one or more individuals, with chapters authored by different individuals. Edited textbooks give primary credit to the chapter authors, who are listed first, and the inclusive page numbers of the entire chapter are provided at the end. Textbooks that are authored do not have different chapter authors and the chapter titles are not listed, but the inclusive page numbers where the information was found are provided, unless the entire book is cited.
Authored text:
Shubert D, Leyba J, Niemann S. *Chemistry and Physics for Nurse Anesthesia*. 3rd ed. Springer; 2017:405-430.
Chapter from an edited text (3.12.4)**:**
Pellegrini JE. Regional anesthesia. In Nagelhout JJ, Elisha S, eds. *Nurse Anesthesia*. 6th ed. Elsevier; 2017:1015-1041.

SUBMISSION CHECK LIST

Adheres to AMA Manual of Style and all other format instructions

___ Total word count not exceeded (1400 for case report, 600 for abstracts, 3000 for EBPA report)
___ The item is one continuous Word document without artificially created page breaks
___ All matters that are not common knowledge to the author are referenced appropriately
___ Generic names for drugs and products are used throughout and spelled correctly in lower-case
___ Units are designated for all dosages, physical findings, and laboratory results
___ Endnotes, footnotes not used
___ Jargon/slang is absent

Heading

___ Concise title less than 70 characters long (including spaces)
___ Author name, credentials, nurse anesthesia program, graduation date and email are included
___ Three to five **Keywords** are provided

Case Report

___ Introduction is less than 100 words.
___ Case Report section states only those facts vital to the account (no opinions or rationale)
___ Case report section is 400-600 words and not longer than the discussion
___ Discussion section is 600-800 words
___ Discussion of the case management is based on a review of current literature
___ Discussion concludes with lessons learned and how the case might be better managed in the future

Abstracts

___ The 600 word count maximum is not exceeded
___ Appropriate format used depending on type of abstract (research vs. EBP project)

EBPA Report

___ The 3000 word count maximum is not exceeded
___ A critical evaluation of a practice pattern in the form of a precise clinical question about a specific intervention, population, and outcome is presented
___ A focused foreground question following either the PICO or SPICE format is used
___ Includes Introduction, Methodology, Literature Analysis (with synthesis table), and Conclusion sections

References

___ Adheres to AMA Style format
___ Reference numbers are sequenced beginning with 1 and superscripted
___ References are from anesthesia and other current (within past 8 years) primary source literature
___ Journal titles are abbreviated as they appear in the PubMed Journals Database
___ Number of references adheres to specific item guidelines (1 textbook allowed for case reports only)
___ Internet sources are currently accessible, reputable, and peer reviewed

Transmission

___ The article is sent as a Word document attachment to **INTSJNA@AOL.COM**
___ The file name is correctly formatted (e.g. PedsPain_Smyth_GU_Pearson_5.19.09)
___ Item is submitted by the mentor
___ Subject heading format - ISJNA Submission_submission type_author last name_mentor last name