20th Anniversary Issue

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The International Student Journal of Nurse Anesthesia

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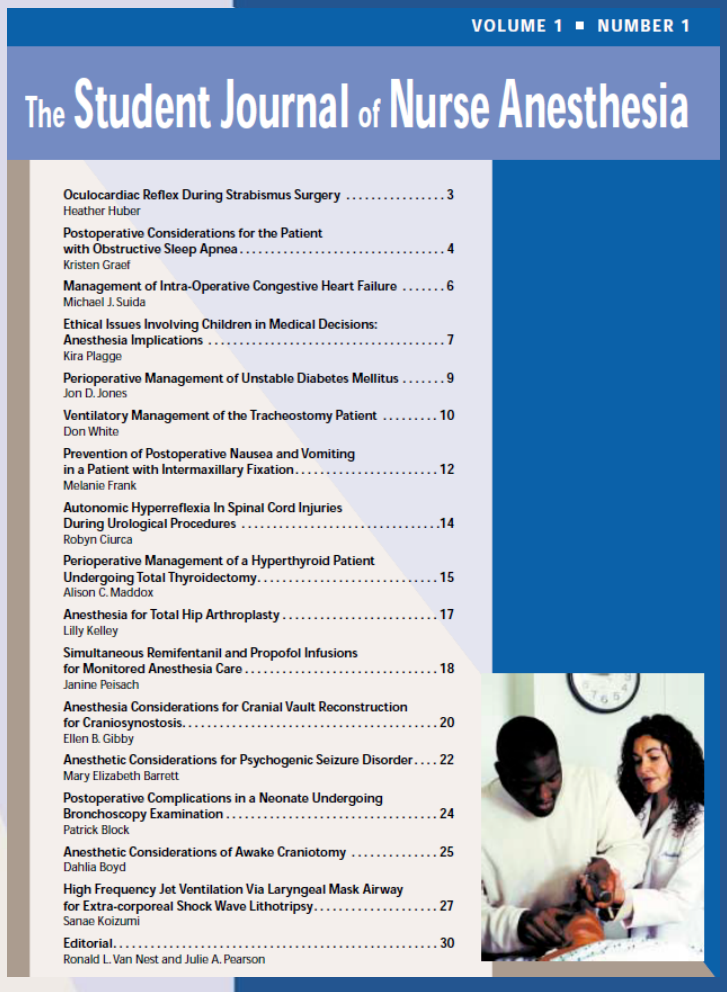
Celebrating 20 years of Student-Authored Publications

Special guest editorial by founding Editor
Ronald Van Nest, JD, CRNA, CAPT, NC, USN(Ret)



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Front Cover:
In celebration of the 20th year of the International Student Journal of Nurse Anesthesia, this cover includes images of the founding editorial board and the first issue of the student journal.

Founding Editorial Board, Georgetown University Nurse Anesthesia Program faculty
Pictured from left to right:
1st row – Ronald Van Nest, founding Editor in Chief
2nd row – Tracy Coverdale, Leah Haskvitz
3rd row – Donna Jasinksi, Ladan Eshkevari, Elizabeth Koop, Julie Pearson

First issue – Spring 2002;1(1)
Pictured from left to right:
Robert [last name unknown], Ladan Eshkevari

*The **opinions** contained in this journal are those of the authors and do not necessarily represent the opinions of the program or the University.*

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Case Reports

Video Assisted Thoracoscopy and Chronic Obstructive Pulmonary Disease

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Keywords: pulmonary, cancer, lung, COPD, thoracoscopy

Patients with chronic obstructive pulmonary disease (COPD) can test the skills of anesthesia practitioners. Patients with this disease exhibit airflow limitations caused by inflammation and scarring. The destruction of the lung parenchyma decreases the area available for gas exchange. Hypoxemia, hypercapnia, and hyperinflation are the result.[1] After surgery, they are at an increased risk of reintubation, pneumonia, increased length of hospital stay, and mortality.[1] Many patients with lung disease have comorbidities that further complicate the anesthetic plan.

Case Report

A 73-year-old male with lung cancer presented for a robotic right lung resection after positron emission tomography revealed an 18 mm right upper lobe pulmonary nodule. On the day of surgery, the patient weighed 73 kg and had a height of 182 cm. He reported an allergy to levofloxacin. He had a history of COPD, a 30 pack-year smoking history, severe emphysema, coronary artery disease (CAD) with stents in 2007, obstructive sleep apnea, depression, hypertension (HTN), gastroesophageal reflux disease, and lung cancer. He had an ejection fraction of 30-35% by echocardiogram. Of note, his pulmonary function tests (PFTs) revealed a forced expiratory volume 1 (FEV1) that was 29% of the predicted volume. His diffusion capacity was 31% of predicted. The patient reported shortness of breath when ambulating.

His daily medications included albuterol sulfate 2 puffs four times a day, carvedilol, lisinopril and hydrochlorothiazide combination pill, and trelegy ellipta powder for inhalation once per day. Pre-procedural vital signs included a blood pressure (BP) of 131/57 mm Hg, heart rate (HR) of 62/min, respiratory rate (RR) of 12/min, and an SpO_2 of 99% on room air. The patient was not a candidate for a lobectomy due to his poor PFTs.

In the operating room, the patient was placed on standard noninvasive monitors and preoxygenated with O_2 10 L/min via the facemask from the anesthesia circuit. At induction of anesthesia, the patient was given propofol 200 mg, fentanyl 100 mcg, and rocuronium 50 mg intravenously. The trachea was intubated with a left sided 39 French double lumen endotracheal tube. General anesthesia was maintained with sevoflurane 2% inspired concentration in a mixture of O_2 at 2 L/min. The ventilator was set with a RR 15/min and tidal volume of 500 mL. Flexible fiberoptic bronchoscopy was utilized to confirm placement. An arterial line was placed in the patient's left radial artery for continuous BP monitoring. The patient was positioned in left lateral decubitus. The tracheal lumen was clamped for one lung ventilation. The patient's respiratory rate was increased to 20 breathes per minute and the tidal volume was reduced to 400 mL. The Da Vinci robot was utilized with a 4 arm technique. Diagnostic right thoracoscopy confirmed right lung isolation and revealed black tarry lungs with the patient's visceral pleura completely fused to the parietal pleura.

An extensive lysis of adhesions was performed by the surgical team. Once the visceral and parietal pleura were separated, a hilar lymphadenectomy was attempted. During this time, the patient became hemodynamically unstable. His HR decreased to 46/min, BP increased to 198/124 mm Hg, and $EtCO_2$ increased to 68 mm Hg. Nitroglycerin 40 mcg was administered intravenously, and the sevoflurane was increased to 3% inspired concentration. The patient was ventilated manually with a respiratory rate of approximately 30/min and tidal volumes of 300-400 mL to reduce the patient's $EtCO_2$. The patient's hemodynamic instability resolved only on resumption of double lung ventilation and a return of his $EtCO_2$ to 40 mm Hg. Due to the patient's unstable operative course and inability to tolerate one lung ventilation, the surgeon revised the original approach and performed a simple apical segmentectomy, which was accomplished without incident. After the procedure, the patient was extubated and taken to the recovery room in stable condition. In the recovery area, the patient's vital signs approximated his pre-procedure values.

Discussion

Patients with COPD and emphysema typically have additional comorbidities that must be managed carefully in the operating room, adding to their complexity. Cardiovascular disease is particularly common in patients with COPD.[2] In fact, the severity of the airflow obstruction has been correlated with an increased risk of cardiovascular disease.[2] The patient discussed had HTN, CAD, and a reduced ejection fraction in addition to his lung disease. This made his episode of bradycardia and hypertension particularly dangerous for him. When the patient became hypertensive in the operating room, the elevation in BP caused a precipitous decrease in HR. This was likely due to the baroreceptor reflex. Arterial baroreceptors in the walls of the carotid sinus and myocardium are activated by vascular stretch.[3] Epithelial sodium channels generate action potentials that propagate to the glossopharyngeal and vagus nerves.[3] The afferent pathway of this reflex terminates in the nucleus tractus solitarius, where it is processed and sent to the caudal ventrolateral medulla (CVLM).[3] The CVLM inhibits sympathetic outflow, attenuating acute hypertension by reducing the HR and vascular tone.[3]

Given the patient's tenuous cardiovascular state, it was imperative to treat the hypertension promptly. The patient's $PaCO_2$, estimated to be above 70 mm Hg based on his $EtCO2$[4], reduced the effectiveness of the pharmacologic interventions administered.[5] In addition to reducing the efficacy of vasoactive drugs, acidosis decreases contractility at a pH of 7.2 or below. The heart's sensitivity to catecholamines is reduced.[6] The patient was ventilated on manual mode at a rate of approximately 30 respirations per minute and tidal volumes of 300-400 mL to reduce the $ETCO_2$. He was also taken off one lung ventilation to facilitate the removal of CO_2. The patient was treated with nitroglycerin to rapidly lower his BP to a safe mean arterial pressure (MAP) rage of 80-85 mm Hg.

The patient's low FEV1 was likely a major contributing factor to his inability to tolerate one lung ventilation. His FEV1 gives him a Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD) score of 4, the most severe category.[7] General anesthesia and endotracheal intubation is associated with higher morbidity in these patients, but for this procedure there was no alternative.[8] Depression of ventilation under anesthesia in patients with severe COPD is profound.[8]

Preoperative administration of albuterol sulfate via inhalation may have allowed the patient to tolerate one lung ventilation for a longer period of time.[1] The albuterol could have been administered again before extubation. This patient could have benefitted from continuous positive airway pressure (CPAP) during the pre-oxygenation phase of induction to reduce atelectasis. This may have attenuated the rapid rise in $EtCO_2$. The patient may have been able to tolerate one lung ventilation with use of smaller tidal volumes, higher respiratory rates, and prolonged expiratory time. In noting the pathophysiology of hyper-inflated lungs and direct pressure on the heart that occurs with COPD, any elevation of intrathoracic pressure results in decreased systemic venous return thus elevating pulmonary vascular resistance (PVR). As PVR is likely already increased in COPD leading to right heart strain, this can exacerbate right heart strain and cause the intraventricular septum to become displaced. This limits left ventricular filling and decreases cardiac output. In consideration of the patient's ejection fraction of 30-35% by echocardiogram, limiting his cardiac output further was of high concern.[8] Allowing more time for exhalation reduces breath stacking and positive end expiratory pressure.[8]

Management of patients with severe disease of multiple organ systems under general anesthesia is very challenging. It is important to consider the type of surgery, positioning, and kind of anesthetic required to be successful. The anesthesia professional must have a solid understanding of the physiologic effects of the patient's disease process and how it will affect the anesthetic. Pharmacologic optimization of the patient before anesthesia may prevent problems before they arise. Through careful consideration of all of these factors, safe anesthesia can be delivered to patients like the one discussed in this case report.

References

1. Budithi R, Dolinski S. Anesthesia for patients chronic obstructive pulmonary disease. UpToDate. Published October 6, 2021. Accessed December 18, 2021. https://www.uptodate.com/contents/anesthesia-for-patients-with-chronic-obstructive-pulmonary-disease.
2. Müllerova H, Agusti A, Erqou S, Mapel DW. Cardiovascular Comorbidity in COPD: Systematic Literature Review. *Chest*. 2013;144(4):1163–1178. doi:10.1378/chest.12-2847
3. Conley A, Biddle C, Baker K. A Tour of Autonomic Reflex Activity Relevant to Clinical Practice. *AANA J*. 2017;85(2):141-147.
4. Razi E, Moosavi GA, Omidi K, Saebi A, Razi A. Correlation of End-Tidal Carbon Dioxide with Arterial Carbon Dioxide in Mechanically Ventilated Patients. *Arch Trauma Res*. 2012;1(2):58-62. doi:10.5812/atr.6444.
5. Kimmoun A, Novy E, Auchet T, Ducrocq N, Levy B. Hemodynamic consequences of severe lactic acidosis in shock states: from bench to bedside. *Critical Care*. 2015;19(1). doi:10.1186/s13054-015-0896-7.
6. Frasch MG, Giussani DA. Heart during acidosis: Etiology and early detection of cardiac dysfunction. *EClinicalMedicine*. 2021;37:100994. doi:10.1016/j.eclinm.2021.100994.
7. Mirza S, Clay RD, Koslow MA, Scanlon PD. COPD Guidelines: A Review of the 2018 GOLD Report. *Mayo Clin Proc*. 2018;93(10):1488-1502. doi:10.1016/j.mayocp.2018.05.026.

8. Kannan S, Duggappa D, Rao Gv. Anaesthesia for patient with chronic obstructive pulmonary disease. *Indian J of Anaesth*. 2015;59(9):574. doi:10.4103/0019-5049.165859.

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Anesthetic Management for Patient with Zenker's Diverticulum

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Keywords: zenker's diverticulum, esophageal structure disorders, multidisciplinary surgical care, shared airway

Zenker's Diverticulum (ZD) is a rare esophageal abnormality occurring in 1 to 2 per 100,000 adults annually.[1] It is caused by an area of weakness in the posterior hypopharyngeal wall of the esophagus, most often around the level of the cricoid cartilage but it can occur anywhere along the esophagus. Often a ZD is asymptomatic but becomes problematic in patients >65 years of age due to further weakening of the esophageal and pharyngeal muscles.[1] If surgical attention is indicated there are some key anesthetic considerations for these patients, not only on induction but also in the maintenance and emergence phases of the anesthetic.

Case Report

A 63-year-old male presented to the emergency room with progressively worsening dysphagia. Initially diagnosed with ZD 8 years prior, he reported active symptoms of solid food dysphagia for 6 years. The patient's medical history included ZD, gastroesophageal reflux disease, adolescent asthma, obstructive sleep apnea, and previous nicotine dependence. Prescription medications included fish oil, a multivitamin, turmeric and a joint supplement. Previous surgeries included left foot arthrodesis, partial colon resection, appendectomy, tonsillectomy, inguinal hernia repair, several esophagogastroduodenoscopies (EGD), and a previous diverticulectomy. The patient denied alcohol use. On hospital day one, a diagnostic barium swallow study revealed a 3.2 x 6.0 x 6.4 cm ZD which compressed the cervical esophagus anteriorly. Additionally, a diagnostic EGD was unsuccessfully attempted under general anesthesia, as the proceduralist was unable to pass the scope distal to the ZD.

On hospital day two, the patient was scheduled to undergo a diverticulectomy under general anesthesia. Preoperative vital signs were as follows: blood pressure 126/86 mm Hg, heart rate 71/min, respiratory rate 16/min, SpO_2 95% on room air. General endotracheal anesthesia was induced using midazolam 1 mg, lidocaine 100 mg, fentanyl 100 mcg, propofol 200 mg and succinylcholine 100 mg intravenously (IV). A rapid sequence induction (RSI) technique was performed without cricoid pressure using a video laryngoscope to place a 7.0 mm neural integrity monitoring (NIM) endotracheal tube. A balanced general anesthetic was maintained with sevoflurane 2.2% (inspired) with a mixture of O_2 1 L/min and air 1 L/min, oxygen concentrations were reduced to <30% FIO2 during the use of electrocautery at the discretion of the surgical and anesthesia team. A lidocaine infusion was initiated at 30 mcg/kg/min.[2]

The surgical team requested muscle relaxation during the suspension laryngoscopy and esophageal dilation. To achieve relaxation of the upper airway, anesthesia was augmented with intermittent bolus doses of propofol 50 mg IV during this portion of the procedure. The surgical team was unable to pass the dilator distal to the ZD. Conversion to an open procedure was initiated to access the pouch through an incision on the left neck at the level of the cricoid cartilage. The pouch was identified in the left paratracheal gutter. A smaller dilator was successfully passed distal to the ZD, and the diverticulum was then removed. The anesthesia team inserted a 12 french nasogastric tube. Following surgical closure, the anesthesia team performed a leak test of the endotracheal cuff to assess for residual airway edema. Additional IV medications given throughout the case included dexamethasone 10 mg, acetaminophen 1000 mg, dexmedetomidine 28 mcg, ketamine 40 mg, ephedrine 35 mg, phenylephrine 200 mcg. Emergence from anesthesia, extubation, and transport to the postoperative care unit were unremarkable.

Discussion

A Zenker's diverticulum can be repaired with either an endoscopic transoral technique or an open technique. When an endoscopic transoral approach is performed a CO_2 laser and electrocautery is commonly utilized and laser safety and fire guidelines should be followed.[3] Either technique would require general anesthesia and share similar anesthetic consideration.[4] The notable anesthetic challenges this case brings to light are rare. Awareness and preparation for these challenges will help facilitate the delivery of a quality anesthetic and ensure patient safety. It is crucial that the anesthesia professional is aware of the case's anesthetic considerations in order to optimize outcomes while providing optimal surgical conditions during the operation. Due to the fact that ZD is characterized by a weakness in the posterior hypopharyngeal wall of the esophagus, these patients are at extremely high risk for airway complications such as aspiration and anatomical anomalies leading to difficult intubations.

The first point of discussion is the type of induction that would be safest for the patient. Due to the involvement of the esophagus and the proximity to the patient's airway, the patient is at high risk for aspiration. An RSI technique is recommended but cricoid pressure may not be indicated and can be contraindicated. Depending on the location of the diverticulum, applying cricoid pressure may push contents out of the sac and displace them in the posterior hypopharynx leading to aspiration. It is typically accepted that cricoid pressure should not be performed with this patient population. Attempts to empty the sac endoscopically by way of EGD should be made and the anesthesia provider should review the barium swallow to determine if cricoid pressure is appropriate.[4] The proximity of the sac relative to the cricoid cartilage will further determine the risk of aspiration, the closer to the cartilage, the higher the risk. Furthermore, video laryngoscopy should be readily available as there is potential for a difficult airway and to minimize time spent manipulating the airway. In this situation, the video laryngoscope was used for the intubation to successfully place the endotracheal tube. Anesthesia practitioners should also consider providing triple aspiration prophylaxis with a neutralizing agent (sodium citrate), gastrointestinal prokinetic (metoclopramide) and histamine antagonist (famotidine).[5]

An anesthetic consideration unique to this case was the surgeon's request for neuromuscular blockade post-intubation NIM tube. The surgeon requested an ultra-short acting agent for the suspension laryngoscopy but did not want interference with nerve monitoring upon completion. The anesthesia team discussed how to obtain these surgical conditions. Giving a nondepolarizing neuromuscular blocking agent post induction and then reversing this agent was an option, but it seemed excessive for the period of time and purpose of the relaxation. It was decided that propofol was an ideal agent to increase anesthetic depth and provide upper airway and neck relaxation during the suspension and passing of the dilating bougie. The anesthesia and analgesia were also augmented by the use of a lidocaine infusion as well as ketamine and dexmedetomidine boluses. This multimodal approach provided the requested surgical circumstances for the surgeon with the airway reflexes of the patient suppressed allowing the patient to tolerate the suspension laryngoscope and manipulation of the airway.[3,5] In cases where nerve monitoring will be implored via a NIM tube it is important to know ways to achieve adequate muscle relaxation without the use of neuromuscular blocking agents.

Complications that may occur include the risk of aspiration or difficult airway. Other possible complications include risk for esophageal rupture, post-operative hematoma, recurrent laryngeal nerve damage, external pharyngeal fistula, mediastinitis or pneumothorax; all of which are emergent conditions that would require prompt medical intervention.[6] When an anesthesia professional is preparing to perform anesthesia for this type of case, it is important that required resources are readily available. The location of the surgical site is surrounded by several large vessels and vital anatomical structures such as the carotid arteries and the recurrent laryngeal nerve. Preparations should be made to mitigate the extent to which these complications could harm the patient. Endotracheal nerve monitoring, adequate IV access, blood product availability, and close post-operative monitoring should be considered. In this case, the patient was extubated without difficulty, but providers should consider transferring the patient to the intensive care unit for airway monitoring. Due to the shared airway at points in the surgical correction, there is risk for unintentional extubation, migration of the endotracheal tube or difficulty ventilating. Meticulous vigilance and continual surgical team communication should be used during the operation to minimize the risk for airway complication.

This case was completed without complication, however the risk of complications from low frequency cases such as ZD repairs can present challenges for the entire surgical team. Open and frequent multidisciplinary communication before and during the case can help prevent complications. The primary learning points for ZD anesthesia included the appropriate RSI technique, aspiration mitigation, and the use of multimodal anesthesia and analgesia to obtain ideal surgical conditions.

References

1. Law R, Baron TH. 20 - Endoscopic Diagnosis and Management of Zenker's Diverticula. In: Chandrasekhara V, Elmunzer BJ, Khashab MA, Muthusamy VR, eds. *Clinical Gastrointestinal Endoscopy (Third Edition)*. Elsevier; 2019:234-240.e1. doi:10.1016/B978-0-323-41509-5.00020-7

2. Omar E, Wallon G, Bauer C, et al. Evaluation of intravenous lidocaine in head and neck cancer surgery: study protocol for a randomized controlled trial. *Trials*. 2019;20(1):220. Published 2019 Apr 15. doi:10.1186/s13063-019-3303-x
3. Apfelbaum JL, Caplan RA, Barker SJ, et al. Practice advisory for the prevention and management of operating room fires: an updated report by the American Society of Anesthesiologists Task Force on Operating Room Fires. *Anesthesiology*. 2013;118(2):271-290. doi:10.1097/ALN.0b013e31827773d2
4. Salem MR, Khorasani A, Saatee S, Crystal GJ, El-Orbany M. Gastric tubes and airway management in patients at risk of aspiration: history, current concepts, and proposal of an algorithm. *Anesth Analg*. 2014;118(3):569-579. doi:10.1213/ANE.0b013e3182917f11
5. Sahinovic MM, Struys MMRF, Absalom AR. Clinical Pharmacokinetics and Pharmacodynamics of Propofol. *Clin Pharmacokinet*. 2018;57(12):1539-1558. doi:10.1007/s40262-018-0672-3
6. Tabola R, Lewandowski A, Cirocchi R, et al. Zenker diverticulum: Experience in surgical treatment of large diverticula. *Medicine (Baltimore)*. 2018;97(19):e0557. doi:10.1097/MD.0000000000010557

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Management of Acute Pulmonary Edema

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Keywords: Pulmonary hypertension, flash pulmonary edema, anesthesia management, milrinone, heart failure

Acute pulmonary edema, colloquially referred to as “flash” pulmonary edema (FPE), is the rapid development of respiratory distress due to fluid accumulation within the lung interstitium secondary to elevated cardiac filling pressures.[1] FPE is a uniquely dramatic form of cardiogenic alveolar pulmonary edema or acute decompensated heart failure (ADHF).[1] Early recognition and treatment of FPE and triggering events directly improves patient mortality.[2] A thorough perioperative evaluation and management of pre-existing cardiopulmonary disease is essential to optimize patient outcomes. While this case report details an inadvertent FPE in the electrophysiology (EP) suite, patients with a similar cardiac profile and risk factors may present for a variety of procedures.

Case Report

A 61-year-old, 114.4 kg, 170 cm female presented for replacement of a biventricular implantable cardioverter-defibrillator (ICD) pulse generator secondary to device malfunction and a history of nonsustained ventricular tachycardia (VT) and atrial fibrillation. The history of present illness began with a transient episode of non-exertional palpitations, dizziness, and a 12 second run of VT that responded to a single ICD shock. Additional history included heart failure with reduced ejection fraction (HFrEF), continuous milrinone infusion (0.125 mcg/kg/min) awaiting left

ventricular assist device (LVAD) placement, hypertension, obesity, myocardial infarction, nonischemic cardiomyopathy, and osteoarthritis. A baseline electrocardiogram showed atrioventricular dual-paced rhythm, heart rate (HR) 68/min, with prolonged QT interval (QTc 609). A transthoracic echocardiogram revealed an ejection fraction (EF) of 10-15% with severely dilated left ventricle and atrium, global hypokinesis and severe mitral regurgitation. Recent right heart catheterization demonstrated elevated right atrial (RA) pressure of 14 mm Hg and severely elevated pulmonary capillary wedge pressure (PCWP) of 55 mm Hg, severely reduced cardiac output (CO) 2.4 L/min and cardiac index (CI) 1.1 L/min/m^2 and severely elevated pulmonary artery (PA) pressure 106/69 mm Hg. All laboratory results were unremarkable. The patient's medications included amiodarone, carvedilol, sacubitril/valsartan, apixaban, torsemide, milrinone, and meloxicam.

During the preoperative assessment, the patient reported resolution of previous dyspnea at rest since initiation of continuous milrinone infusion one week prior. While the patient's baseline functional status was < 4 metabolic equivalents, she demonstrated improvement by her ability to ambulate to the bathroom with minimal dyspnea. The patient's milrinone infusion was continued via peripherally inserted central catheter at her baseline rate. After being transferred to the EP suite, the patient was placed in semi-fowlers position with a wedge cushion to decrease orthopnea and standard noninvasive monitors were applied including end-tidal carbon dioxide monitoring. Initial vital signs were HR 65/min, blood pressure (BP) 132/68 mm Hg, SpO_2 100%, and respiratory rate (RR) 16/min. Oxygen was administered via nasal continuous positive airway pressure (CPAP) mask at 6 L/min with positive end expiratory pressure (PEEP) of 5 mm Hg. Moderate sedation was initiated with incremental boluses of dexmedetomidine totaling to 20 mcg IV and an infusion at 0.2 mcg/kg/hr. A phenylephrine infusion at 30 mcg/min was initiated to maintain baseline BP carried by normal saline infusion (200 mL total). After the patient expressed increasing anxiety related to the CPAP mask and drapes, midazolam 1 mg IV was administered. Subsequently, she remained calm for most of the case until the surgeon began closing. The patient became extremely anxious, noted by HR 140/min, RR 28/min, and dyspnea. She demanded the CPAP mask be removed and additional incremental doses of dexmedetomidine 10 mcg and propofol 80 mg were administered IV.

Upon completion of the procedure, the patient was transferred from the EP table to the stretcher where she developed worsening dyspnea with auditory crackles. The SpO_2 was 87% on O_2 10 L/min and lethargy was noted. Minimal improvement was observed after the reapplication of CPAP via anesthesia mask, patient repositioning, and furosemide 40 mg IV. When the SpO_2 decreased to 71%, a rapid-sequence intubation was performed via direct laryngoscopy with the administration of propofol 50 mg, ketamine 40 mg, and succinylcholine 100 mg IV. A 7.0 mm endotracheal tube was inserted into the trachea and correct placement confirmed with capnography and auscultation of bilateral breath sounds. Copious amounts of pink frothy sputum were noted. Sevoflurane 0.3-1.2% inspired concentration was titrated with O_2 at 4-10 L/min. Excessive secretions required frequent humification filter and anesthesia circuit changes. To improve gas exchange, rocuronium 40 mg IV, additional furosemide 80 mg IV, and albuterol 8 puffs were administered. Systolic BP decreased to 70 mm Hg and an epinephrine 8 mcg bolus was administered. Epinephrine 4 mcg/min and vasopressin 0.04 u/min infusions were initiated. Subsequent placement of a right radial arterial line and right internal jugular central venous catheter with a PA catheter were performed. Equipment was obtained for possible intra-aortic

balloon pump (IABP) and percutaneously inserted VAD. The patient was transferred to the cardiac catheterization lab to evaluate cardiac function. Evaluation revealed a CO 4.9 L/min, CI 2.2 L/min/m_2, RA 9 mm Hg, right ventricular pressure 26/5 mm Hg, PA 30/15 mm Hg, PCWP 18 mm Hg. The patient was transported to the intensive care unit (ICU) for further ADHF management, but successfully obtained LVAD placement as destination therapy one week later.

Discussion

Sedation is a common technique for an ICD battery or generator change due to the short duration of significant operative stimulus.[3] Anesthetic depth of sedation varies from local anesthesia to deep sedation depending on the patient's comorbities and risk factors. This patient had significant HFrEF and severe pulmonary hypertension (PH), which increased the risk of perioperative mortality. The anesthetic plan utilized local anesthesia with minimal sedation to avoid significant cardiopulmonary changes. Dexmedetomidine was selected as the primary anesthetic because as an alpha-2 agonist, it provides sedation without compromising spontaneous respiration and has demonstrated minimal effect on pulmonary vascular resistance (PVR).[4] Benzodiazepines, opioids, and propofol were limited due to their known side effect of respiratory depression resulting in hypoxia and increased PVR.

Milrinone, a phosphodiesterase-3 inhibitor, improves contractility by preventing the breakdown of cyclic adenosine monophosphate (cAMP) thereby increasing the availability of intracellular calcium.[5] Milrinone's effects on cAMP also creates vasodilatory effects by reducing SVR, PCWP, and PVR, decreasing cardiac filling pressures, and prolonging diastolic filling time.[5,6] Continuous milrinone infusions are approved for use as a bridge therapy to LVAD placement in patients with HFrEF refractory guideline-direct medical management.[5,6] Fewer symptoms of HFrEF have been reported after initiating bridge therapy and optimize clinical condition before destination therapy.[6] Concurrent maintenance of the ICD with continuous phosphodiesterase therapy is essential as milrinone induces hypotension and tachyarrhythmias.[7] While minimal evidence is available to direct intraoperative management of chronic milrinone, the continuation of baseline pulmonary vasodilator infusion rates is recommended to avoid rebound PAH that may result from abrupt cessation.[7]

The primary goals of treatment for ADHF include intravascular volume reduction, SVR reduction via vasodilators, and optimizing oxygen delivery to the organs.[1] Prompt administration of furosemide was provided upon recognizing signs and symptoms of ADHF, which included acute dyspnea, hypoxia, and severe crackles. Furosemide provides both vasodilatory and diuretic effects.[1] The milrinone infusion rate was increased to improve contractility and vasodilation, while the epinephrine and vasopressin infusions were added to correct severe hypotension secondary to ADHF treatment and cardiogenic shock.[6] Milrinone is the only inotropic agent indicated for cardiogenic shock in advanced HFrEF that decreases SVR and PVR.[6] Application of noninvasive positive pressure ventilation (CPAP or Bi-level PAP) is a primary intervention for treatment of ADHF to improve oxygenation and cardiac function while potentially reducing the need for intubation.[6] After worsening hypoxia refractory to CPAP and titration of supplemental oxygen, rapid sequence induction and mechanical ventilation with pressure control ventilation RR 14/min, inspiratory pressure 15 cmH_2O, inspiratory time 1:2, PEEP 5 cmH_2O was provided. Bronchodilator therapy and neuromuscular blockade were initiated to improve

oxygenation and prevent desynchrony. Peak airway pressures greater than 35 cmH_2O prevented further increases of PEEP. Positive pressure ventilation (PPV) prevents worsening fluid accumulation in lung tissues by displacing alveolar edema through hydrostatic pressure.[8] While PPV may increase intrathoracic pressure and PVR, titration of PEEP to 10-15 cmH_2O can potentially improve CO in left ventricular failure.[8] The cardiac parameters obtained from the cardiac catheterization revealed adequate management of ADHF and cardiogenic shock. If the cardiac catheterization revealed persistent cardiogenic shock or the hypotension was refractory to aggressive inotropic support, the next appropriate intervention would be IABP or percutaneous LVAD insertion.

The medical fragility of patients with PAH and advanced HFrEF makes sedation management extremely challenging. While the dexmedetomidine has been safely administered as a sedative technique for a variety of cardiovascular procedures on medically frail patients, its use on patients with EF < 30% is discouraged.[4] CPAP was chosen as a noninvasive technique to prevent hypoxia and increased pulmonary pressures from disordered breathing secondary to sedation. Retrospectively, other oxygen delivery systems may have been sufficient with no baseline oxygen dependence and the patient's apprehension related to CPAP. Anxiety surrounding the new experience of nasal CPAP may have precipitated the patient's increased heart rate. New onset of tachyarrhythmia or loss of normal sinus rhythm and subsequent increase in myocardial oxygen demand is the most likely cause of ADHF during this case.[1] A hypertensive emergency, myocardial ischemia, tachyarrhythmias, volume overload or stenotic valvular disease may result in suddenly increased left-sided cardiac filling pressures.[1] Once the patient became anxious, tachycardic, and tachypneic, the priority should be to slow her heart rate rather than provide additional sedation. Esmolol would have been a good beta-blocker choice to facilitate this goal. The propofol boluses likely exacerbated myocardial ischemia by decreasing preload, causing respiratory depression, and worsening the ventilation-perfusion mismatch. Small doses of etomidate would have provided a more cardioprotective sedation selection to bolus. Modification of sedation technique or more aggressive tachycardia management may have prevented ADHF, but the treatment of the acute decompensation was prompt and well-executed.

More conservative anesthetic management would have included a pre-sedation arterial line with advanced hemodynamic interpretation (CO, CI, SVR, etc.). Enabling assessment of preoperative preload to optimize intravascular volume and promptly respond hemodynamic variations to better guided anesthetic management. In a patient with similar clinical presentation, an exclusively regional anesthetic (both serratus anterior plane (SAP) and thoracic paravertebral blocks) was utilized for subcutaneous ICD placement to avoid the cardiopulmonary changes associated with even minimal sedation. [3] Application of a solely regional approach with use of only the SAP block to cover the anterior chest incision may have prevented the complication of ADHF in this case.

References

1. Rimoldi SF, Yuzefpolskaya M, Allemann Y, Messerli F. Flash Pulmonary Edema. *Prog Cardiovasc Dis*. 2009;52(3):249-259. doi:10.1016/j.pcad.2009.10.002
2. Figueras J, Bañeras J, Peña-Gil C, Barrabés JA, Palomares JR, Dorado DG. Hospital and 4-year mortality predictors in patients with acute pulmonary edema with and without coronary

artery disease. *J Am Heart Assoc*. 2016;5(2):1-10. doi:10.1161/JAHA.115.002581
3. Braver O, Semyonov M, Reina Y, Konstantino Y, Haim M, Winter J. Novel Strategy of Subcutaneous Implantable Cardioverter Defibrillator Implantation Under Regional Anesthesia. *Journal of cardiothoracic and vascular anesthesia*. 2019;33:2513-2516.
4. Gallego-Ligorit L, Vives M, Vallés-Torres J, Sanjuán-Villarreal TA, Pajares A, Iglesias M. Use of Dexmedetomidine in Cardiothoracic and Vascular Anesthesia. *Journal of cardiothoracic and vascular anesthesia*. 2018;2017;32:1426-1438.
5. Tariq S, Aronow WS. Use of inotropic agents in treatment of systolic heart failure. *Int J Mol Sci*. 2015;16(12):29060-29068. doi:10.3390/ijms161226147
6. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: Executive summary: A report of the American college of cardiology foundation/American Heart Association task force on practice guidelines. *Circulation*. 2013;128(16):1810-1852. doi:10.1161/CIR.0b013e31829e8807
7. Popescu WM, Malik A. Heart Failure and Cardiomyopathies. In: Hines RH, Marschall KE. *Stoelting's Anesthesia and Co-Existing Disease.* 7th ed. Philadelphia, PA: Elsevier Saunders; 2017: 199-223.
8. Alviar CL, Miller PE, McAreavey D, et al. Positive Pressure Ventilation in the Cardiac Intensive Care Unit. *J Am Coll Cardiol*. 2018;72(13):1532-1553. doi:10.1016/j.jacc.2018.06.074

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Opioid-Sparing Measures for Laparoscopic-Assisted Segmental Colectomy

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Keywords: quadratus lumborum block, transversus abdominis plane block, postoperative analgesia, colorectal surgery, liposomal bupivacaine

Opioid-sparing anesthesia is at the core of evidence-based practice for enhanced recovery protocols. Peripheral nerve blocks are employed when the "gold standard" thoracic epidural anesthesia is contraindicated.[1] The transversus abdominis plane block (TAPB) is an invaluable multimodal component in achieving somatosensory analgesia in abdominal procedures.[2] Research conducted to verify the benefits of TAPB revealed the advantage of the quadratus lumborum block (QLB). The purpose of this study is to demonstrate the superiority of QLB with liposomal bupivacaine (LB), compared to TAPB, in producing longer-lasting analgesia of the anterior abdominal and thoracic wall segments, resulting in reduced opioid requirements.

Case Report

A 70-year-old female with a body mass index of 25.7 kg/m^2 presented for a laparoscopic-assisted extended right hemicolectomy and sigmoid colon resection. The patient's medical history was significant for unresectable colon polyps, hypertension, depression, anxiety, chronic leg cramps, gastroesophageal reflux disease, and a 15 pack-year cigarette-smoking history (quit in 2000). Her

surgical history was remarkable for an appendectomy and total abdominal hysterectomy. Her home medications included doxepin, hydrochlorothiazide, metoprolol, tizanidine, and sertraline. The patient reported allergies to codeine, hydrocodone, oxycodone, morphine, and severe reactions to latex and sulfonamide antibiotics. The anesthesia plan included the placement of a TAPB after the conclusion of surgery, prior to emergence from anesthesia.

Upon arrival to the operating suite, standard non-invasive monitors were applied, displaying a baseline blood pressure of 140/70 mmHg, a heart rate of 62/min. The patient was pre-oxygenated for 5 minutes with O_2 10 L/min via facemask. Medications administered for slow intravenous (IV) induction were midazolam 1 mg, fentanyl 100 mcg, rocuronium 10 mg, lidocaine 100 mg, and propofol 130 mg. Upon loss of consciousness, successful mask ventilation was followed by the administration of succinylcholine 140 mg, one minute of mask ventilation, direct laryngoscopy, and tracheal intubation with a Macintosh 3 blade and a 7.0 mm endotracheal tube. General anesthesia was maintained with isoflurane at 1.5% inspired concentration in O_2 1 L/min and air 1 L/min, and pressure-controlled ventilation. Before incision, rocuronium 10 mg IV was administered to achieve a train-of-four count (TOFC) of 1/4 twitches.

With the patient supine, and both arms tucked at the patient's sides, the surgeon created a vertical midline incision, approximately 6 cm. long. After abdominal insufflation, the patient was maintained in the Trendelenburg position and tilted to the left for optimal surgical exposure. Intermittent boluses of rocuronium maintained neuromuscular blockade at a TOFC of 1/4 twitches. A total of fentanyl 150 mcg IV was administered during the three-hour procedure.

Following closure of the incision, an ultrasound guided TAPB was performed bilaterally. The ultrasound was oriented transversely to the abdomen and positioned posterior to the mid-axillary line, between the iliac crest and the costal margin. The needle was introduced, advanced, and maneuvered until the tip was visualized within the plane between the internal oblique and transversus abdominis muscles. A total of 20 mL of bupivacaine 0.25 % was administered on each side. After successful extubation, the patient was transferred to the post-anesthesia care unit (PACU). The postoperative course was unremarkable; vital signs remained stable.

A total of fentanyl 100 mcg IV was administered in PACU. On postoperative days (POD) 1 and 2, the medication record revealed 3 doses of ketorolac 30mg, acetaminophen 2g (1g each 12 hrs), hydromorphone 1.5 mg, and meperidine 50 mg. On POD 3 and 4, the patient received totals of fentanyl 50 mcg and meperidine 100 mg IV. The patient did not require patient-controlled intravenous analgesia. The patient was discharged home on POD 5 on tramadol hydrochloride.

Discussion

Poorly controlled pain has been associated with cardiac morbidity, impaired sleep, altered immune function, anxiety, and feelings of demoralization. Pain also contributes to reduced mobility, often causing ileus and other complications, including pneumonia and deep vein thrombosis. Often, pain leads to nausea and vomiting with resulting wound dehiscence. These sequelae from inadequate pain management often lead to a prolonged hospital length of stay (LOS) and increased incidence of hospital readmission.[3] Insufficiently treated acute post-surgical pain is purported to be a reliable indicator of the development of chronic pain.[3] One multimodal

approach to effectively control postoperative pain for open or laparoscopic abdominal surgeries is peripheral nerve blocks. These blocks are accomplished by injecting local anesthetics into the neurofascial plane through which peripheral nerves run.[2] Several techniques exist to achieve abdominal peripheral nerve blocks; two are the TAPB and QLB.

The TAPB has been useful in laparoscopic surgeries and procedures involving an abdominal wall incision.[2] However, it is primarily indicated for lower abdominal surgeries involving the appendix, ureters, ovaries, fallopian tubes, and the colon (ascending, descending, sigmoid, cecum). Medications are injected between the transversus abdominis and internal oblique muscles blocking the T6-L1 and T12-L1 neural afferents, producing analgesia.

The TAPB lacks the ability to produce visceral analgesia. It is recommended to be used in conjunction with another IV or oral analgesic to provide adequate pain relief. In contrast, QLB targets the deepest abdominal muscle, the quadratus lumborum. It is positioned dorsal to the iliopsoas muscle, with its origin on the iliac crest, and innervates into the 12th rib and the transverse processes of L1-L4 vertebrae. Research has shown that QLB results in a T7-L1 sensory block, which is more extensive compared to a T10-T12 with TAPB.[4]

The novel extended-release local anesthetic formulation, LB, has gained traction in anesthesia and surgery due to the current shift in focus towards opioid-sparing techniques. Employing LB wound infiltration with IV metoclopramide and ketorolac in colectomy patients has resulted in exceptional postoperative pain control, higher patient satisfaction, and reduced postoperative parenteral opioid (PPO) consumption compared with the group who were treated with parenteral opioids without LB infiltration.[5] The patient in the above detailed case may have benefited from the extended release of bupivacaine, noted to be up to 72-hours. This may have decreased fentanyl, hydromorphone, and meperidine use on POD 1 and 2. Additionally, this patient was at risk for an ileus due to the procedure and opioid administration. Decreasing the need for opioids in the initial postoperative period reduces the likelihood of ileus formation.

Wang et al. reported that QLB is superior to TAPB in providing postoperative analgesia, reducing the number of patients requiring analgesia postoperatively, decreasing 24-hr visual analog score (VAS) rating, PPO, and reducing the incidence of dizziness.[6] These results were further substantiated by a randomized controlled trial conducted by Deng et al., demonstrating a significantly reduced sufentanil consumption at 24-hr and 48-hr postoperatively. It was shown that the numeric rating scale (NRS) reported by the QLB group was consistently lower from 2-hr to 48-hr postoperatively, and the TAPB group reported a higher incidence of dizziness compared to the QLB group.[7] Less opioid administration and increased duration of the block due to LB would likely promote earlier activity and ambulation.

Elsharkawy et al. published a case report in 2016 regarding the use of LB in TAPB and QLB using the same anesthetic mixture.[4] This was a single patient study of a 32-year-old with ulcerative colitis who underwent a subtotal colectomy. The patient received both blocks with the same anesthetic mixture: TAPB-LB was placed on the right abdominal area while QLB-LB was administered on the left. The authors reported that on the QLB side, the duration of analgesia was 48 hours vs. 24 hours on the TAP side. It is speculated that the duration from a QLB is longer due to increased spread to the thoracic paravertebral space. The authors further suggested

this dose and technique could extend analgesia for specific abdominal surgeries such as the subtotal colectomy performed in the setting of ulcerative colitis.[4]

The novel QLB technique with LB anesthetic show exceptional promise in producing reliable, efficacious, and longer-lasting analgesia. Surgical site infiltration with LB can be a distinctive element in the early recovery after surgery pathway, minimizing opioid use while maximizing pain control. The patient who underwent laparoscopic-assisted extended right hemicolectomy and sigmoid colon resection might have benefited from a more extensive, longer-lasting analgesic technique such as the QLB-LB compared to TAPB. The evidence suggests that this anesthesia technique results in reduced VAS scores decreased opioid requirement, increased length of time to first analgesic requirement, increased tolerance to out of bed activity, hastened return of bowel and urinary function, and decreased LOS. These favorable outcomes can reduce the overall cost of hospitalization, promoting the cost-effectiveness of using liposomal bupivacaine, with the added benefit of increasing patient satisfaction.

References:

1. Hughes MJ, Ventham NT, McNally S, Harrison E, Wigmore S. Analgesia after open abdominal surgery in the setting of enhanced recovery surgery: a systematic review and meta-analysis. *JAMA Surg.* 2014;149(12):1224–1230. doi:10.1001/jamasurg.2014.210
2. Rosenblatt MA, Lai Y. Abdominal nerve block techniques. In: Post TW, ed. *UpToDate.* UpToDate; 2019. Accessed March 14, 2020.
3. Gan TJ. Poorly controlled postoperative pain: prevalence, consequences, and prevention. *J Pain Res*. 2017;10:2287–2298. doi:10.2147/JPR.S144066
4. Elsharkawy H, Salmasi V, Soliman LM, Esa WAS, Blanco R. Anterior quadratus lumborum block versus transversus abdominis plane block with liposomal bupivacaine: a case report. *J Anesth Crit Care Open Access*. 2016;6(1): 1-5. doi:10.15406/jaccoa.2016.06.00214
5. Pricolo VE, Fei P, Crowley S, Camisa V, Bonvini M. A novel enhanced recovery protocol, combining multimodal analgesia with liposomal bupivacaine and pharmacologic intervention, reduces parenteral opioid use and hospital length of stay after colectomy – a cohort study. *Int J Surg Open*. 2018;13:24-28. doi:10.1016/j.ijso.2018.07.007
6. Wang Y, Wang X, Zhang K. Effects of transversus abdominis plane block versus quadratus lumborum block on postoperative analgesia: a meta-analysis of randomized controlled trials. *BMC Anesthesiol*. 2020;20(1):1-9. doi:10.1186/s12871-020-01000-2
7. Deng W, Long X, Li M, et al. Quadratus lumborum block versus transversus abdominis plane block for postoperative pain management after laparoscopic colorectal surgery: a randomized controlled trial. *Med*. 2019;98(52):e18448. doi:10.1097/MD.0000000000018448

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Anesthetic Considerations for Carotid Endarterectomy under Regional Anesthesia

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Key words: carotid endarterectomy, local anesthesia, neurologic monitoring, carotid artery shunting, permissive hypertension

Carotid artery disease occurs when atherosclerotic plaques block one or both of the major blood vessels that deliver blood to the brain. Patients with symptomatic, severe internal carotid artery disease may benefit from surgical intervention in the form of a carotid endarterectomy (CEA). Surgical intervention is significantly effective in reducing five-year risk of ipsilateral stroke in patients with 70% occlusion or greater when compared to medical management.[1] The procedure can be done under either regional or general anesthesia. The risks and benefits of each technique, surgeon preference, the patient's individual co-morbidities and ability to tolerate regional technique, should be considered prior to choosing an anesthetic technique.

Case Report

A 76-year-old, 173 cm, 89 kg male with a body mass index of 29.7 (BMI) and an American Society of Anesthesiology physical class III presented to the hospital for a left-sided CEA. The patient was diagnosed with left-sided carotid artery stenosis greater than 70% by a computed tomography angiogram (CTA). The CTA also revealed that right-sided carotid artery stenosis was present, but was measured to be less than 50%. The patient had a history of multiple transient ischemic attacks (TIAs) without prolonged deficits, essential hypertension, coronary artery disease requiring coronary artery bypass grafting, chronic atrial fibrillation, and obstructive sleep apnea. The patient was compliant with his continuous positive airway pressure therapy (CPAP), and his daily home medication regimen included metoprolol 50 mg extended release, aspirin 81 mg, lisinopril 20 mg, amlodipine 10 mg, and rivaroxaban 20 mg. The patient took his last dose of rivaroxaban 48 hours prior to surgery and stopped his aspirin 7 days prior to surgery with his cardiologist's approval. Preoperative vital signs included an irregular heart rate (atrial fibrillation) at 75 beats per minute, a blood pressure of 150/68 mm Hg, and the patient was breathing comfortably on room air. After extensive discussion with the patient regarding the risks and benefits as well as an assessment of the patient's ability to cooperate, the decision was made to perform the procedure awake with the use of regional anesthesia and minimal sedation.

Upon arrival in the operating room, a left radial arterial line was placed for continuous blood pressure monitoring and a second large bore intravenous catheter was inserted. Midazolam 2 mg was administered prior to placement of an ultrasound guided intermediate cervical plexus block using sterile technique. With the patient in the semi-recumbent position and the head turned slightly to the right, an ultrasound probe was placed in a transverse position over the posterior border of the left sternocleidomastoid muscle. The cervical plexus was identified as a collection of hypoechoic structures under the sternocleidomastoid muscle, deep to the cervical fascia. A 22g block needle was inserted lateral to the transducer and advanced in-plane medially until the tip was visualized next to the plexus. After negative aspiration, 0.5% ropivacaine 10 mL was injected. Prior to draping, the patient was given a small squeaky ball to hold in his right hand.

During the procedure the surgeon periodically asked him to squeeze the ball and occasionally to respond verbally in order to assess the patient's neurologic function. His systolic blood pressure was maintained between 150-160 mm Hg during carotid cross-clamping with the use of a phenylephrine infusion titrated between 30 mcg/min and 75 mcg/min, and then decreased to 110-120 mm Hg with the use of a nitroglycerin infusion titrated between 0.2 mcg/kg/min and 1 mcg/kg/min after the release of the cross-clamp. Throughout the procedure the patient received a total of midazolam 8 mg and fentanyl 250 mcg. He remained alert and cooperative throughout the procedure and tolerated the surgery well without any neurologic deficits and without the need for shunting.

Discussion

During a CEA it is imperative to monitor cerebral blood flow in order to prevent intraoperative stroke. If deficits in blood flow to the brain during carotid artery clamping are identified early, ischemia can be ameliorated by shunting across the clamped artery.[1] Though shunting is beneficial in patients whose cerebral blood flow has been compromised, it is not without complications. Shunts can lead to iatrogenic complications such as embolism, re-thrombosis, and late stenosis of the shunt which can ultimately lead to stroke, increased length of stay, ICU admissions, death, and overall increased costs to the hospital.[1-4] An awake patient is considered the "gold standard" for measuring neurological status during carotid endarterectomy[3,4] and allows for faster identification of patients who require shunting as well as fewer unnecessary shunt placements.[3]

Under general anesthesia a stroke may only be identified after recovery from anesthesia, therefore other forms of cerebral oxygen monitoring must be utilized intraoperatively to assess cerebral blood flow. Available methods include electroencephalogram (EEG), near-infrared spectroscopy (NIRS), transcranial doppler (TCD) and stump monitoring. Several studies have examined the efficacy and accuracy of these monitors. Celio et al[5] conducted a retrospective study of 125 carotid endarterectomies performed under regional anesthesia. In this study incidence of shunt use was only 2.4% (3 cases). In all three cases, neurologic deficits were quickly identified in the awake patient by either an acute onset of mental confusion or motor deficits, and in each case all neurologic symptoms improved immediately after shunt placement.[5] In a 2020 study on cerebral oximetry monitoring through the use of NIRS, a drop in 10% was found to correlate well with both clinical signs of cerebral ischemia as well as a decrease in stump pressures[6], thus indicating it to be a suitable yet less invasive alternative to stump pressure monitoring. Guay & Kopp[2] determined that utilization of stump pressures plus either TCD or EEG delivers better results in detecting brain ischemia than any singular monitoring method, but no stand-alone system is as successful as an awake patient in accurately identifying brain ischemia and need for shunt during a CEA.

The patient in discussion had a history significant for hypertension, atrial fibrillation, and obstructive sleep apnea, which put him at risk for adverse cardiovascular events. It was therefore important to determine which anesthetic technique would be safest for him. Kfoury et al[7] compared outcomes of patients who underwent a CEA from 2005 to 2011 under either regional or general anesthesia. Their analysis revealed that CEA under regional anesthesia decreased risk of 30-day postoperative myocardial infarction (MI) (0.4% versus 0.9%, $p = 0.012$).[7]

Additionally, regional technique seemed to be associated with a lower incidence of postoperative pneumonia, less blood loss and need for blood transfusions, shorter operative times, and less ICU admissions.[3] However both Kfoury et al[7] and Vaniyapong et al[1] reported no statistically significant difference in 30-day postoperative stroke or death when using regional anesthesia versus general anesthesia.

Permissive hypertension, which in this case was defined as a systolic blood pressure of 150 mm Hg or greater, was utilized in order to maintain adequate cerebral perfusion during cross-clamping. LeSar et al[8] looked at permissive hypertension and its effect on clamp time, need for shunting, and hemodynamics in patients receiving regional anesthesia for carotid endarterectomy. They found that routine use of permissive hypertension recruits collateral blood flow networks and significantly reduces operative times and need for shunting in awake patients, thus potentially decreasing risk of stroke down the line.[8]

Much of the literature surrounding pharmacologic interventions for anxiety during awake carotid endarterectomies suggests that alpha-2 receptor agonists such as clonidine and dexmedetomidine are ideal pharmacologic options compared to other sedatives because they are associated with less postoperative hypertension, less postoperative pain, and cause minimal respiratory depression.[4] Narcotics have also been shown to improve tolerance to operation time and calm the patient while not hampering the patient's response to verbal commands.[5] In this case, the patient was treated solely with midazolam and fentanyl IV pushes as needed, with no additional pharmacologic interventions due primarily to surgeon preference. After reviewing the literature, dexmedetomidine may have been an effective pharmacologic adjunct for this patient that could have reduced the amount of midazolam needed while still maintaining the patient responsive enough for continuous neurologic monitoring.

In conclusion, patients undergoing CEA are at high risk for developing stroke intraoperatively, particularly during carotid artery cross-clamping. It is imperative that steps are taken to minimize interruptions of blood flow to the brain, and that accurate and reliable methods are utilized to monitor neurologic function. Maintaining an awake patient is the gold standard for quickly identifying signs and symptoms of decreased cerebral perfusion intraoperatively. Additionally, the use of permissive hypertension during carotid artery cross-clamping is supported as an effective method of maintaining adequate cerebral perfusion during carotid endarterectomy.

References

1. Vaniyapong T, Chongruksut W, Rerkasem K. Local versus general anaesthesia for carotid endarterectomy. *Cochrane Database of Syst Rev.* 2013(12). doi: 10.1002/14651858.CD000126.pub4
2. Guay J, Kopp S. Cerebral monitors versus regional anesthesia to detect cerebral ischemia in patients undergoing carotid endarterectomy: a meta-analysis. *Can J Anaesth*. 2013;60(3):266-79. doi: 10.1007/s12630-012-9876-4
3. Erdinç İ. Carotid endarterectomy in awake patient: Review article. *E Journal of Cardiovascular Medicine*. 2019;7(1):1-8. doi: http://dx.doi.org.libdb.fairfield.edu/10.32596/ejcm.galenos.2019.00012
4. Stoneham MD, Stamou D, Mason J. Regional anaesthesia for carotid endarterectomy. *Br J Aneasth.* 2015;114(3):372-83. doi: 10.1093/bja/aeu304

5. Celio TM, Fortunato JA Jr, deCarvalho CA, et al. Carotid endarterectomy in awake patients: safety, tolerability and results. *Braz J Cardiovasc Surg.* 2014;29(4). doi: http://dx.doi.org/10.5935/1678-9741.20140053
6. Inčiūra D, Antuševas A, Aladaitis A, Gimžauskaitė A, Velička L, Kavaliauskienė Ž. Near-infrared spectroscopy as a predictor of cerebral ischaemia during carotid endarterectomy in awake patients. *Vascular.* 2020;28(3):301-308. doi:10.1177/1708538119893830
7. Kfoury E, Dort J, Trickey A, et al. Carotid endarterectomy under local and/or regional anesthesia has less risk of myocardial infarction compared to general anesthesia: An analysis of national surgical quality improvement program database. *Vascular.* 2015;23(2):113-119. doi: 10.1177/1708538114537489
8. LeSar CJ, Sprouse LR, Harris WB. Permissive hypertension during awake eversion carotid endarterectomy: A physiologic approach for cerebral protection. *J Am Coll Surg.* 2014;218(4):760-766. https://doi.org/10.1016/j.jamcollsurg.2013.12.029. Accessed February 14, 2021

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Failed Spinal in a Parturient: A Case Report

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Keywords: Failed spinal, neuraxial anesthesia, spinal anesthesia, c-section

Over the last two decades, neuraxial anesthesia has been the preferred anesthetic choice for the parturient undergoing cesarean section (CS).[1] Due to its ability to limit fetal drug exposure and reduce maternal risk of gastric aspiration without compromising maternal participation in the birth, neuraxial anesthesia is a safe alternative to general anesthesia.[2] Although rare, neuraxial anesthesia may fail intraoperatively. Failed neuraxial anesthesia in a parturient is associated with significant morbidity and mortality.[1] This case report describes failed spinal anesthesia in a parturient, potential causes, and prevention methods.

Case Report

A 39-year-old, 86 kg multiparous ($G_3T_1P_0A_1L_1$) African American female was scheduled for a repeat CS. The current pregnancy was uncomplicated. Her first CS was 10 years prior for failed induction of labor, completed successfully under spinal anesthesia. Past medical history included gastroesophageal reflux and childhood asthma. Current medications included famotidine 20 mg QD. Preoperative coagulation values were within normal limits. The anesthetic plan was spinal anesthesia with general endotracheal anesthesia (GETA) as a backup. Bilateral transversus abdominis plane (TAP) blocks were planned for postoperative analgesia.

In the operating room, the patient was placed in the sitting position. Standard noninvasive monitors were applied. A Ringer's lactate 500 mL bolus was administered IV. After the patient's back was sterilely prepped and draped, a 25-gauge pencil-point needle was inserted into the

subarachnoid space at the lumbar 3-4 level. Free flowing cerebrospinal fluid (CSF) was noted on the first attempt. After confirmation of CSF aspiration, 0.75% bupivacaine 1.8 mL, fentanyl 10 mcg, preservative-free morphine 150 mcg, and epinephrine 10 mcg were administered intrathecally without resistance. The patient was transitioned to the supine position with left uterine displacement.

While the surgical team began prepping and draping, the anesthetist assessed the level of sympathectomy with an alcohol wipe. The patient confirmed decreased cold sensation at the T4 level. Once draped, the surgical team verified the level of spinal anesthesia by performing an Allis test. The patient denied sharp pain or discomfort, reporting feeling only touch. Incision was made.

Twenty minutes into the procedure, the patient suddenly began screaming, complaining of sharp right lower quadrant pain. The surgical team stopped. In attempt to displace local anesthetic to the painful area, the patient's position was changed to a right lateral side-tilt. Five minutes later, the surgical team attempted to cauterize the patient's right lower quadrant. The patient immediately screamed, complaining of sharp pain. During cauterization, it was noted that the patient's right foot began to move up and down off the surgical bed. The surgeon injected 1% lidocaine 10 mL into the fascia. Meanwhile, the anesthesia practitioners administered intravenous (IV) fentanyl 100 mcg and acetaminophen 1 g. The patient denied pain relief.

After the patient and husband were informed that GETA was required, the father was escorted out of the room. A rapid sequence induction was initiated with administration of midazolam 2 mg, fentanyl 50 mcg, propofol 200 mg, and succinylcholine 90 mg IV. A 6.5 mm ETT was placed with use of video laryngoscopy. Cricoid pressure was held until verification of proper ETT placement. To maintain anesthesia, inspired sevoflurane 2% was administered in O_2 2 L/min. Once the fetus was delivered, sevoflurane was decreased to 1% with N_2O 1 L/min and O_2 1 L/min. A 300 mL bolus of oxytocin 60 units/L, ondansetron 4 mg, metoclopramide 10 mg, and ketorolac 30 mg were given IV.

While the patient remained mechanically ventilated, bilateral TAP blocks were performed. Upon completion of the procedure, the inhaled anesthetics were discontinued. The ETT was removed after the patient appropriately followed commands and met standard extubation criteria. The patient was transported to the post-anesthesia care unit with the newborn latched to the breast.

Discussion

This case presents a unique failed neuraxial anesthetic in a woman undergoing a CS.
The single-shot method for spinal is the most widely used technique for elective and emergent CS.[2] Unless there is a contraindication, a spinal is the preferred anesthetic for CS, providing adequate anesthesia with a T4 level sensory block.[2] Although spinal anesthesia has high reliability, there is always the possibility for failure. Failure rates are reported to range from 1-17%.[1] Failure includes a spectrum of issues such as partial or total absence and insufficient height or duration of block.[2]

Failed spinal anesthesia can be related to operator, technical, equipment, or drug errors.[2] The most obvious failure is the lack of accessing the subarachnoid space and not obtaining free-flowing CSF. The absence of free-flowing CSF may arise from a clot, tissue, or vein blocking the lumen of the needle, resulting in inadequate anesthesia spread.[3] While the observation of CSF is necessary, it is imperative to the success of the block that it be free-flowing. If absent, the practitioner should attempt to manipulate the needle by increasing or decreasing its depth until free-flowing CSF is noted.[4]

Anesthesia and obstetric practitioners should verify the adequacy of surgical anesthesia prior to incision. Testing the block prior to incision allows the anesthesia practitioner to redo the block if there are issues. A blunt tip needle or an alcohol swab may be used to test the level of sympathectomy. Additionally, the obstetrician will pinch the skin in the operative area with an Allis clamp, a toothed surgical instrument, to confirm surgical anesthesia. Surgical anesthesia is confirmed when the mother denies sharp pain. In this case, the parturient initially noted a decreased cold sensation with an alcohol wipe at the T4 level. Official confirmation of block adequacy was noted with a negative high and low Allis clamp application.[2]

In the absence of a luer lock, connection between the spinal needle and syringe must be tightly secured to prevent leakage of medication during injection. Given the small volumes involved, the loss of even a few drops can cause a significant decrease in effect.[5] With attachment of the syringe to the needle, great care must be taken to avoid either anterior or posterior displacement of the needle tip into or from the subarachnoid space. A distinguishing factor of the pencil point needle is that the eyelet is located on the ventral surface, meaning care must be taken to prevent the bevel from straddling the dura. This would result in inadvertent spread between the subarachnoid and epidural spaces, creating a “flap valve” across the puncture site. Initially, CSF pressure pushes the dura outward resulting in successful aspiration. Subsequent injection pushes the dura forward causing medication displacement.[1] Unfortunately, this event cannot be identified in real time. Rotation of the needle 360° after the initial appearance of CSF and before aspiration reduces the risk of membrane edges obstructing the opening of the needle.[5]

A late failure may result from inadvertent injection of lidocaine into the subarachnoid space during localization. This would result in a flow of clear, CSF-appearing fluid, mimicking a successful puncture.[1] Practitioners should consider using a shorter length needle for local wheal, particularly in cases involving a parturient of small body habitus. To rule out this false positive, time for the block to establish adequately is required. The maximum amount of time for the onset of action after intrathecal administration is 15-20 minutes.[5] If the block is ineffective after 20 minutes, it should be assumed that the block has failed.[5]

Another cause of failed spinal is the administration of inactive local anesthetic solutions. Ester-type local anesthetics are chemically labile. When stored for long periods of time or exposed to heat, hydrolysis may occur and has been found to make the solution ineffective. Amide local anesthetics are considered more stable and carry a much lower risk of destabilization.[1] During the presented CS, bupivacaine was administered intrathecally. Aspiration was checked post injection and CSF was again noted. Despite the presence of a valid expiration date, the bupivacaine vial was believed to be inactive. Considering the patient’s clinical presentation following the spinal block, it was determined the local anesthetic was likely destabilized,

exerting no pharmacological effect. The anesthesia providers in this case study took the appropriate subsequent measures to ensure safety of both the mother and fetus.

During placement of spinal anesthesia, it is prudent that the anesthesia practitioner pays meticulous attention to set up and insertion. Constant communication with both the parturient and the obstetric team is key. By identifying elements that contribute to spinal anesthesia failure, the practitioner should be able to recognize a failed block early which can decrease parturient morbidity and mortality.

References

1. Parikh KS, Seetharamaiah S. Approach to failed spinal anaesthesia for caesarean section. *Indian J Anaesth*. 2018;62(9):691-697. doi:10.4103/ija.IJA45718
2. Chin A, Zundert A. Spinal anesthesia. In: Hadzic A, Ed. *Hazdic's Textbook of Regional Anesthesia and Acute Pain Management*. 2nd ed. McGraw Hill; 2017:328-364.
3. Agrawal J, Rajput A, Mittal R. Failed spinal anaesthesia – a review. *Anaesth Critic Care Med J.* 2019;4(1):1-4.
4. Yuksek A, Miniksar O, Honca M, Oz H. Incidence and causes of failed spinal anesthesia. *Dubai Med. J.* 2020;3(2):50-54. https://doi.org/10.1159/000508837
5. Rattenbery W, Hertling A, Erksine R. Spinal anaesthesia for ambulatory surgery. BJA. 2019; 19(10)321-328. doi: 10.1016/j.bjae.2019.06.001

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Non-Obstetric Surgical Anesthesia: Considerations for the Parturient and Fetus

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Key words: Anesthesia, non-obstetric surgery, pregnant surgical patient, laparoscopy

The need for surgical intervention can arise at any point during gestation, and while elective surgeries are typically delayed until after delivery of the fetus, urgent and emergency procedures are not delayed because the patient is pregnant.[1] Informed anesthesia care of the parturient involves knowledge of her physiological and pharmacological differences compared with the non-pregnant patient. A thorough understanding of these principals helps the anesthetist formulate a safe, comprehensive, multidisciplinary anesthetic plan for this unique patient population.

Case Study

A 31-year-old parturient presented to the emergency department with the complaint of sharp right upper abdominal pain that radiated to her back. Obstetric history was documented in the electronic medical record and gestational age was noted to be 30 weeks 4 days. Height was recorded as 160cm, weight 69 kg, with no known drug allergies. Past medical history was

significant for anxiety, depression, and migraines. Clinical work up for abdominal pain included ultrasound imaging, which indicated cholelithiasis. Surgical consult was obtained, and the patient was prescribed protonix, augmentin, and a low-fat diet and discharged home. She was administered a single dose of betamethasone per obstetric recommendation to hasten fetal lung maturity in the event of preterm labor. The patient returned to the hospital 4 days later after failing attempted medical management. Extensive discussion surrounding care and safety of both mother and fetus was conducted among obstetric, surgical, neonatal, and anesthesia teams and the decision was made to proceed to the operating room for a laparoscopic cholecystectomy.

Anesthesia consent was obtained, time of last oral intake was verified and airway exam completed. Baseline fetal heart rate tracing was classified as category 1 and was to be continuously monitored throughout the procedure by obstetric team. The patient had been experiencing intermittent nausea and was unable to tolerate oral sodium citrate. In the operating room the patient was positioned on OR table with a wedge placed under her right side to create left uterine displacement. The surgeon communicated that trocar insertion would be through a subcostal approach to accommodate fundal height and fetal monitor. The neonatal team was present in OR with warmer, isolette located outside room, and preparations for neonatal transfer were in place pending the need for emergency delivery. Preoperative huddle was performed while the patient was preoxygenated with O_2 10 L/min for 3 minutes in the ramp position. Intravenous induction medications included fentanyl 100 mcg, lidocaine 40 mg, propofol 200 mg, and succinylcholine 100 mg. A planned rapid sequence induction was commenced with cricoid pressure. The trachea was intubated with a 6.5 mm endotracheal tube using a GlideScope (Verathon Inc) followed by insertion of a 16 French orogastric tube. Phenylephrine 80 mcg IV in incremental bolus doses were administered to maintain the patient's mean blood pressure between 65-85mmHg. Cefoxitin 2 g IV was administered prior to incision.

General anesthesia was maintained with a propofol infusion at 125 mcg/kg/min, sevoflurane 1% inspired concentration in a mixture O_2 1.5 L/min and air 0.5 L/min each, along with a phenylephrine infusion. Neuromuscular blockade was maintained after return of train of four from succinylcholine with rocuronium bolus doses of 10 mg as needed for continued muscle relaxation. Pneumoperitoneum was limited to 10 cm H_2O.pressure. Hemodynamics remained within +/- 20% of baseline with no significant fluctuations upon insufflation. The patient's ventilation was controlled using volume control with TV of 6-8 L/kg, RR of 16-18/min, peep of 5 cm H_2O; $ETCO_2$ was maintained between 35-40 mm Hg. Warming blanket was turned on to 40 degrees. LR was infused with a total input of 1400 mL, EBL 50 mL, and urine output of 340 mL.

Upon completion of the 80-minute surgical procedure both propofol infusion and sevoflurane were discontinued. Oxygen flows were gradually increased to 10L/min. Neuromuscular blockade was reversed using intravenous neostigmine 2mg and glycopyrrolate 0.4mg. Train of four was checked and patient demonstrated 4/4 of twitches, sustained tetany with no fade after reversal. Ondansetron 4mg IV was administered. Fentanyl was titrated to effect upon emergence for additional analgesia, noting patient maintained adequate respiratory rate and tidal volumes. Marcaine 0.25% 30ml was injected around port sites by surgical team. The trachea was extubated with the patient awake. She was transferred to PACU with continued fetal monitoring.

Discussion

According to Buser[5] laparoscopic surgery during pregnancy has not been associated with an increase in adverse outcomes and should no longer be considered a contraindication to performing laparoscopy. Surgery during pregnancy poses additional concerns for the anesthetist, with the main goals of preserving maternal safety, maintaining the pregnant state of the fetus, and achieving the best outcomes for both mother and fetus.[6] According to American College of Obstetricians and Gynecologists (ACOG)[5], the parturient should not be prevented from receiving necessary surgery, nor should surgery be delayed, during any period of the pregnancy, as this has the potential to increase both maternal and fetal morbidity.

To ensure both maternal and fetal safety, avoiding certain drugs during fetal development and maintaining an adequate utero-placental perfusion remain cornerstones of anesthetic management.[6] Pharmacological considerations relevant to fetal safety include exposure to potentially teratogenic agents, timing during fetal development, and dose and route of drug administration.[6] Factors that influence placental transfer of drugs include lipid solubility, ionization, molecular size, and protein binding. Some common anesthetic concerns include avoidance of non-steroidal anti-inflammatory drugs in the third trimester of pregnancy because of the risk of premature closure of the ductus arteriosus in the fetus. Nitrous oxide inhibits methionine synthetase, an enzyme necessary for DNA synthesis and listed as pregnancy risk class C, noting the potential risk for fetal harm.[2] Of note, there is no definite evidence to show that volatile anesthetics are teratogenic and other anesthetic medications, including propofol, opioids, muscle relaxants, and local anesthetics have been widely used during pregnancy for many years with few side effects noted to mother and fetus.[6] However, many anesthetic agents can induce hypotension, which in turn can compromise utero-placental perfusion.[1] It is important to recognize that placental perfusion is solely dependent on maternal mean arterial pressure and is not autoregulated.[1] ACOG recommends single course of corticosteroids for pregnant women between 24-33 weeks gestation who are at risk for premature delivery to stimulate and synthesize the release of surfacant.[5] Routine administration of tocolytics is not recommended and have no proven benefit.[6] Opioids cross the placenta, yet there is no conclusive evidence to support withholding opioids for the treatment of acute pain episodes, as much of the evidence supports that brief exposure is safe.[6] While ephedrine has been a staple in the treatment of maternal hypotension, many studies support the use of phenylephrine to treat hypotension along with left uterine displacement and liberal fluid administration.[1] Neostigmine readily crosses the placenta while glycopyrrolate does not.[7] There have been case reports of fetal bradycardia associated with this combination as noted by Clark et al.,[7] which is why the author suggests use of atropine over glycopyrrolate. However, with judicious administration of muscle relaxants to our patient, glycopyrrolate was chosen to avoid fetal tachycardia and beat-to-beat variability that could occur with atropine administration. According to Society for Obstetric Anesthesia and Perinatology[8] they have advised against the use of sugammadex. It binds and encapsulates progesterone which is a vital hormone in maintaining homeostasis during pregnancy and has many physiological implications.

Physiological considerations included 15 degree left uterine displacement to minimize aortocaval compression. Meticulous preoxygenation was commenced as FRC is reduced 20% in pregnancy and increased oxygen consumption make the mother prone to rapid desaturation. Insufflation

pressures up to 15mmHg have been utilized without adverse events to mother and fetus; yet, recommendations to limit pressure to less than 12mmHg have been advocated to reduce pulmonary insufiency.[3] Other respiratory considerations in the parturient include vascular and capillary engorgement that can lead to decreased airway diameter, increased tissue fragility, and airway edema that may require a smaller ETT. Aspiration risk is increased in pregnancy as progesterone relaxes the lower esophageal sphincter tone.[1] Ventilation was maintained to keep the PCO_2 within normal range. Anesthetic requirements are generally reduced about 20-30% in pregnancy. Volatile agents are known to cause uterine atony inhibiting uterine contractility. This may be beneficial in preventing preterm uterine contractions.

Surgery can be safely performed during pregnancy. In our case the interdisciplinary team coordinated an approach that supported the anesthetic concerns that differentiate care of the parturient, and addressed potential complications and risks/benefits to both mother and fetus. Adequate availability of resuscitative resources was assured before proceeding with surgical intervention. These considerations impact the safety and care of both mother and fetus undergoing non-obstetric surgery.

References

1. Sviggum H. Anesthesia for nonobstetric surgery during pregnancy. UpToDate. https://www.uptodate.com/contents/anesthesia-for-nonobstetric-surgery-during-pregnancy. Published December 2, 2021. Accessed May 2, 2022.
2. SM Brown, FRCA, JR Sneyd, FRCA, Nitrous oxide in modern anaesthetic practice, *BJA Education*, Volume 16, Issue 3, March 2016, Pages 87–91, https://doi.org/10.1093/bjaceaccp/mkv019
3. Pearl JP, Price RR, Tonkin AE, Richardson WS, Stefanidis D. SAGES guidelines for the use of laparoscopy during pregnancy. *Surg Endosc*. 2017;31(10):3767-3782. doi: 10.1007/s00464-017-5637-3.
4. Buser KB. Laparoscopic surgery in the pregnant patient: results and recommendations. JSLS. 2009;13(1):32-35.
5. Nonobstetric surgery during pregnancy. ACOG. https://www.acog.org/clinical/clinical guidance/committee-opinion/articles/2019/04/nonobstetric-surgery-during-pregnancy. Accessed May 2, 2022.
6. Upadya M, Saneesh P. Anaesthesia for non-obstetric surgery during pregnancy. *Indian J Anaesth*. 2016;60(4):234-241. doi: 10.4103/0019-5049.179445.
7. Clark RB, Brown MA, Lattin DL. Neostigmine, atropine, and glycopyrrolate: does neostigmine cross the placenta?. *Anesthesiology*. 1996;84(2):450-452. doi:10.1097/00000542-199602000-00026
8. Willett, Butwick, Togioka, Bensadigh, Hofer, Zakowski. Soap statement sugammadex during pregnancy lactation approved. https://www.soap.org/assets/docs/SOAP_Statement_Sugammadex_During_Pregnancy_Lactation_APPROVED.pdf. Published April 22, 2019. Accessed May 2, 2022.

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Anesthetic Considerations for a Pediatric Patient with Mastocytosis

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Keywords: mastocytosis, pediatric, anesthesia, immediate hypersensitivity reaction, mast cell degranulation

Mastocytosis, a disorder characterized by abnormal increases in tissue mast cells, affects about 1 in 20,000 individuals.[1] A wide range of symptoms and clinical manifestations are based on the affected mast cells' location which can be limited to the skin or infiltrate the bone marrow and other organs. Mastocytosis is divided into seven categories based on onset of age, phenotype, and clinical characteristics.[2] Cutaneous mastocytosis is the most frequent phenotype and occurs mainly in childhood, with resolution of symptoms at or shortly after puberty.[1] Perioperative triggers cause mast cell degranulation with corresponding symptoms in a patient with mastocytosis.

Case Report

An 8-year-old male presented to the healthcare facility for dental restoration under general anesthesia. The patient had no known allergies, weighed 31.3 kg and was 125 cm in height. Past medical history included former 36-week prematurity, mastocystoma, mild obstructive sleep apnea, and active dental caries. The patient was prescribed cetirizine 10 mg daily, montelukast 5 mg nightly, and diphenhydramine 10 mg as needed for allergy symptoms. There was no prior surgical or anesthetic history and no family history of anesthetic complications. Review of systems revealed mastocytomas on the right calf and right posterior shoulder. The patient otherwise had a normal physical exam.

The patient was premedicated in the preoperative area 30 minutes prior to induction of anesthesia with oral diphenhydramine 25 mg, midazolam 20 mg, and famotidine 20 mg. Upon arrival to the operating room (OR), the patient was transferred to the OR table and induced in the supine position with N_2O 7 L/min, O_2 3 L/min, and sevoflurane with an inspired concentration of 8%. After inhalational induction, standard monitors were applied. Peripheral intravenous (IV) access was obtained in the dorsum of the left hand. Oxymetazoline 0.05% nasal spray was administered into bilateral nares to facilitate nasal intubation. The patient received propofol 30 mg, fentanyl 30 mcg, and a maintenance of lactated Ringer's (LR), intravenously. The trachea was intubated through the right naris via direct laryngoscopy with use of McGill forceps. Once placement of the nasotracheal tube was verified by bilateral breath sounds and positive end-tidal CO_2, the endotracheal tube was secured and mechanical ventilation initiated. General anesthesia was maintained with sevoflurane 3% inspired concentration in a mixture of O_2 1 L/min and air 1 L/min. A nasopharyngeal temperature probe was placed to monitor core temperature throughout the procedure.

The table was turned 90 degrees and a lower body Bair Hugger (3M) was applied. The patient's face was draped by the surgeon with care to protect the eyes, ears, and nose. An opening in the drapes allowed for the patient's cheeks to remain exposed to monitor for flushing.

Dexamethasone 12 mg IV was given immediately post intubation. Ondansetron 3 mg IV was given for postoperative nausea and vomiting (PONV) prophylaxis. At the conclusion of the procedure, lidocaine 2% with 1:100,000 epinephrine 0.5 mL was given by the surgeon at the tooth extraction sites to reduce postoperative pain. After local anesthetic administration, the patient's heart rate transiently increased from 82 to 106/min; otherwise, vital signs remained stable throughout the procedure.

At the conclusion of the surgery, acetaminophen 310 mg IV was given for postoperative analgesia. Mechanical ventilation was discontinued and O_2 8 L/min was administered. At this time, the patient was spontaneously breathing. The trachea was extubated while the patient remained under a deep plane of anesthesia, and an appropriately sized oral airway was placed. The patient was moved to the stretcher and positioned in the left lateral decubitus position. A Jackson Rees circuit with O_2 6 L/min via face mask and pulse oximetry monitor were used to transport the patient to the post anesthetic care unit. The patient's perioperative course was uncomplicated; no immediate hypersensitivity reactions were triggered.

Discussion

Immediate hypersensitivity reactions in the perioperative period result from exposure to a defined stimulus at a dose that is normally tolerated by others.[2] There are two subgroups of immediate hypersensitivity reactions: non-allergic and allergic. Non-allergic hypersensitivity reactions do not involve immune mechanisms while allergic hypersensitivity reactions involve an immune response. Allergic hypersensitivity is IgE-mediated through the release of basophil and mast cell degranulation and inflammatory mediators.[2,3]

Mastocytosis is a non-IgE-mediated immediate hypersensitivity reaction. Mast cell degranulation results from nonspecific triggers which include psychological, pharmacological, and mechanical factors, and temperature changes. Degranulation of mast cells results in the release of histamine, proteases (tryptase, chymase), lipid mediators (LTC4, PGD2), and cytokines (TNFa, IL1, IL6).[2,3]

Perioperative management of a patient with mastocytosis is guided by the clinical expression of the immediate hypersensitivity reaction. Clinical features mainly involve the skin and cardiovascular system. The primary actions of release of mediators and cytokines include vasodilation, increase in capillary permeability, smooth muscle contraction, nerve end stimulation, and direct cardiac effect.[2,3] Symptoms include pruritus, flushing, erythema, urticaria, scleral and eyelid edema, tachycardia, hypotension, gastroesophageal reflux, vomiting, and diarrhea. Reactions usually occur within minutes of the triggering event.[2] The main goal in the perioperative period is to prevent mediator release.[4]

Anxiolysis in the perioperative period is common among pediatric patients. Depending on the age of the pediatric patient, separation from parents upon call to the operating room can cause psychological stress. This, anxiety, and pain can all precipitate mast cell degranulation.[3] Administering midazolam orally preoperatively was determined to be safest way to achieve separation with the least amount of stress induced on the child. Pain was controlled with fentanyl and acetaminophen IV, both of which are considered safe agents.[2-5] Local anesthetic of lidocaine 2% was administered by the surgeon to help with postoperative pain management from tooth

extractions. Lidocaine for local injection is safe for those with mastocytosis.[5] Other considerations to avoid triggering mastocytosis include ensuring a quiet OR environment and scheduling the surgery early in the day to reduce anxiety of the pediatric patient.[2]

Histamine-releasing agents should be avoided. Medications that are not recommended for use in patients with mastocytosis include atracurium, mivacurium, and nefopam. NSAIDs, dextromethorphan, opioids such as morphine and codeine, muscle relaxants, and antibiotics are also potential triggers of an immediate hypersensitivity reaction.[5] Rapid administration of histamine-releasing medications should be avoided, and careful titration should be utilized.[2,3] Histamine-releasing medications were avoided during this surgical procedure. Histamine receptor antagonists and corticosteroids are recommended to be administered preoperatively. Diphenhydramine and famotidine were administered orally preoperatively, and dexamethasone administered IV immediately post induction. The patient's prescribed medications of cetirizine and montelukast were continued until day of surgery. While antibiotics were not indicated for this procedure, they were not purposefully withheld since there was no history of sensitivity.

Extremes of temperature can induce mast cell degranulation.[2,3] Core temperature should be monitored throughout all phases of the surgical procedure. Avoidance of hypothermia is essential. Prevention techniques include forced-air warming devices, warmed anesthetic gas and higher OR temperatures. Other ways recommended to maintain normothermia include using warmed IV fluids and irrigation.[2]

Mechanical factors such as mild trauma to skin lesions associated with cutaneous mastocytosis can lead to mast cell degranulation through the release of chymase. Chymase is a neutral protease released from mast cells, causing a weakening of dermo-epidermal junction. A wheal-and-flare response (Darier's sign) occurs which leads to urticaria, edema, and blister formation. This occurs especially in young children since the dermo-epidermal junction is poorly formed.[2,3] Direct pressure to any of these skin lesions can cause this response in the patient with mastocytosis. Anesthetic considerations include positioning around skin lesions, careful facemask placement (if facial lesions are present) and tourniquet use, either for IV placement or surgical procedure. This patient had skin lesions on his right calf and posterior shoulder. Care was taken to ensure no trauma occurred to these lesions during positioning and transferring.

Surgery itself can also induce mast cell degranulation, not only due to mechanical factors but also from the stress response to painful stimulation.[2] It is important for the anesthesia provider to anticipate the stimulating or painful events of the surgical procedure by providing pain relief with opioids which do not release histamine. Ensuring adequate depth of anesthesia prior to manipulating the airway for intubation and extubation is imperative. Deep extubation technique was utilized in this case to reduce the likelihood of mast cell degranulation.

In conclusion, the main perioperative goal for a patient with mastocytosis is to prevent mast cell degranulation. Avoidance of triggering agents is key. A knowledge of triggers and methods to prevent this type of hypersensitivity reaction are important when caring for pediatric patients with mastocytosis. Current recommendations for perioperative management of the patient with systemic mastocytosis include administration of H_1- and H_2-receptor antagonists, leukotriene blockers, and low-dose corticosteroids at least one hour prior to anesthesia, contrast

administration, and surgery.[3-6] The presented patient was diagnosed with cutaneous mastocytosis; however, precautions were taken as though the patient had systemic mastocytosis since this was the first anesthetic encountered by the child.

References

1. Akin C, Broesby-Olsen S, Valent P. Mastocytosis: overview of diagnosis and clarification. In: Akin C. *Mastocytosis.* Springer Nature Switzerland AG; 2020:23-31.
2. Dewachter P, Castells MC, Hepner DL, Mouton-Faivre C. Perioperative management of patients with mastocytosis. *Anesthesiology.* 2014;120(3):753-759. doi:10.1097/ALN.0000000000000031
3. Castells M. Drug allergy and perioperative management of mastocytosis. In: Akin C. *Mastocytosis.* Springer Nature Switzerland AG; 2020:175-184.
4. Matito A, Morgado JM, Sánchez-López P, Álvarez-Twose I, Sánchez-Muñoz L, Orfao A, Escribano L. Management of anesthesia in adult and pediatric mastocytosis: a study of the Spanish network on mastocytosis (REMA) based on 726 anesthetic procedures. *Int Arch Allergy Immunol*. 2015;167:47-56. doi:10.1159/000436969
5. Schaffer, JV. Pediatric mastocytosis: recognition and management. *Am J Clin Dermatol.* 2021(22):205-220. doi:10.1007/s40257-020-00581-5
6. Bocca-Tjeertes IFA, van de Ven AAJM, Koppelman GH, Sprikkelman AB, Oude Elberink HNG. Medical algorithm: peri-operative management of mastocytosis patients. *Allergy*. 2021;(00):1-3. doi:10.1111/all.14891

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Case Study of a Patient with Mast Cell Activation Syndrome

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Keywords: Anesthesia, oral surgery, anaphylaxis, mast cell activation syndrome, mast cell disease, mastocytosis

Mast cell activation syndrome (MCAS), a subtype of mastocytosis, is a term used to define a rare disorder. It is characterized by abnormal accumulation of tissue mast cells in one or more organ systems, with recurrent systemic symptoms of mast cell activation.[1] The release of proinflammatory and vasoactive mediators results in clinical manifestations ranging in severity from mild flushing or headache to anaphylaxis.[1] For adult patients with mastocytosis, anaphylactic reactions have been observed in 22% to 49% of individuals.[2] Little is known about the mechanisms and triggers underlying this disorder.[1] Patients suffering from this disorder who present for anesthesia may prove challenging and require delicate anesthetic management.

Case Report

A 25-year-old female presented with a diagnosis of active caries for dental restoration. Medical history was significant for mast cell disease, dyslexia, gastroesophageal reflux, migraines, anxiety, stroke, iron deficiency anemia, asthma, mitochondrial metabolism disorder, dystonia, bipolar disorder, attention deficit hyperactivity disorder, Ehlers-Danlos syndrome, degenerative joint disease, opisthotonos, dysautonomia, and risk for malignant hyperthermia (MH). Medications included albuterol, diphenhydramine, ferrous gluconate, hydrocortisone cream, lorazepam, medroxyprogesterone, mometasone, desmopressin, calcium carbonate, cetirizine, cholecalciferol, cimetidine, cyproheptadine, magnesium, mometasone-formoterol inhaler, and montelukast. The last eight medications were taken the day of surgery. The patient weighed 76 kg with a BMI of 30.65 kg/m^2. She had an extensive drug allergy list, which included the following medications with the reaction shown in parentheses. Allergies included aspirin (bleeding disorder), barium iodide (anaphylaxis), barium sulfate (pulseless ventricular tachycardia), celecoxib (anaphylaxis), clarithromycin (hives), influenza vaccine (hives), mint (anaphylaxis), non-steroidal anti-inflammatory agents (mitochondrial disease), trimethoprim (hives), triptans-5-HT1 antimigraine agents (anaphylaxis), lactated Ringer's (dystonia), monosodium glutamate (hallucinations), aminocaproic acid (mitochondrial disease), gentamicin (hearing loss), nitrous oxide (dystonia), succinylcholine (MH risk), lidocaine (dystonia), sulfanomide antibiotics (hives), and penicillin (dystonia). Her past anesthetic history consisted of PEG tube placement and removal, dental surgery, knee surgery, and removal of a benign tumor. All laboratory values and preoperative vital signs were within normal limits. She had a normal airway examination with a Mallampati score of II and thyromental distance greater than 6 cm. The patient was alert and oriented; however, she was very anxious regarding the procedure for fear of anaphylaxis.

The anesthetic plan was devised, taking precautions to remove any medications known to trigger MH. Volatile inhaled anesthetics and succinylcholine were removed from the room. Lidocaine was also removed from the room due to the patient's reaction to this medication in the past. The anesthesia machine was flushed for 20 minutes with a new CO_2 absorber and charcoal filters in place. After 20 minutes, the filters, circuit, and absorber were changed a second time. The patient had an uncomplicated intravenous (IV) induction with midazolam 2 mg, propofol 200 mg, fentanyl 50 mcg, and rocuronium 50 mg. Induction was followed by video laryngoscopy and endotracheal tube intubation, and mechanical ventilation was initiated after placement. Immediately after induction, diphenhydramine 25 mg, famotidine 20 mg, and dexamethasone 10 mg were given IV. Anesthesia was maintained with a propofol infusion at 120 mcg/kg/min and a remifentanil infusion of 0.2 mcg/kg/min with a target mean arterial pressure (MAP) of greater than 65 mm Hg.

The patient received a total of 1000 ml of 0.9% sodium chloride during the 3-hour procedure. Hydromorphone was titrated throughout the case for a total of 2 mg IV along with fentanyl 125 mcg IV. Stable vital signs were maintained throughout the surgery, and the procedure was completed without surgical or anesthetic complications. With a train of four count showing 4/4 twitches, neuromuscular blockade was antagonized with neostigmine 2 mg and glycopyrrolate 0.4 mg IV. Extubation proceeded without incident, and the patient was transported from the operating room to the post-anesthesia care unit (PACU).

Shortly after arrival to the PACU, the patient began to have recurrent dystonic reactions with periods of unconsciousness. Vital signs remained stable throughout. This incident was thought to be either a dystonic reaction or possibly a vasovagal episode. The episode was treated with lorazepam 2 mg, diphenhydramine 25 mg, and propofol 20 mg IV, and dissipated without consequent sequelae. A basic metabolic panel (BMP) was drawn; all electrolytes were within normal limits. The patient was admitted for monitoring and treatment of dystonia. Upon waking, she reported feeling body aches and myalgia for which she received acetaminophen 1 g and magnesium sulfate 2 g IV. She was monitored overnight with no other episodes and discharged home the following morning.

Discussion

Perioperative anaphylaxis is an immediate hypersensitivity reaction that is usually IgE-mediated and involves mast cells.[2] Mast cells are an important component of immunity, interacting with the innate and adaptive immune systems in the detection of harmful pathogens such as viruses, bacteria, parasites, and toxins.[3] Mast cells also act as the main effector cells in Type I allergic reactions and diseases (e.g., anaphylaxis, asthma, allergic rhinitis, conjunctivitis, and urticaria).[3] Pathologies begin to arise when excessive mast cell activation occurs and the incidence of recurrent anaphylactic reactions surface. Intraoperative anaphylaxis is most likely to be triggered by antibiotics and neuromuscular blocking agents.[2]

The most common presentation of anaphylaxis involves clinical signs within the grade III category, including cardiovascular collapse, tachycardia, and cutaneous features.[2] Cutaneous features may involve generalized erythema, extensive urticaria, and swelling of the eyelid, lip, and/or tongue can occur.[2] Tachycardia may rapidly evolve into bradycardia or cardiac dysrhythmia. The mechanism behind paradoxical bradycardia involves the Bezold-Jarisch reflex. This reflex occurs due to sudden decreases in peripheral resistance combined with decreased venous return, due to the release of vasoactive mediators causing interstitial capillary leakage and subsequent massive hypovolemia.[2] If cardiovascular collapse is associated with paradoxical bradycardia, atropine must be avoided as it can induce circulatory arrest.[2]

Management of anaphylaxis involves multiple steps that must be completed in rapid succession. Withdrawal of the culprit drug (if known) is the first step that must be considered, followed by placement of 100% oxygen and a liberal infusion of intravenous fluids.[3] Temporary discontinuation or lightening of the depth of anesthesia should be considered as cardiovascular disturbances that accompany anaphylaxis will be exacerbated by the depressant effects of general anesthesia.[2] A recommended 10 to 30 ml/kg of IV fluid is needed to compensate for the peripheral vasodilation and severe capillary leakage that occurs with anaphylactic onset.[4] Up to 73% of the blood volume may extravasate into the interstitial space within 15 minutes after onset.[2] Positioning of the patient can facilitate venous return to the heart by utilizing the leg raise maneuver or Trendelenburg position.[2] Epinephrine should be administered according to the severity of the anaphylactic reaction. Grade III reactions should be treated with 100 to 200 mcg given either subcutaneously, intramuscularly, or intravenously every 1 to 2 minutes.[4] In grade IV reactions involving cardiac and/or respiratory arrest, epinephrine 1 mg should be administered intravenously per American Heart Association's protocol.[4]

Patients with mastocytosis require certain precautions to be taken throughout the perioperative period. Preoperative H_1 or H_2 antihistamine or corticosteroid administration is usually recommended for patients with a history of mastocytosis, but this intervention has never been evaluated.[5] Any medications that the patient currently uses to maintain mast cell stability should be continued until surgery, and known triggers avoided whenever possible.[5,6] The aim of chronic treatment is to prevent symptoms of mast cell activation through prophylactic drug administration, with the first-line agent including histamine receptor blockers.[3,6] In the event any grade of anaphylaxis is suspected (e.g., I to IV), a subsequent investigation should be completed postoperatively through plasma histamine measurements, tryptase measurements, and skin testing to determine the specific causes.[5]

In this case, the patient was on a home regimen of oral cetirizine 10 mg twice daily, ranitidine 150 mg twice daily, montelukast 20 mg daily, and an EpiPen available at all times for treatment of mastocytosis. In addition to the patient's home medication regimen, IV diphenhydramine 25 mg, famotidine 20 mg, and dexamethasone 10 mg were given prophylactically. The patient received corticosteroids upon induction of anesthesia but may have further benefited from earlier administration. All medications used during this procedure were previously administered during the patient's last surgery with no adverse events occurring at that time. As current recommendations state, the patient's medication regimen was continued up to the day of surgery and preoperatively an H_2 receptor blocker was administered.

By increasing practitioner awareness of MCAS-based anaphylactic reactions, treatment can be quickly and efficiently delivered for this high-risk group. Further education for practitioners and clinical protocols are needed for MCAS patients presenting to the operating room to improve knowledge of this syndrome and treatments.

References

1. Valent P. Risk factors and management of severe life-threatening anaphylaxis in patients with clonal mast cell disorders. *Clin Exp Allergy.* 2014; 44(7):914-20. doi:10.1111/cea.12318
2. Dewachter P, Savic L. Perioperative anaphylaxis: pathophysiology, clinical presentation, and management. *Br J Anaesth.* 2019;19(10):313-320. doi:10.1016/j.bjae.2019.06.002
3. Romantowski J, Gorsak A, Lange M, Nedoszytko B, Gruchala-Niedoszytko M, Niedoszytko M. How to diagnose mast cell activation syndrome: practical considerations. *Pol Arch Intern Med.* 2020;130(4):317-323. doi:10.20452/pamw.15212
4. Higgens-Roche B. The immune system and anesthesia. In: Nagelhout J, Elisha S. *Nurse Anesthesia*. 6th ed. Elsevier; 2018:969-971.
5. Dewachter P, Kopac P, Laguna J, et al. Anaesthetic management of patients with pre-existing allergic conditions: a narrative review. *Br J Anaesth.* 2019;123(1):65-81. doi:10.1016/j.bja.2019.01.020
6. Valent P, Akin C, Nedoszytko B, et al. Diagnosis, classification and management of mast cell activation syndromes (mcas) in the era of personalized medicine. *Int J Mol Sci.* 2020;21:9030. doi:10.3390/ijms21239030

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Argatroban: A Non-heparin Alternative during Carotid Endarterectomy

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Keywords: Carotid endarterectomy, argatroban, anticoagulation, HIT, direct thrombin inhibitor

Heparin is the most widely used anticoagulant in the United States. However, patients are at risk for developing heparin-induced thrombocytopenia (HIT), with an incidence between 0.1-7%.[1] This case report discusses the use of argatroban, a non-heparin alternative for anticoagulation therapy during carotid endarterectomy (CEA) in a patient with a history of HIT. Appropriate intraoperative use of this drug is highlighted and followed by recommendations from the American Society of Hematology (ASH).

Case Report

A 65-year-old male weighing 95 kg presented to the hospital for an elective right-sided CEA. The patient was referred for a computed tomography-angiogram study and diagnosed with 90% stenosis of his right internal carotid artery. The patient had a history of a right-sided cerebrovascular accident (CVA) 3 years prior, hypertension, and non-insulin dependent diabetes mellitus. He had residual expressive aphasia and a gait disturbance.

During the preoperative exam, the patient claimed to have no known drug or food allergies. However, the electronic medical record listed heparin as an allergy with no specified reaction. It was discovered that the patient received heparin approximately one month after his CVA. At that time, his platelet count decreased significantly to 87 K/uL with a concern for HIT. Heparin administration was immediately ceased, and his platelet count returned to normal over two days. Laboratory testing for heparin-induced platelet factor 4 antibodies revealed that the patient's serum had no reactivity for IgG antibodies to heparinoid and platelet factor 4 complexes. While the history of HIT was unclear, the decision was made to use argatroban for intraoperative anticoagulation as an alternative to heparin. The patient's most recent complete blood count revealed a platelet count of 144 K/uL.

The patient was brought to the operating room and general anesthesia was induced with fentanyl 100 mcg, lidocaine 100 mg, propofol 200 mg, and rocuronium 60 mg intravenously (IV). After an uneventful intubation, an arterial line was placed in the right radial artery to allow for continuous blood pressure monitoring and frequent blood sampling. The surgeon requested the systolic blood pressure to be maintained at 150 mm Hg, which required titration of a phenylephrine IV infusion. An arterial blood sample was obtained to check a baseline activated clotting time (ACT) which was 99 seconds. The surgeon dissected via an incision to the right lateral neck to isolate the internal, external, and common carotid arteries. The surgeon placed a shunt between the common carotid and internal carotid arteries to preserve cerebral perfusion while they were clamped. At that time, an initial bolus of argatroban 350 mcg/kg was administered IV to the patient over 3 minutes. An IV infusion of argatroban was initiated after the bolus at a rate of 25 mcg/kg/min. A blood sample was obtained five minutes after the bolus which resulted in an ACT of 382 seconds. This ACT was within the goal parameters of 300-450

seconds. Therefore, no adjustments were made to the argatroban infusion. The surgeon proceeded to clamp the carotid arteries and removed the atherosclerotic plaques. ACTs were obtained every 30 minutes, with consecutive times of 392 and 386 seconds.

After removal of the plaques, the surgeon repaired the defects in the carotid arterial walls, and removed the shunt. Vascular control was removed from the common and external carotid arteries simultaneously, followed by the internal carotid artery. The argatroban infusion was discontinued. The surgeon closed the incision after achieving hemostasis, and the patient emerged from general anesthesia. Dexmedetomidine 20 mcg IV was administered to aid in producing a smooth emergence from general anesthesia and to minimize blood pressure fluctuations upon extubation. After extubation, the patient was transported to the post-anesthesia care unit in stable condition. The estimated blood loss was 50 mL.

Discussion

Heparin is the most widely utilized anticoagulant among hospitalized patients, with an estimated 12 million patients receiving the drug annually.[1] Despite the frequent use of heparin, practitioners must remain vigilant for the presence of HIT. HIT is characterized by a marked decrease in platelets. This autoimmune disease process occurs due to the formation of IgG antibodies to platelet factor 4/heparin complexes. Antibodies attack and destroy platelets while simultaneously activating platelets. If recognition of HIT goes undiagnosed, it can progress to a prothrombotic state that places patients at risk for thrombus formation. This severely increases morbidity and mortality by increasing the risk of deep vein thrombosis, pulmonary embolism, limb necrosis, acute myocardial ischemia, cerebrovascular accidents, and disseminated intravascular coagulation (DIC) if left untreated.[1] If clinicians are suspicious of HIT, it is imperative to cease heparin therapy immediately and transition to an alternative anticoagulant to prevent the formation of a thrombus.

This case study highlighted the need for anticoagulation during CEA in a patient with a questionable history of HIT. The patient had a history of a marked decrease in platelets to 87 K/uL while on heparin therapy. However, the lack of IgG antibodies to platelet factor 4/heparin complexes did not support this assumption. Therefore, the decision was made to use argatroban for anticoagulation. Argatroban is a direct thrombin inhibitor that works by reversibly binding to the active site on thrombin.[2] It is approved by the United States Food and Drug Administration (FDA) for prophylaxis and treatment of HIT with or without thrombosis, as well as approval for anticoagulation during percutaneous coronary intervention (PCI) in patients with HIT.[2] Argatroban has several non-FDA uses in the presence of HIT such as during cardiopulmonary bypass and renal replacement therapy.[2]

Argatroban is metabolized by the liver, specifically via cytochrome P-450 enzymes. Consequently, practitioners should use caution in patients with hepatic impairment. It has a short half-life of approximately 45 minutes.[3] This brief half-life is a beneficial attribute because there is no currently approved reversal agent for argatroban.[3] After cessation of an infusion, the anticoagulant effects will dissipate within 4 hours. Patients with hepatic impairment will have a significantly prolonged clearance of the drug. The only contraindications to the use of argatroban are overt bleeding and a history of hypersensitivity to the drug.[2]

There are different dosage recommendations based on the type of anticoagulation therapy necessary. Anticoagulation during vascular surgeries such as CEA should follow percutaneous coronary intervention (PCI) dosing. In this case, an initial IV bolus of argatroban at 350 mcg/kg over 3 minutes was administered, followed by initiation of an IV infusion at 25 mcg/kg/min. ACTs are favored over partial thromboplastin times (PTT) in the operating room; however, both are acceptable forms of monitoring when administering argatroban. During the CEA, all ACTs were within the targeted therapeutic range of 300-450 seconds. No adjustments were made to the IV infusion during the procedure. At the end of the surgery, after the carotid artery cross clamps were removed, the infusion was discontinued. Blood samples were obtained one hour post-operatively and resulted in a PTT of 89 seconds and international normalized ratio (INR) of 2.2. One week later, additional blood samples were taken, revealing a normalized INR of 1.1. In hindsight, it would have been more appropriate to order coagulation studies between 2-4 hours postoperatively to monitor for a return to pre-treatment levels.

In 2018, the American Society of Hematology (ASH) released guidelines for the management of HIT. The ASH classifies HIT into several categories. In this case report, the patient would fall under the category of having remote HIT. Remote HIT is defined as platelet counts which have returned to normal with no detectable anti-PF4 antibodies.[4] The ASH recommends that patients with remote HIT undergoing PCI should receive bivalirudin, a direct thrombin inhibitor, for anticoagulation.[4] They add that argatroban might be a suitable substitute.[4] The ASH also recommends that heparin may be used as an anticoagulant for PCI in patients with remote HIT if a heparin alternative such as bivalirudin or argatroban is not available, but use should be limited to the intraoperative setting.[4] Furthermore, the ASH recommends using heparin for patients with remote HIT who require cardiovascular surgery.[4] These recommendations were surprising; however, a systematic review of 136 patients with a history of HIT who received heparin for cardiac or vascular surgeries found the incidence of recurrence of HIT to be 2.1%.[5] This percentage falls within the clinically anticipated 0.2-5% incidence of HIT after initial exposure to heparin.[5] Thus, there is no difference in the risk of developing HIT, regardless of patient history. Future anesthetic plans for this patient population should include the use of argatroban; bivalirudin and heparin may also be considered.

References

1. Salter BS, Weiner MM, Trinh MA, et al. Heparin-induced thrombocytopenia: a comprehensive clinical review. *J Am Coll Cardiol*. 2016;67(21):2519-2532. doi:10.1016/j.jacc.2016.02.073
2. Mahat KC, Sedhai YR, Krishnan P. Argatroban. *StatPearls*. Treasure Island, FL. StatPearls Publishing. November 12, 2020. Accessed July 15, 2021.
3. Thomas S, Makris M. The reversal of anticoagulation in clinical practice. *Clin Med*. 2018;18(4):314-319. doi:10.7861/clinmedicine.18-4-314
4. Cuker A, Arepally GM, Chong BH, et al. American Society of Hematology 2018 guidelines for management of venous thromboembolism: heparin-induced thrombocytopenia. *Blood Adv*. 2018;2(22):3360-3392. doi:10.1182/bloodadvances.2018024489

5. Dhakal P, Giri S, Pathak R, et al. Heparin reexposure in patients with a history of heparin-induced thrombocytopenia. *Clin and Appl Thromb Hemost*. 2015:626-631. doi:10.1177/1076029615578167\

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Intraoperative Anaphylactic versus Anaphylactoid Reaction

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Keywords: anaphylactic, anaphylaxis, anaphylactoid, anesthesia, rocuronium, sugammadex, albumin

Anaphylactic reactions during the intraoperative period involve multiple organ systems and can cause serious and potentially fatal conditions. Anaphylaxis is an immune-mediated type I reaction from IgE activation that occurs after the second exposure to a substance. Anaphylactoid reactions are classified as non-IgE mediated type I reactions. These reactions occur upon first exposure to an antigen through the direct degranulation of basophils and mast cells. Early recognition and management of these reactions in the anesthetized patient is imperative. This case report discusses the care of a patient with a type I reaction of unknown etiology during a cervical 6 (C6) to thoracic 1 (T1) posterior fusion.

Case Report

A 30-year-old male presented for a C6-T1 posterior fusion. The patient was three days post motor vehicle accident (MVA) with a closed LeFort I fracture, bilateral mandibular fractures, and multiple closed fractures of facial bones. His medical history was significant for polysubstance abuse. His past surgical history was negative and he was not taking any medications. No allergies were reported. The patient was alert and oriented. A metabolic panel, complete blood count (CBC), urine toxicology and type and crossmatch were obtained. All laboratory values were unremarkable, except for the urine toxicology which was positive for marijuana and cocaine.

In the operating room (OR), standard noninvasive monitors were applied. Vital signs were all within normal limits prior to induction. The patient was preoxygenated with oxygen at 8L/min via facemask. General anesthesia was induced with intravenous (IV) midazolam 2 mg, fentanyl 100 mcg, lidocaine 80 mg, propofol 200 mg, and succinylcholine 100 mg. A Glidescope (Verathon Inc.) with a size four blade was used for intubation while maintaining cervical spine stabilization. A grade I view was achieved and a 7.0 mm endotracheal tube (ETT) was passed with ease and secured at 22 cm at the teeth. Placement was confirmed with chest rise, equal and bilateral breath sounds, and positive end-tidal carbon dioxide ($ETCO_2$) tracing. The patient was mechanically ventilated without complications. Total intravenous anesthesia (TIVA) was initiated with 100mcg/kg/min of propofol and 0.2 mcg/kg/min of remifentanil. Propofol and remifentanil infusions were increased to a maximum rate of 185 mcg/kg/min and 0.5

mcg/kg/min, respectively. Continuous blood pressure monitoring was achieved with a right radial arterial line. A phenylephrine infusion was titrated to maintain a mean arterial pressure (MAP) of 70-85 mm Hg. Dexamethasone 10 mg IV was administered per surgeon request.

The patient was positioned prone while maintaining a neutral neck position. Bilateral breath sounds were auscultated and $ETCO_2$ was adequate while prone. Arms were padded, tucked at the sides with patent IVs infusing. Cefazolin 2 g and gentamicin 180 mg IV were administered slowly, without reaction. Baseline neuromonitoring was assessed. At 1012, incision was made and the patient was given rocuronium 40 mg IV per surgeon request to facilitate exposure. At 1042, the surgeon requested reversal of the paralytic and sugammadex 200 mg IV was administered. At 1050, albumin 25 g IV was added to the remaining 400 mL of lactated Ringers currently infusing. At 1100, a precipitous drop in blood pressure from 125/70 to 60/30 mm Hg was noted. There was no evidence of increased peak inspiratory pressures (PIP), urticaria, or tachycardia. Albumin containing fluids were disconnected and a lactated Ringer's bolus was administered. Ephedrine 20 mg and phenylephrine 200 mcg were administered IV with little result. Epinephrine 0.1 mg and diphenhydramine 50 mg IV were administered. The procedure was aborted and the patient was emergently returned to supine position. The patient's blood pressure stabilized and he was transported to the Intensive Care Unit (ICU) intubated, sedated with propofol, and not requiring further support from the phenylephrine infusion. No additional doses of epinephrine were needed.

The patient returned to the OR 4 days later for bilateral mandible-maxillary open reduction internal fixation. Albumin was now listed as an allergy. Both rocuronium and sugammadex were administered without incident. One month after the first surgery, the patient returned to the OR for bilateral orbital floor fracture reconstruction with custom plates. During this surgery, both rocuronium and sugammadex were listed as allergies and vecuronium was used as the neuromuscular antagonist for this case. Reversal of neuromuscular blockade was achieved with neostigmine and glycopyrrolate.

Discussion

Anaphylaxis is a life-threatening, generalized form of systemic hypersensitivity that is usually diagnosed based on the clinical course.[1] It is difficult to identify the cause of anaphylaxis during anesthesia because there are often multiple drugs to consider. This patient was given rocuronium, sugammadex, and albumin within a short period of time, leaving any of these medications to be the culprit. There was no previous exposure to any of these agents. However, allergic reactions can happen if prior exposed to a product that is similar to the triggering substance or, in the case of an anaphylactoid reaction, on initial exposure.

Anaphylactoid reactions are immediate and systemic, mimicking anaphylaxis without IgE-mediation. These reactions are caused by agents or events that induce sudden, massive mast cell or basophil degranulation. They account for approximately 77% of all hypersensitivity reactions and can be induced by substances of many kinds, including antibiotics, anticonvulsants, and nonsteroidal anti-inflammatory drugs (NSAIDs).[2] Hypersensitivity reactions are more common after certain foods and additives such as benzoates or sulfites.[2]

Attributes of drugs and triggering agents that may be more antigenic include molecular weight or prompting the release of vasoactive substances such as histamine. High molecular weight allergens are known to induce type I hypersensitivity responses by inducing IgE antibodies.[2] Sugammadex has a molecular weight that is almost three times that of rocuronium which increases its antigenic properties. Additionally, metabolites of some drugs can have a higher rate of antigenicity than the parent compound. Skin tests for these drugs could present as false negatives unless testing for the specific metabolite.[2]

Neuromuscular blocking agents are the most common cause of perioperative anaphylaxis (69.2%), followed by latex (12.1%) and antibiotics (8%).[1] However, this patient received rocuronium during the second surgical case and did not have a reaction. This led to the conclusion that it was not the rocuronium that caused the initial allergic reaction in the patient. It may also indicate that there was no IgE-mediated response as it was the second exposure to the drug.

There have been reports of anaphylaxis after the administration of sugammadex. Sugammadex is a modified gamma-cyclodextrin. Cyclodextrin is a food preservative that is used worldwide. Studies suggest the increase in reactions is due to prior sensitization to sugammadex through the ingestion of this preservative.[3] Newer studies focus on the sugammadex-rocuronium inclusion complex as an allergen, with IgE-dependent anaphylaxis in some patients.[4] This patient received sugammadex during the second surgery, almost eight hours after the initial dose of rocuronium, without incident. The half-life of rocuronium is 1.4-2.4 hours; therefore, the majority administered should have been metabolized. Reaction to the inclusion complex would likely have been seen during the first surgery since sugammadex was administered forty minutes after rocuronium was given.

While severe reactions are rare, those to albumin have been noted to occur in 1 in 6600 administrations.[5] Albumin is produced from batched human plasma, sterilized by filtration and pasteurization.[6] Currently, human albumin contains 99% albumin and 1% contaminating proteins or globulins.[5] Stabilizing compounds such as caprylate are added to prevent aggregation and have been shown to represent potential allergens.[5] The Federal Drug Administration (FDA) states that anaphylactic reactions and hypotension are rare (>1/10,000, <1/1,000 respectively) and skin disorders such as urticaria, rash, and angioedema are very rare (<1/10,000). These definitive symptoms were lacking in the patient discussed; his only symptom of allergic reaction was profound hypotension. Albumin is not only found in its pure form; it is also a component of certain fibrinogen and erythrocyte concentrates that can trigger anaphylaxis.[7] Specific testing for this hidden allergen should be included in skin prick testing to confirm potential allergy.

Recognition and treatment of intraoperative anaphylactic/anaphylactoid reactions needs to be timely to prevent cardiovascular collapse. The first response is to remove the potential triggering agent and call for help. Administration of epinephrine 0.01 mg/kg IM/IV is suggested to prevent further progression into anaphylactic shock. Additionally, focus on support of blood pressure, stabilization of mast cell degranulation, and reversal of the effects of histamine and vasoactive substances is crucial. Fluid resuscitation combined with the use of vasopressors will help support the blood pressure. The patient should remain intubated until stabilized to avoid complications

from potential airway swelling. H1 and H2 antihistamines, bronchodilators, and glucocorticoids should be considered as additional supportive measures.[8]

In this case, a young, healthy patient with no surgical history had received steroids at the beginning of the case, rocuronium, sugammadex, and albumin slowly, in a diluted form. Given the information presented, no definitive cause of the allergic reaction can be concluded. Either albumin or the sugammadex-rocuronium inclusion complex may have been triggering agents for this patient's anaphylactic or anaphylactoid reaction. It was recommended that the patient undergo allergy testing prior to upcoming surgeries to identify the true cause of his anaphylactic reaction.

References

1. Yoo JH, Kim SI, Ok SI, Park SY, Cho AC, et al. Suspected anaphylactic reaction associated with sugammadex: a case report. *Korean J Anesthesiol*. 2016;69(4):413-416. doi:10.4097/kjae.2016.69.4.413
2. Böhm R, Proksch E, Schwarz T, Cascorbi I. Drug hypersensitivity. *Dtsch Arztebl Int*. 2018;115(29-30):501-512. doi:10.3238/arztebl.2018.0501
3. Gregory RJ, Woehlck H, Lien CA. Sugammadex and hypersensitivity-related reactions: a review. *Curr Anesthesiol Rep*. 2020;10:123-130. doi:10.1007/s40140-020-00390-w
4. Baldo BA. Perioperative reactions to sugammadex. *Curr Treat Options Allergy.* 2020; 7:43-63. doi:10.1007/s40521-020-00248-w
5. Beavers C, Flinchum D, Ayyoubi MT. Severe intraoperative albumin transfusion reaction and review of the literature. *Laboratory Medicine*. 2013;44(4);129-131. doi:10.1309/LMC964NVBLJKBFZC
6. Food and Drug Administration. Albumin (Human) 5%. Updated February 27, 2018. https://www.fda.gov/media/70406/download
7. Komericki P, Grims RH, Aberer W, Kranke B. Near-fatal anaphylaxis cause by human serum albumin in fibrinogen and erythrocyte concentrates. *Anaesthesia*. 2014;69:176-178. doi:10.1111/anae.12411
8. Higgins Roche BT. The immune system and anesthesia. In: Nagelhout JJ, Elisha S, eds. *Nurse Anesthesia.* 6th ed. Elsevier; 2018:969-970.

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Anesthesia for Noncardiac Surgery after Recent Percutaneous Coronary Intervention

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Keywords: drug-eluting stent, percutaneous coronary intervention, anesthesia, noncardiac surgery

Patients who undergo noncardiac surgery within 6 months following percutaneous coronary intervention (PCI) are at markedly increased risk for adverse cardiovascular events.[1,2] Risks are

primarily related to stent thrombosis or excessive bleeding secondary to cessation or continuation of antiplatelet agents, respectively.[2] The incidence of perioperative adverse cardiovascular and cerebrovascular events following noncardiac surgery has decreased over the years; however, it remains unsatisfactory at 15%.[1] The primary goals while managing anesthesia in this patient population is to decrease myocardial oxygen demand and improve plaque stabilization. Thorough communication between the anesthetist, surgeon, and cardiologist is essential for safe management of antiplatelet therapy.

Case Report

A 57-year-old, 168 cm, 79 kg female presented for right profunda to popliteal artery (below knee) bypass under general anesthesia. One day prior to vascular surgery, the patient underwent left heart catheterization prompted by a mildly elevated troponin (0.02 ng/mL) and transthoracic echocardiogram (TTE) with low-risk stress test. The results of the TTE showed akinesis and ischemia at the apex of the heart. Cardiac catheterization revealed diffuse three-vessel disease. Moderate-to-severe diffusely diseased distal left anterior descending and circumflex coronary arteries were present. In addition, the right coronary artery (RCA) demonstrated 80% stenosis. Two drug-eluting stents (DES) were successfully placed in the RCA, leaving a residual 20% stenosis. Post-procedure, dual antiplatelet therapy (DAPT) was initiated, consisting of aspirin and clopidogrel.

The patient's past medical history was significant for peripheral vascular disease, coronary artery disease, myocardial infarction (MI), critical lower limb ischemia, type 2 diabetes mellitus, BMI 28.1 kg/m^2, deep vein thrombosis, and hypertension. Surgical history included left below knee amputation. Relevant medication history included long term anticoagulation for management of peripheral vascular disease (oral apixaban 5 mg every 12 hours and clopidogrel 75 mg daily). Additional medication history included duloxetine, gabapentin, insulin glargine, insulin lispro, lisinopril, morphine, and oxycodone. The patient received oral clopidogrel 75 mg and aspirin 81 mg on the morning of surgery; apixaban was held. The morning of the day of surgery, the patient's hemoglobin and hematocrit were 8.4 g/dL and 27.7%, respectively.

The patient was brought into the operating room, placed in supine position, and standard anesthesia monitors were applied. Pre-induction vital signs were non-invasive blood pressure 171/88 mmHg, heart rate 97/min, and SpO_2 97% on room air. The patient was given midazolam 2 mg intravenously (IV). Arterial cannulation was performed in the right radial artery for continuous blood pressure monitoring using a 20-gauge catheterization set. Induction of anesthesia commenced with administration of fentanyl 300 mcg, lidocaine 100 mg, propofol 180 mg, and rocuronium 50 mg IV. Airway access was established with the use of video laryngoscopy and insertion of a 7.0 mm oral endotracheal tube (ETT). During intubation, the patient's arterial blood pressure increased to 192/94 mmHg and nitroglycerin 40 mcg IV was administered. After confirmation of correct ETT placement by auscultation and sustained capnography, the tube was secured at 22 cm at the lip. A second large bore IV was placed.

Cefazolin 2 g IV was administered prior to incision. Anesthesia was maintained using sevoflurane 1% inspired concentration in a mixture of O_2 1 L/min and air 1 L/min and propofol 60-100 mcg/kg/min infusion. The patient's blood pressure was labile throughout the procedure,

ranging from 103/51 mmHg to 195/90 mmHg. Phenylephrine 0.1-0.7 mcg/kg/min infusion and IV boluses totaling 250 mcg, and nitroglycerin 40 mcg IV boluses were administered twice to maintain normotension. A total of 120 mg rocuronium IV was administered to maintain neuromuscular blockade. Heparin 9000 units IV was administered throughout the duration of the surgery. For pain control, acetaminophen 1 g IV and hydromorphone 0.4 mg IV was given. During the procedure, arterial blood gas revealed hemoglobin 6.8 g/dL and hematocrit 23%; 1 unit (350 mL) packed red blood cells was transfused. In addition, the patient received albumin 25% 25 g and a total of 1,700 mL lactated Ringers crystalloid solution IV. For heparin reversal, protamine 30 mg IV was given. For reversal of neuromuscular blockade, sugammadex 200 mg IV was given.

After a 6.5-hour surgery, the patient was extubated, placed on O_2 10 L via nonrebreather mask and transferred to the post-anesthesia care unit (PACU) during which vital signs remained stable. From PACU, the patient was transferred to the Intensive Care Unit for close monitoring and to the floor two days post-op, where she received continued evaluation for PVD.

Discussion

Each year, approximately one million patients receive coronary stent implantation in the United States and Europe.[3] Of these patients, approximately 15% undergo noncardiac surgery within one year after stent surgery.[4] These patients are at increased risk for adverse cardiovascular and/or cerebrovascular perioperative events.[4] This risk is primarily due to stent thrombosis or bleeding, depending upon administration of antiplatelet therapy.[4] In a multicenter observational study that viewed 432 surgical procedures of patients with coronary stents, 15% underwent noncardiac surgery and experienced a major adverse cardiac and/or cerebrovascular event while 37% experienced a major bleeding event.[1] Effects of general anesthesia such as myocardial depression, drastic shifts in hemodynamics, tachycardia or bradycardia, and anesthetic medication exposure aggravates this risk. Therefore, it is important for anesthesia providers to understand current guidelines when managing anesthesia for these patients.

Patients who receive bare metal stents (BMS) or drug-eluting stents (DES) for coronary artery revascularization are required to begin DAPT promptly. This therapy typically consists of aspirin and a $P2Y_{12}$ inhibitor such as clopidogrel.[1] Dual antiplatelet therapy is required for several months or a lifetime to avoid restenosis or in-stent thrombosis.[4] Prior to surgery, the type of stent should be identified, and subsequent management should be performed in collaboration with a cardiologist.[1,4,5]

Perioperative management of antiplatelet therapies presents important challenges and safety concerns. The decision must be made whether to withhold therapy to decrease risk of bleeding or to continue therapy to decrease risk of stent thrombosis, MI, and stroke. Close communication with the surgeon, who can define hemorrhagic risk, and the cardiologist, who can define risk of thrombosis, is essential for management of antiplatelet therapy.[5]

Current guidelines recommend delay of elective noncardiac surgery for 14 days following balloon angioplasty and 30 days after BMS implantation.[2] Ideally, elective noncardiac surgery should be delayed 365 days following DES implantation but may be considered after 180 days if

risk of further delay is greater than risk of ischemia and stent thrombosis.[2] If urgent surgery is needed, it is recommended to continue antiplatelet therapy perioperatively in conjunction with close monitoring for myocardial injury.[2] The vast majority of procedures may be performed with the continuation of aspirin with the possible exception of surgeries carrying an extremely high risk of bleeding, such as neurosurgery.[5] Unfractionated heparin and low-molecular-weight heparin are not appropriate to "bridge" patients after being withdrawn from antiplatelet therapy.[4]

When feasible, surgery should be delayed as long as possible in patients receiving DAPT for coronary stents.[5] For urgent surgical procedures (surgery needed within 48 hours) that are considered high hemorrhagic risk, antiplatelet therapy should be immediately discontinued and all supportive measures implemented to manage possible excessive bleeding.[5] Currently, no commercially available antiplatelet agent antidotes exist; therefore, platelet function should be restored with platelet transfusions once antiplatelet agents are no longer in circulation.[5]

The Revised Cardiac Risk Index (RCRI) is an extensively validated preoperative tool that is useful in determining perioperative risk for major cardiac events during noncardiac surgery. Components of the RCRI include high-risk surgery (intraperitoneal, intrathoracic, or suprainguinal vascular procedures), renal insufficiency (creatinine >2.0 mg/dL), and history of ischemic heart disease, heart failure, cerebrovascular disease, or insulin-requiring diabetes mellitus. The patient in this case had two risk factors which placed her at a class III risk:10.1% 30-day risk of death, MI, or cardiac arrest.

The fundamental anesthetic goals in patients with ischemic heart disease are to improve plaque stabilization and decrease determinants of myocardial oxygen demand by controlling heart rate, ventricular wall tension, and contractile strength.[6] Long-term medical management is designed to preserve healthy myocardial tissue. These strategies include continuation of beta-blocker and antihypertensive therapy, vasodilation, aspirin, statins, exercise, and diet.[6] In this case study, coronary perfusion was maintained and myocardial oxygen demand was limited by controlling heart rate and ventricular wall tension. Fentanyl 3.8 mcg/kg IV bolus was administered prior to laryngoscopy and intubation to mitigate sympathetic outflow and myocardial oxygen demand. Ventricular wall tension was limited, and coronary blood flow increased with the use of nitroglycerin. The combined anesthetic interventions resulted in successful, uncomplicated right profunda to popliteal artery bypass in a patient who had undergone coronary stent implantation within 24 hours prior to vascular surgery.

References

1. Rodriguez A, Guilera N, Mases A, et al. Management of antiplatelet therapy in patients with coronary stents undergoing noncardiac surgery: association with adverse events. *Br J Anaesth*. 2018;120(1):67–76. doi:10.1016/j.bja.2017.11.012
2. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation.* 2014;130(24):e278-e333. doi:10.1161/CIR.0000000000000106

3. Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics-2017 update: a report from the American Heart Association. *Circulation*. 2017; 135:e146–603. doi:10.1161/CIR.0000000000000485
4. Capodanno D, Angiolillo DJ. Management of antiplatelet therapy in patients with coronary artery disease requiring cardiac and noncardiac surgery. *Circulation.* 2013;128:2785–98.
5. Rossini R, Tarantini G, Musumeci G, et al. A multidisciplinary approach on the perioperative antithrombotic management of patients with coronary stents undergoing surgery: surgery after stenting 2. *JACC Cardiovasc Interv*. 2018;11(5):417-434. doi:10.1016/j.jcin.2017.10.051
6. Fleisher LA, Mythen M. Anesthetic implications of concurrent diseases. In: Miller RD, Cohen NH, Eriksson LI, Fleisher LA, Wiener-Kronish JP, Young WL, Eds. *Miller's Anesthesia.* 8th ed. Elsevier; 2015:1156-1225.

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Systolic Anterior Motion of the Mitral Valve after Coronary Artery Bypass

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Keywords: systolic anterior motion, SAM, mitral valve, left ventricular outflow tract obstruction, coronary artery bypass graft, CABG

Systolic anterior motion (SAM) of the mitral valve is a life-threatening condition that occurs when the anterior leaflet of the mitral valve (MV) becomes displaced into the left ventricular outflow tract (LVOT) during systole, producing obstruction that reduces stroke volume.[1] First identified in the 1960s, SAM has traditionally been an associated condition of hypertrophic cardiomyopathy and a perioperative risk of mitral valve repair.[2] Known presence of SAM allows providers to predict risk and anticipate critical interventions. As evidenced by the following case, providers should be aware of SAM as a differential diagnosis when any sudden, profound hypotension is experienced. Although rare and varying in severity, it can result in severe hemodynamic compromise leading to shock and cardiac arrest.

Case Report

A 74-year-old, 75 kg male with unstable angina presented to the operating room for an elective coronary artery bypass graft (CABG) for triple-vessel disease. The patient's past medical history included coronary artery disease, diabetes mellitus type II, hypertension, hyperlipidemia, peripheral vascular disease, and multiple cardiac stent placements. Cardiac evaluation demonstrated severe ostial right coronary artery and distal left main disease. His echocardiogram revealed normal left ventricular systolic function with an ejection fraction (EF) of 60-65%. His right ventricular function was normal. It was noted that his mitral leaflets were slightly thickened with mild annular calcification. Mild mitral regurgitation was also present. Hospital-administered medications included a heparin infusion and PO aspirin, atorvastatin, losartan, and metoprolol.

Heparin and losartan were discontinued preoperatively. His hematocrit was 33.5%, chest x-ray was normal, and EKG showed normal sinus rhythm.

The patient was brought to the OR where monitors were placed, midazolam 2 mg was given intravenously (IV), and an arterial line was inserted. Anesthesia was induced with fentanyl 100 mcg, etomidate 20 mg, and rocuronium 50 mg IV. After intubation, a Cordis central line was placed in his right internal jugular vein. Bilateral rectus sheath and transversus thoracic plane blocks were placed with 0.25% bupivacaine 40 mL and bupivacaine liposomal injectable suspension 20 mL. Anesthesia was maintained with inspired sevoflurane 1.7%, and depth was followed using a bispectral index (BIS; Medtronic) monitor. The procedure began and the patient tolerated the cardiopulmonary bypass period. While being weaned from bypass, the patient required infusions of phenylephrine, norepinephrine, and epinephrine to maintain a mean arterial pressure (MAP) greater than 65 mm Hg. He had temporary transthoracic pacing wires placed but was not actively being paced. He also received returned cell saver blood, one unit of packed red blood cells, and one unit of pooled platelets.

With chest closure completed and hemodynamics stabilized, the patient was ready to transfer to the ICU. Blood pressure was approximately 110 mm Hg systolic maintained on infusions of norepinephrine 8 mcg/min, epinephrine 2 mcg/min, and phenylephrine 50 mcg/min. He was in normal sinus rhythm. As staff was preparing to transfer him from the OR table, he had a precipitous decrease in blood pressure. Despite boluses of epinephrine, the blood pressure continued to drop to approximately 60 mm Hg systolic and heart rate increased to 90-100/min. The anesthesiologist was suspicious for SAM, which was promptly diagnosed on transesophageal echocardiography (TEE). The epinephrine infusion was stopped, phenylephrine infusion was increased to 80 mcg/min, and albumin 5% 250 mL was given. The patient's blood pressure stabilized, and he was transferred to the ICU. He was extubated and weaned from vasopressors the following day.

Discussion

An understanding of the physiology of SAM is essential to its recognition and management. Mild SAM may present as dyspnea and cough due to pulmonary congestion.[3,4] Severe SAM leads to hemodynamic instability, low cardiac output, and intractable hypotension.[5] This occurs when the anterior leaflet of the mitral valve becomes displaced into the LVOT during systole, producing flow obstruction that reduces stroke volume and causes acute mitral regurgitation. A systolic murmur will be present.[6] As pressure builds in the LVOT, a hyperdynamic state ensues as the heart attempts to compensate for decreased cardiac output.[4] The obstruction may be transient or constant, and severity is defined by a grading system (I-IV).[5,6,8] Systolic anterior motion is, in fact, a potential risk during any setting that can alter the dynamic physiology of the LV[7] such as weaning from CPB. General predisposing intraoperative factors include reduced preload, increased inotropic state, and decreased afterload,[6] all of which were encountered in this case.

As mentioned earlier, SAM is most common in the setting of hypertrophic cardiomyopathy or mitral valve repair procedures. Anatomy associated with producing SAM includes a smaller LV, tall posterior leaflet, narrow aorto-mitral angle, and enlarged basal septum.[5,7] With hypertrophic

cardiomyopathy, a thickened LV muscle produces an asymmetrical bulging of the interventricular septum, narrowing the LVOT. Additionally, this distorted anatomy results in close proximity of the anterior mitral valve leaflet and basal septum.[1] Because patients undergoing mitral valve repair often have a small, hyperkinetic LV, they are also predisposed to SAM. Nenna et al. suggest that the most significant risk for SAM is a short distance between the septum and leaflet coaptation point.[3,8] In addition to these pathological risks, MV repair procedural hazards include insertion of a small prosthetic ring or insufficient reduction of the posterior leaflet.[5] SAM is usually detected after weaning from CPB once the repair is complete.[8] The incidence of SAM after MV repair is estimated to be 1-16%.[7]

Definitive diagnosis of SAM is made with TEE evaluation of the LVOT gradient, ventricular wall thickness, septal features, and hypokinesis. Hypovolemia will also be apparent on TEE. The longer the contact between the anterior mitral leaflet and septum (if any), the more opportunity for LVOT obstruction, refractory hypotension, and decreased cardiac output.
Initial medical management of SAM includes intravascular volume expansion, discontinuation of inotropic drugs, and phenylephrine administration.[5,8] In this case, sudden hypotension unresponsive to epinephrine was an indication to suspect SAM. Once diagnosed, the crucial step to mitigating SAM was to stop epinephrine and increase phenylephrine. This slowed the patient's heart rate to the 80s and increased preload, thereby increasing the LV diastolic time to accommodate the volume needed to push the mitral valve back up. Albumin and crystalloid were also given for volume repletion. SAM disappears in approximately one third of patients at this point.[5] If these interventions had not stabilized the patient, the next step would have been to administer esmolol. Beta blockers can be used to improve diastolic filling time through negative chronotropy.[9] Approximately 30% of patients improve with intravascular volume expansion alone, and 80% of patients recover hemodynamic stability with the addition of a beta blocker.[5] Post-operative care includes maintaining a higher MAP of 75-90 mmHg, beta blocker administration, and minimizing use of diuretics.[8] Transient SAM is not linked to worse long-term outcomes.[8] In the rare case medical management fails and SAM is persistent, surgical correction of the mitral valve is the definitive treatment.

It is notable that, in rare cases, SAM may occur in multiple clinical settings. A consistent finding is the combination of hypovolemia and a hyperdynamic LV. For instance, patients without cardiac comorbidities undergoing general anesthesia may experience hypovolemia and vasodilation secondary to effects of anesthetics. These agents decrease preload needed to maintain cardiac function in the setting of SAM.[7] Post-myocardial infarction patients may also be predisposed to SAM due to abnormal LV geometry that is the result of having both hyper- and hypokinetic regions of cardiac muscle.[7] Abbas et al. cited a case of SAM in the critical care setting that was attributed to development of hypovolemia and a hyperdynamic LV.[3] Initial symptoms were intractable hypotension and a new systolic murmur. Hypovolemia was secondary to a post-acute kidney injury diuresis phase, and a hyperdynamic LV was the result of catecholamine exposure from vasopressor infusions. Sabzwari et al. also reported an instance of SAM, but in an otherwise healthy patient. This patient presented with acute heart failure and chest pain, and workup including TEE demonstrated SAM. Providers determined that the combination of an elongated anterior mitral valve leaflet and dehydration secondary to active viral illness caused an outflow obstruction and subsequent hemodynamic compromise.[9]

This case demonstrated the importance of understanding cardiac anatomy and physiology, as identifying the etiology of this patient's hemodynamic instability was the key to treatment. Simply treating the blood pressure with inotropic vasopressors would have worsened the patient's already rapid deterioration. Fortunately for this patient, TEE was immediately available and SAM was diagnosed. With knowledge of the cause of SAM, anesthesia practitioners can adjust anesthetic management to reverse this dangerous phenomenon.

References

1. Landesberg G, Hillel Z. Electrocardiography, Perioperative ischemia, and myocardial infarction. In: Miller RD, and Pardo MC, eds. *Basics of Anesthesia*. 8th ed. Elsevier; 2015: 2056-2057.
2. Luckie M, Khattar RS. Systolic anterior motion of the mitral valve - beyond hypertrophic cardiomyopathy. *Heart.* 2008;94:1383-1385. doi: 10.1136/hrt.2007.122069
3. Abbas H, Senthil Kumaran S, Zain MA, Ahmad A, Ali Z. Transient systolic anterior motion of the anterior mitral valve leaflet in a critical care patient with a structurally normal heart. *Cureus*. 2019;11(1):e3963. doi:10.7759/cureus.3963
4. Manabe S, Kasegawa H, Arai H, Takanashi S. Management of systolic anterior motion of the mitral valve: a mechanism-based approach. *Gen Thorac Cardiovasc Surg*. 2018;66(7):379-389. doi: 10.1007/s11748-018-0915-0
5. Alfieri O, Lapenna E. Systolic anterior motion after mitral valve repair: where do we stand in 2015? *Eur J Cardiothorac Surg*. 2015;48(3):344-6. doi: 10.1093/ejcts/ezv230
6. Raut M, Maheshwari A, Swain B. Awareness of 'systolic anterior motion' in different conditions. *Clin Med Insights Cardiol.* 2018;10(12):1179546817751921. doi: 10.1177/1179546817751921
7. Ibrahim M, Rao C, Ashrafian H, Chaudhry U, Darzi A, Athanasiou T. Modern management of systolic anterior motion of the mitral valve. *Eur J Cardiothorac Surg*. 2012;41(6):1260-70. doi: 10.1093/ejcts/ezr232
8. Nenna A, Nappi F, Spadaccio C, Barberi F, Greco SM, Lusini M, Chello M. Systolic anterior motion (SAM) complicating mitral valve repair: current concepts of intraoperative and postoperative management. *Surg Technol Int*. 2020;28(37):225-232. PMID: 32557521
9. Sabzwari SRA, Kimber JR, Ayele H, et al. The disappearing murmur: systolic anterior motion of the mitral valve leaflet in a non-hypertrophic cardiomyopathy patient. *Cureus*. 2018;10(6):e2855. doi:10.7759/cureus.2855

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Management of Patient with Uterine Rupture for Emergent Cesarean Section

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Keywords: uterine rupture, obstetric anesthesia, cesarean section, massive transfusion, hemorrhage

Uterine rupture is a rare obstetric event, occurring in only 0.08% of full-term pregnancies.[1] It is more commonly seen in women with previous cesarean sections, however the rate of rupture for both scarred and unscarred uterus' is increasing.[2] Presentation commonly includes fetal bradycardia with sudden maternal abdominal pain.[2] Management of this condition is a surgical emergency and requires immediate cesarean section. Anesthetic management includes general endotracheal anesthesia with anticipation and preparation for potential significant hemorrhage and hemodynamic instability.[2]

Case Report

A 38-year-old, 167 cm, 86 kg, G3P2 female presented for induction of labor at 38.4 weeks due to development of gestational hypertension. Past medical history included gestational diabetes and previous vaginal delivery. The patient was started on an oxytocin infusion, two large bore IVs were established, and labs were sent including a type and cross for two units of packed red blood cells (PRBCs). Baseline lab values: hemoglobin (hgb) 11 g/dL, hematocrit (hct) of 34%, and platelets > 150,000/µl. The patient received a labor epidural, per request, without complication that was dosed with an infusion of 0.1% ropivacaine with 2 mcg/mL of fentanyl at 8 mL/hr. Patient stated pain relief and was resting comfortably with a T10 block. Five hours after placement, the patient experienced an acute increase in abdominal pain with fetal bradycardia from 130 to 70/min. During the next 2 minutes, fetal bradycardia worsened, the anesthesia provider was contacted, and the decision was made by the obstetric team to perform an emergency cesarean section.

The patient was rapidly transported to the operating room with standard monitors and pre-oxygenated with O_2 15 L/min via anesthesia machine circuit. Pre-induction vital signs included a blood pressure (BP) of 130/80 mm Hg, heart rate (HR) 100/min, respiratory rate (RR) 22/min, and SpO_2 99%. Due to urgency, dosing of the epidural was unattainable and general anesthesia was induced as a rapid-sequence induction with cricoid pressure and intravenous doses of succinylcholine 160 mg and propofol 120 mg. The trachea was intubated without difficulty, confirmed via presence of end-tidal CO_2 and bilateral breath sounds. At this time mechanical ventilation was initiated and general anesthesia was maintained with end-tidal Sevoflurane 1.4-1.6% in O_2 1 L/min and air 1 L/min for a FiO_2 of 60%. Post induction vital signs were within 10% of baseline. The time between the obstetric team's decision to perform a cesarean section and delivery of the fetus was 6 minutes, with initial APGAR scores of 8 and 9 at 1 and 5 minutes.

Following delivery, estimated blood loss (EBL) was reported to be 800 mL per surgeon with quantitative blood loss (QBL) around 950 mL. Oxytocin infusion was started per protocol and

crystalloid infusion was moved to a pressure bag infusion due to patient BP of 82/40 mm Hg with HR of 120/min. The surgical team reported marginal uterine tone. The decision was made to give rectal misoprostol 400 μg, 5% albumin 500 mL IV, intramuscular methergine 0.2 mg, tranexamic acid (TXA) 1g IV, and 2 units PRBCs. At this time a third large bore (14 G) IV was established and an arterial blood gas (ABG), basic metabolic panel (BMP), complete blood count (CBC), and thromboelastography (TEG) was drawn and sent.

After infusion of the 2 units of PRBCs via pressure bag and 3 L of crystalloid, vital signs improved to baseline. Communication between anesthesia and the surgical team revealed a diagnosis of uterine rupture into the left broad ligament. The patient's BP decreased again to 70/30 mm Hg with an increase in HR to 130/min. The massive transfusion protocol (MTP) was activated, and maternal fetal medicine was consulted. An arterial line was inserted in the right radial artery and blood product were infused via Belmont Rapid Infuser with a transfusion ratio of 1:1:1 PRBC to fresh frozen plasma to platelets. Blood samples for CBC and ABG were drawn every 30 minutes via the arterial line. Thromboelastography analysis was also utilized and showed proper blood product resuscitation, yet bleeding could not be controlled and ultimately the surgical team decided to perform a hysterectomy. At the end of the procedure, hemodynamics had stabilized and the MTP was discontinued. The EBL/QBL was calculated to be 5,140 mL and the patient received a total of 13 units PRBCs, 13 units FFP, 3 jumbo-packs of single donor apheresis platelets, 2 units of cryoprecipitate, TXA 2 g, calcium chloride 2 g, sodium bicarbonate 100 mEq, and 4 L of crystalloid.

The patient remained intubated and was transferred to the intensive care unit (ICU) for close hemodynamic monitoring. No additional blood products were needed and laboratory values on admission to the ICU were: pH 7.28, hgb 14 g/dL, hct 45%, platelets 27,000/μL, temperature 35.8°C with electrolytes within normal limits. The patient was extubated the following morning after meeting appropriate criteria. The patient was seen on postoperative day 1 and was assessed to be stable without further complications. Laboratory values on post-operative day 1 were: hgb 14 g/dL, hct 43%, platelets 183,000/μL. The patient was transferred to the postpartum floor until she was safely discharged home with a healthy infant 4 days later.

Discussion

Uterine rupture is a rare emergent obstetrical occurrence that can result in massive maternal hemorrhage, maternal death, and fetal demise.[3] Uterine rupture is defined as the complete division of all three layers of the uterus: endometrium, myometrium, and perimetrium.[2] It is estimated to occur in 1 out of every 5,000-7,000 births and can result in severe maternal and fetal morbidity and mortality, with a perinatal death rate of up to 35% and maternal hysterectomy rate of up to 31%.[1,2]

Risk factors and causes of uterine rupture are different based on whether the woman has a scarred uterus. For women with a scarred uterus, usually from prior cesarean section, risk of uterine rupture is increased based on location of previous uterine incision, with women with midline incisions at a higher risk than those with low transverse incisions.[1] Furthermore, for women that attempt trial of labor after cesarean section uterine rupture is the largest risk factor with the largest increase in maternal and neonatal morbidity.[4] For women with an unscarred

uterus, neonatal and maternal morbidity is even higher and etiology is due to one of the following: trauma, genetic disorder with uterine wall weakness, prolonged induction/augmentation of labor with oxytocin, or overstretching of the uterine wall.[1] Maternal conditions such as multiparity, gestational diabetes, polyhydramnios, multiple gestation pregnancies and uterine anomalies can result is over-stretching of the myometrium above optimal range and also increase risk.[1]

The classic presentation for uterine rupture includes fetal bradycardia with acute onset severe abdominal pain and maternal hypotension.[2] One unique symptom aside from acute fetal bradycardia, may be acute onset midline abdominal pain. There was previous concern regarding neuraxial anesthesia masking symptoms of uterine rupture, however this has proven to be inaccurate as even with presence of a labor epidural, patients have experienced sharp breakthrough pain.[4] Other common symptoms seen include vaginal bleeding, tachycardia, anxiety, nausea, and vomiting, which can make uterine rupture difficult to identify or differentiate from other possible diagnosis.[5]

The presence of uterine rupture prompts immediate action with emergency cesarean section with laparotomy and hemorrhage control, usually resulting in a hysterectomy.[2] General endotracheal anesthesia is most often utilized due to urgent delivery, however dosing of functional epidural with chloropropane may also be utilized. Due to the urgency of the situation patient awareness is a high concern thus careful drug titration and practitioner awareness is indicated as to help prevent any psychological truama[6]. Succinylcholine and propofol may be used with stable hemodynamics, but ketamine and etomidate may be preferred for an unstable patient.[2] General anesthesia is noted to have the advantages of facilitating better control of patient airway, maternal acid-base status, and neuromuscular blockade for laparotomy.[2] Further anesthetic implications include large-bore IV access and/or placement of a central venous catheter. Resuscitation should be managed initially with a balanced crystalloid solution, with identification of large blood loss promoting early MTP activation. The placement of an arterial line should strongly be considered to help facilitate accuracy and trending of maternal blood pressure, as well as to facilitate serial lab draws. Postpartum hemorrhage is defined as EBL > 1,000 mL and requires prompt initiation of massive transfusion protocols as early blood infusion has been shown to improve maternal outcomes by preventing or treating development of coagulopathy.[5] In event of MTP, evidence supports early and aggressive transfusion at an RBC:FFP:PC ratio of 1:1:1.[7] Resuscitation should be aimed to keep hct > 24%, INR < 1.4, platelets > 50,000/uL, pH > 7.2, and temperature above 35°C with a normal ionized calcium as to optimize physiologic coagulation.[7]

The incidence of fetal and maternal morbidity is varied based on location and degree of rupture as well as time to surgical intervention. Mortality is increased in the event of delayed diagnosis, inadequate or delayed blood transfusion, or delayed intervention.[1] Awareness of maternal risk factors and obstetric hemorrhage protocols are essential for prompt diagnosis and treatment. Post-operative care for uterine rupture patients is based on hemodynamic status and relative laboratory values.[1] The safest recommendation is that patients be monitored in the intensive care unit due to ability for closer hemodynamic monitoring and further resuscitation if required.

References

1. Gibbins KJ, Weber T, Holmgren CM, Porter TF, Varner MW, Manuck TA. Maternal and fetal morbidity associated with uterine rupture of the unscarred uterus. Am J Obstet Gynecol. 2015;213(3):382.e1-382.e3826. doi:10.1016/j.ajog.2015.05.048
2. Togioka BM, Tonismae T. Uterine rupture. National Center for Biotechnology Information. https://www.ncbi.nlm.nih.gov/books/NBK559209/?report=reader#_NBK559209_pubdet_. Published July 1, 2021. Accessed August 10, 2021.
3. Savukyne E, Bykovaite-Stankeviciene R, Machtejeviene E, Nadisauskiene R, Maciuleviciene R. Symptomatic Uterine Rupture: A Fifteen Year Review. Medicina (Kaunas). 2020;56(11):574. Published 2020 Oct 29. doi:10.3390/medicina56110574
4. Markou GA, Muray JM, Poncelet C. Risk factors and symptoms associated with maternal and neonatal complications in women with uterine rupture. A 16 years multicentric experience. Eur J Obstet Gynecol Reprod Biol. 2017;217:126-130. doi:10.1016/j.ejogrb.2017.09.001
5. Henriquez DDCA, Caram-Deelder C, le Cessie S, et al. Association of Timing of Plasma Transfusion With Adverse Maternal Outcomes in Women With Persistent Postpartum Hemorrhage. JAMA Netw Open. 2019;2(11):e1915628. Published 2019 Nov 1. doi:10.1001/jamanetworkopen.2019.15628
6. Odor PM, Bampoe S, Lucas DN, et al. Incidence of accidental awareness during general anaesthesia in obstetrics: a multicentre, prospective cohort study. *Anaesthesia*. 2021;76(6):759-776. doi:10.1111/anae.15385
7. Tanaka H, Matsunaga S, Yamashita T, et al. A systematic review of massive transfusion protocol in obstetrics. Taiwan J Obstet Gynecol. 2017;56(6):715-718. doi:10.1016/j.tjog.2017.10.001

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Anesthetic Management of Gastrostomy Tube Placement with Oral Cancer

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Keywords: pharyngeal cancer, human papilloma virus, oral squamous cell carcinoma, anesthetic management, awake fiberoptic intubation, nasal intubation

Rates of Human papilloma virus (HPV) and associated oral squamous cell carcinoma (OSCC) are on the rise.[1] However, the increased awareness of smoking and alcohol has led to a decrease in OSCC non-HPV cases.[1] A Scandinavian study showed 85% of screened OSCC patients was linked to HPV.[1] In a European study, 50% of participants with OSCC was associated with HPV.[1] Anesthetic management of patients with OSCC has a high probability of difficult airway management.[1] This case study analyzes the risks, benefits, and alternatives to securing the airway in patients with HPV OSCC that require a general anesthetic for gastrostomy tube surgery.

Case Report

A 61-year-old, 89.9kg male presented to the operating room (OR) for insertion of a gastrostomy tube. Allergies noted were daptomycin, moxifloxacin, piperacillin-tazobactam, and penicillin. Past medical history included chronic kidney disease, diabetes mellitus type two, hypertension, venous insufficiency, spinal stenosis, and recurrent urinary tract infections. He was recently diagnosed with HPV+OSCC of the right palatine tonsil found incidentally on-computed tomography scan (CT) after a fall. The CT revealed a 4.9 cm soft tissue mass with ipsilateral lymph node involvement. The tumor was classified as T3N1M0 Stage II (size 3, nodal involvement 1, and no metastasis to outside structures).[2] Due to the location of the tumor, the patient's glottic opening was shifted laterally on CT scan. Past surgical history included a cholecystectomy with no anesthetic complications. He reported a remote history of smoking and heavy drinking but quit in 2014. The airway examination included a mallampati score II, class 1 mandibular protrusion, mouth opening of 3 fingerbreadths, and limited cervical extension.

Except for an elevated blood urea nitrogen (57mg/dL) and creatine (3.6mg/dL), pre-anesthetic evaluation of his labs and vital signs were unremarkable. Informed consent was obtained highlighting the risks, benefits, and plan of anesthesia. An intravenous (IV) catheter was placed preoperatively and the patient was given midazolam 2 mg then transferred to the OR. The patient required general anesthesia with a secure airway for the procedure. An awake fiberoptic nasal intubation was performed. With the patient in the high fowler's position, the oropharynx was prepped with lidocaine 4% spray and a 34 french (Fr) nasopharyngeal airway soaked in 2% lidocaine was used for dilation of the naris. At the start of nasal dilation glycopyrrolate 0.3 mg IV was administered along with dexmedetomidine 20mcg IV bolus. Simultaneously, a dexmedetomidine infusion was initiated at 0.2mcg/kg/hr. The fiberoptic (FOB) scope, prepared with a 6 mm nasal endotracheal tube, was inserted into the patient's right naris. After passing the curvature of the nasopharynx, the glottic opening was visualized and the FOB scope advanced through the vocal cords. At this time propofol 150 mg IV, etomidate 10mg IV, and cisatracurium 10 mg IV boluses were administered. The nasal endotracheal tube was inserted uneventfully into the trachea and secured in place.

The patient's anesthetic level was maintained with sevoflurane 1% inspired and a propofol infusion at 50 mcg/kg/min. Dexamethasone 4mg IV was given at the start of the case. The general surgery staff conducted a successful gastrostomy tube placement without complications. At the end of the case-ondansetron 4 mg, neostigmine 5 mg, and glycopyrrolate 0.6 mg IV were administered. The patient required an additional dose of neostigmine 1 mg and glycopyrrolate 0.2 mg IV to render complete antagonism of neuromuscular blockade. An uneventful awake extubation was conducted.

The patient was transferred to the recovery unit on O_2 10 L/min via face mask. Postoperative vital signs were within normal limits in the recovery room. The patient was discharged from the recovery unit without complications once standard discharge criteria were met.

Discussion

Human Papilloma Virus is a small virus derived from human deoxyribonucleic acid (DNA) most often transmitted via sexual contact.[3,4] Transmission occurs in the genital or oral mucosa from person to person.[3,4] A common manifestation of this disease in females is cervical cancer.[3,4] A lesser-known complication is head and neck cancer.[3,4] Approximately 6.9% of HPV cases in the United States is oral form.[4] Typically the oral form is prevalent between ages 30-34 and 60-64 and usually affects males.[3,4] Smoking plays a significant role in the development of oral HPV that causes head/neck cancer.[3] Furthermore, certain genotypes of HPV have a higher risk of causing head/neck carcinoma. The most common high risk genotype is hrHPV 16, present in 90% of oral cancer from HPV.[3] The palatine and lingual tonsils are affected because of their anatomical makeup of surface pits.[3] Lastly, survival rate of patients with OSCC from HPV has a better success rate than those who are HPV OSCC negative. This is due in part because HPV+ OSCC responds better to chemotherapy and radiation treatments.[3]

Anesthetic management for an open gastrostomy tube in patients with HPV+ OSCC can vary. A literature search revealed several techniques including regional and general anesthesia.[5-7] In this case, the surgical team requested full paralysis throughout the procedure therefore general anesthesia was deemed most appropriate. An awake FOB approach was selected due to the potential for difficult intubation and aspiration risk from his underlying oral pathology.
The literature described a similar anesthetic option to the one performed for a known difficult airway caused by oral cancer requiring general anesthesia. This patient had a large hemi laryngeal tumor.[5,6] The anesthesia provider prepared for a backup emergent tracheostomy and had the ear nose throat (ENT) specialist in the room.[5,6] The patient was positioned with the head of bed at 60 degrees, and nebulized epinephrine was administered.[5,6] Clonidine 100mcg IV was given and an IV propofol infusion was titrated.[5,6] The patient was allowed to breathe inspired sevoflurane at 8% and once unresponsive to verbal stimuli, direct laryngoscopy (DL) was performed with a pediatric gum elastic bougie.[5,6] This option may have worked for our patient as well. Instead of clonidine/sevoflurane we used dexmedetomidine and midazolam to aid in sedation while allowing the patient to maintain spontaneous respirations. Once the FOB was passed through the vocal cords, the patient was anesthetized with propofol/etomidate and the nasal endotracheal tube inserted. The concern with utilizing a DL technique is the risk of the tumor obscuring an adequate view of the glottic opening.[5,6]

Additionally, oral tumors often are associated with the tracheal opening shifted laterally making it challenging to achieve an optimal view for successful intubation.[5,6] Direct laryngoscopy may be associated with increased risk for airway trauma due to friable tissue potentially resulting in complete loss of the glottic opening.[5,6] Moreover, our patient's mass was located within the oropharynx making it potentially difficult to maneuver the laryngoscope and insert an oral endotracheal tube. As an alternative, the oropharynx was bypassed with the insertion of the nasal tracheal tube.

One potential alternative anesthetic for performing gastrostomy tube surgery in patients with a known or suspected difficult airway would be to utilize regional anesthesia which may minimize the risk of aspiration or failed intubation.[7] Unilateral left-sided subcostal transversus abdominis plane (TAP) block is performed using local anesthetic deposited within the transversus

abdominis (TA) and internal oblique (IO) muscles.[7] The skin is prepared with an antiseptic solution. Following that, a small amount of local anesthetic is deposited within the skin near the insertion site.[7] Under ultrasound guidance, the needle is advanced to the space between the TA and IO muscles. After negative aspiration, 20 mL of bupivacaine 0.25% is instilled.[7] This type of anesthesia for our case poses potential disadvantages. An inadequate surgical blockade for the appropriate dermatomal level would delay the case and possibly result in the need for urgent conversion to general anesthesia.[7] There is also a chance of apnea with sedation in conjunction to nerve block that can lead to an emergent mask ventilation/intubation scenario.[7] Finally, as pharyngeal muscles relax during anesthesia, the potential for aspiration could necessitate an emergent mask ventilation/intubation in a much less controlled scenario. A positive feature of this type of anesthesia is that, if successful, the patient would remain spontaneously breathing.[7]

Identification of all options to secure airways in patients with HPV+ OSCC, and known anatomically distorted airways, is imperative.[5-7] There are many ways to do so depending on the surgical procedure, degree of obstruction, and level of tolerance of the patient.[5-7] To aid in the decision making process, it's crucial to perform a comprehensive airway examination, review available imaging, and collaborate the plan with the surgical team, including emergency airway procedures.[5-7]

References

1. Wittekindt C, Wagner S, Sharma SJ, et al. HPV - A different view on head and neck cancer. HPV – Das andere Kopf-Hals-Karzinom. *Laryngorhinootologie*. 2018;97(S 01):S48-S113. doi:10.1055/s-0043-121596
2. Hines RL, Marschall KE, Stoelting RK. Cancer. In: Hines RL, Marschall KE, eds. *Stoelting's Anesthesia and Co-existing Disease*. 7th ed. Elsevier; 2018:584-588.
3. Pinatti LM, Walline HM, Carey TE. Human papillomavirus genome integration and head and neck cancer. *J Dent Res*. 2018;97(6):691-700. doi:10.1177/0022034517744213
4. Gillison ML, Broutian T, Pickard RK, et al. Prevalence of oral HPV infection in the United States, 2009-2010. *JAMA*. 2012;307(7):693–703. doi:10.1001/jama.2012.101
5. Constable N, Thomas C, Jones M, Walters M. Acute presentation of a partially obstructing laryngeal tumour: adjuvant agents to gaseous induction of anaesthesia. *BMJ Case Rep*. 2018;2018:bcr2018224700. Published 2018 Jul 12. doi:10.1136/bcr-2018-224700
6. Zhang X, Cavus O, Zhou Y, Dusitkasem S. airway management during anesthetic induction of secondary laryngectomy for recurrent laryngeal cancer: three cases of report and analysis. *Frontiers in Medicine.* 2018;5(264). Published 2018 Sep 19. doi:10.3389/fmed.2018.00264
7. Lee AR, Choe YS. Anesthesia experience for open gastrostomy with ultrasound guided unilateral subcostal transversus abdominis plane block in a high risk elderly patient: A case report. *Anesth Pain Med*. 2015;5(4):e24890. Published 2015 Aug 22. doi:10.5812/aapm.24890v2

Mentor: Quinn C. Leeper, DNP, CRNA

Assessment of Coagulation Status During Intraoperative Hemorrhage

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Keywords: TEG testing, ROTEM testing, hemorrhage, blood component transfusion

Introduction

Intraoperative hemorrhage is a challenging situation requiring immediate action from anesthesia professionals. Hemorrhage is the number one contributing factor to patient mortality in operating rooms worldwide, accounting for two thirds of deaths in the setting of emergent surgery and one third of deaths during elective procedures.[1] Additionally, blood loss from initial hemorrhage contributes to the development of coagulopathies leading to further hemorrhage, progressive hypothermia, persistent metabolic acidosis, and increasing patient morbidity.[2] To complicate the issue further, expert groups such as the American Society of Anesthesiologists and the Society of Cardiac Anesthesiologists do not offer recommendations regarding perioperative transfusion which leads to variations in transfusion practice amongst anesthesia providers.

In the local setting, it has been observed that coagulopathies are often treated with blood products under the discretion of anesthesia professionals' clinical judgement aided by conventional coagulation tests (CCT) such as prothrombin time, partial thromboplastin time, international normalized ratio, and platelet count. During hemorrhage, the use of CCT as a guide to replacement of coagulation factors may delay the recognition of life-threatening coagulopathies due to slower processing times.[3] Additionally, CCT uses platelet poor plasma samples that only provide information regarding the time to initiation of fibrin formation but no data past that time regarding the efficacy of clot formation.[4] CCT tests are not reliable for decision making in the event of a hemorrhage as they provide limited value to correlate with surgical bleeding.[4] In contrast, thromboelastography (TEG) and rotational thromboelastometry (ROTEM) have proven to be more functional for rapidly diagnosing and treating coagulopathies due to intraoperative hemorrhage.[5]

The intent of this evidence-based practice analysis is to determine best practice for coagulopathy testing in order to guide transfusion practices during intraoperative hemorrhage in the adult surgical population. The scientific framework used to support this inquiry is two-fold. First, is the pathologic process known as trauma induced coagulopathy (TIC), which describes abnormal coagulation that can be triggered by an event such as intraoperative hemorrhage.[6] Second, is the phenomenon known as dilutional coagulopathy, which occurs with overzealous crystalloid or colloid administration during hemorrhage.[6] Normalizing a coagulopathy is detrimental given the pathology's association with thromboembolisms, multiorgan failure, and mortality.[6]

Methods

The population, intervention, comparison, and outcomes (PICO) framework was used to construct the clinical question to guide this analysis: In adult surgical patients experiencing

intraoperative hemorrhage, how do TEG and ROTEM testing affect patient mortality and blood product wastage when compared to CCT.

The literature search was completed using Medline, Embase, and Google Scholar databases. Keywords searched in the Medline database included: hemorrhag, blood loss, haemorrhag, bleeding, coagulation test, international normalized ratio, partial thromboplastin time, prothrombin time, thrombelastograph, thromb-elastograph, rotational thromboelastomet, intraoperative, operative, and protocol. Keywords searched in the Embase database included: hemorrhage, haemorrhag, blood loss, surgical, bleeding, coagulation test, international normalized ratio, partial thromboplastin time, prothrombin time, thrombelastograph, thromb-elastograph, rotational thromboelastomet, intraoperative, operative, and protocol. All keywords were truncated with an asterisk to allow the search to include all potential suffixes of the keyword. The Medline and Embase databases yielded 58 and 222 articles respectively. Google Scholar was searched using the terms intraoperative coagulation testing protocol, TEG, or ROTEM. The Google Scholar search yielded 16 additional articles for a total of 296 articles. Duplicates were first removed narrowing the total articles to 275. Eighty-three articles did not have full text availability, which left 192 articles to screen.

Screening involved a review of article abstracts to determine article relevancy to the PICO question, which yielded 182 irrelevant articles. Two articles were animal studies and were therefore excluded resulting in eight articles for analysis. Among the eight articles, three are randomized controlled trials and can be categorized as level two evidence.[7] The five remaining articles are retrospective comparative studies and are classified as level three evidence.[7]

Literature Analysis

Articles were analyzed with the intent of determining the efficacy of CCT versus (vs.) TEG and/or ROTEM in regard to patient mortality and blood product wastage during intraoperative hemorrhage. Patient populations evaluated by the articles consisted of trauma patients, liver transplant recipients, and patients undergoing cardiac surgery. Table 1 describes each article in terms of design, groups compared and outcome summary. A discussion of the articles examines their findings via the following groupings: TEG vs. CCT and patient mortality, TEG or ROTEM vs. CCT and patient mortality, TEG vs. CCT and blood product wastage, and ROTEM vs. CCT and blood product wastage.

Table 1. Synthesis Table

Article	Design	Groups compared	Outcome summary
Gonzalez et al[9]	Randomized controlled trial	TEG vs. CCT	Higher TEG group 28-day ($P = 0.027$) and overall survival rate ($P = 0.032$)
Nascimento et al[11]	Retrospective comparative study	ROTEM vs. CCT	ROTEM testing reduced the administration of FFP ($P = 0.047$)
Kandeel et al[12]	Retrospective comparative study	ROTEM vs. CCT	ROTEM decreased administration of PRBCs, FFP, and activation of massive transfusion protocol ($P < 0.01$, $P < 0.001$, and $P < 0.005$, respectively)

Khalaf-Adeli[14]	Retrospective comparative study	ROTEM vs. CCT	ROTEM decreased transfusion of plasma products ($P < 0.05$)
Baksaas-Aasen et al[10]	Randomized controlled trial	ROTEM/TEG vs. CCT	No difference in mortality rates between groups ($P = 0.495$)
Peng et al[5]	Randomized controlled trial	ROTEM/TEG vs. CCT	TEG decreased administration of FFP ($P = .042$)
Cochrane et al[8]	Retrospective comparative study	TEG vs. CCT	Decreased mortality rate in TEG group at 24 hours post hemorrhage and 30 days ($P = 0.006$, $P = 0.002$, respectively). Decreased FFP and RBC wastage in the TEG group ($P < 0.01$, $P < 0.02$ respectively). Overall lower blood product wastage in the TEG group ($P = 0.002$)
St-Onge et al[13]	Retrospective comparative study	ROTEM vs. CCT	ROTEM reduced PRBC and FFP transfusion ($P = 0.08$, $P = 0.04$, respectively)

TEG vs. CCT and Patient Mortality. Two of the eight articles included in the evidence-based practice analysis compared CCT techniques with TEG analysis in regard to patient mortality. Outcomes of these articles included 24-hour and 30-day mortality in one article and 28-day survival in the other.[8-9] Cochrane et al and Gonzalez et al concluded the beneficial use of implementing TEG analysis over CCT.[8-9] Cochrane et al found mortality was significantly lower in the TEG group at 24-hours post hemorrhage ($P = 0.006$) and at 30-days ($P = 0.002$).[8] Gonzalez et al demonstrated 28-day survival in the TEG group was significantly higher than the CCT group ($P = 0.027$) with higher survival in the TEG group overall ($P = 0.032$).[9] Collectively, the empirical evidence concluded a significantly higher patient survival among patients suffering from intraoperative hemorrhage whose coagulation status was analyzed using the TEG technique.[8-9]

TEG or ROTEM vs CCT and Patient Mortality. Patient outcomes of coagulation testing using both TEG and ROTEM assays as compared to CCT were examined by Baksaas-Aasen et al.[10] Data was not differentiated between TEG and ROTEM and results are a combination of the two techniques. The RCT by Baksaas-Aasen et al sought to compare the proportion of subjects who were still alive and free of massive transfusion after 24 hours.[10] At 24 hours after injury, the mortality rate amongst the TEG and ROTEM participants versus the CCT group were comparable ($P = 0.495$).[10] Analysis of secondary morbidity outcomes showed significant thromboembolic events occurred in 9% of the TEG and ROTEM group participants versus the 14% of the CCT participants ($P = 0.088$).[10] Although this study established no difference in patient mortality between CCT and TEG or ROTEM testing 24 hour post-transfusion, significant differences in thromboembolic events, which can be potentially life-threatening, support the use of TEG and ROTEM over CCT.

TEG vs. CCT and Blood Product Usage. Peng et al and Cochrane et al concluded TEG analysis was associated with reduced blood product wastage compared to CCT.[5,8] Peng et al found the use of TEG rather than CCT resulted in less FFP transfusion over 24 hours ($P = .042$).[5]

Cochrane et al sought to examine blood product usage with the use of TEG found FFP ($P < 0.01$) and RBC ($P < 0.02$) wastage was significantly lower in the TEG group.[8] Additionally, the overall blood product wastage was significantly lower in the TEG group ($P = 0.002$).[8] Lastly, Cochrane et al concluded that an average of 1.1 units was wasted per patient in the TEG group, compared to 1.8 units in the CCT group.[8]

ROTEM vs. CCT and Blood Product Usage. Four studies compared blood product wastage that resulted from the use of ROTEM coagulation testing vs.CCT.[11-14] The study conducted by Nascimento et al found the incidence of patients transfused with FFP was significantly higher in the CCT group than in the ROTEM group ($P = 0.047$), with a moderate correlation to PRBC transfusion ($P < 0.001$).[11] The study by Kandeel et al indicated PRBCs, FFP, and activation of massive transfusion protocol (MTP) were significantly lower in the ROTEM group compared to pre-ROTEM group ($P < 0.01$, $P < 0.001$, and $P < 0.005$, respectively).[12] In the third study, St-Onge et al concluded ROTEM implementation was associated with reduced PRBC and FFP transfusion ($P = 0.08$ and $P = 0.04$, respectively).[13] A fourth study by Khalaf-Adeli found ROTEM values have a higher correlation to existing fibrinogen levels than CCT leading to decreased transfusion of plasma products ($P < 0.05$).[14] Thus, ROTEM testing, as opposed to CCT, resulted in a reduced rate of unnecessary administration of blood products such as fresh FFP and PRBCs.

Strengths and Limitations. The literature included in this evidence-based practice analysis contains both strengths and limitations. One major strength was the large sample size consisting of 1,647 patients between the eight studies. Moreover, only three studies had a sample size of less than 100 patients. The studies were not limited to a single surgical patient population as they were comprised of trauma patients, liver transplant patients, and cardiac surgery patients. A large sample size alongside a diverse patient population creates confidence in the ability to generalize the data. The limitation of the literature review was primarily attributed to the varying levels of evidence, the review contains level two and three evidence. This variability between levels of evidence occurred in some studies due to the inability to entirely randomize groups, especially during emergency situations. For example, patients in the Nascimento et al and Kandeel et al studies were placed into their respective groups based on the availability of the ROTEM machine.[11-12] The aforementioned scenario may be viewed as a form of bias within the study. Additionally, Gonzalez et al potentially demonstrated bias when a weekly schedule of testing techniques was assigned to trauma patients due to the inability to randomize patients prior to sustaining the trauma.[9] Furthermore, multiple studies had to use retrospective data for the control groups which used CCT methods such as PT, PTT, INR, and platelet count. Considering this, St-Onge et al utilized propensity score matching, which caused the cohort size to decrease.[13] All studies except one were conducted in a single center setting which may be less preferable compared to multi-center studies. These limitations can guide future research in order to improve the validity and reliability of evidence regarding CCT versus TEG and ROTEM testing in regard to mortality and blood product wastage.

Conclusion

This evidence-based practice analysis supports the intraoperative use of TEG or ROTEM, as opposed to CCT, in efforts to guide transfusion therapy during major surgeries such as cardiac,

transplant, or trauma surgery. Viscoelastic testing was associated with decreased patient 30-day mortality rates as well as an overall decrease in blood component transfusion, which has several potential benefits such as decreased incidence of exposing the patient to unnecessary transfusion risk, decreased cost, and preservation of banked blood. Conversely, the analysis of current research did identify limitations with the existing literature and the use of TEG or ROTEM. For example, no current level one evidence on the subject exists. Therefore, a systematic review or meta-analysis is suggested. Furthermore, it would be beneficial if future studies incorporated a variety of surgical procedures to increase the generalizability of the findings.

Prior to integrating TEG or ROTEM into clinical practice, one must understand these devices' specifications compared to CCT. A thorough study on anesthesia professionals' comfort level using and interpreting TEG or ROTEM results should be completed. One final issue on integrating viscoelastic testing into clinical practice is the decision to use either TEG or ROTEM. One study by Jackson et al sought to discover which viscoelastic testing system was more beneficial. The discussion revealed that TEG is more affordable for institutions ($16,500) when compared to ROTEM ($26,400).[15] Additionally, there is more literature regarding TEG as its use is more widespread and better recognized by anesthesia professionals as compared to ROTEM. TEG uses Windows® software which takes less than five minutes to warm up and allows anesthesia professionals to review previous results while the current test runs.[15] In contrast, ROTEM uses Linux® software which requires up to 15 minutes to warm up, and the screen locks while the test runs.[15] Anesthesia professionals considered TEG easier to understand as compared to ROTEM. [15] Considering these factors, current literature supports utilizing TEG as a guide for blood product transfusions. Proven benefits to TEG are reductions in patient mortality and transfusion associated morbidities as well as blood product usage resulting in increased savings for the hospital and preservation of banked blood.[5,8-10]

References

1. Dhoon TQ, Raphael D, Rajan GRC, Vaughn D, Engwall S, Vakharia S. Management of massive intraoperative hemorrhage. Anesthesia Patient Safety Foundation. Published October 1, 2021. Accessed January 21, 2022. https://www.apsf.org/article/management-of-massive-intraoperative-hemorrhage/
2. Lim G, Harper-Kirksey K, Parekh R, Manini AF. Efficacy of a massive transfusion protocol for hemorrhagic trauma resuscitation. *Am J Emerg Med*. 2018;36(7):1178-1181. doi:10.1016/j.ajem.2017.11.060
3. Patil V, Shetmahajan M. Massive transfusion and massive transfusion protocol. *Indian J Anaesth*. 2014;58(5):590-595. doi:10.4103/0019-5049.144662
4. Dias JD, Haney EI, Mathew BA, Lopez-Espina CG, Orr AW, Popovsky MA. New-generation thromboelastography: Comprehensive evaluation of citrated and heparinized blood sample storage effect on clot-forming variables. *Arch Pathol Lab Med*. 2017;141(4):569-577. doi:10.5858/arpa.2016-0088-oa
5. Peng HT, Nascimento B, Tien H, et al. A comparative study of viscoelastic hemostatic assays and conventional coagulation tests in trauma patients receiving fibrinogen concentrate. *Clin Chim Acta*. 2019;495:253-262. doi:10.1016/j.cca.2019.04.066
6. Moore EE, Moore HB, Kornblith LZ, et al. Trauma-induced coagulopathy. *Nat Rev Dis Primers*. 2021;7(1):30. doi:10.1038/s41572-021-00264-3

7. Murad MH, Asi N, Alsawas M, Alahdab F. New evidence pyramid. *Evid Based Med*. 2016;21(4):125-127. doi:10.1136/ebmed-2016-110401
8. Cochrane C, Chinna S, Um JY, et al. Site-of-care viscoelastic assay in major trauma improves outcomes and is cost neutral compared with standard coagulation tests. *Diagnostics (Basel)*. 2020;10(7):486. doi:10.3390/diagnostics10070486
9. Gonzalez E, Moore EE, Moore HB, et al. Goal-directed hemostatic resuscitation of trauma-induced coagulopathy. *Ann Surg*. 2016;263(6):1051-1059. doi:10.1097/sla.0000000000001608
10. Baksaas-Aasen K, Gall LS, Stensballe J, et al. Viscoelastic haemostatic assay augmented protocols for major trauma haemorrhage (ITACTIC): A randomized, controlled trial. *Intensive Care Med*. 2021;47(1):49-59. doi:10.1007/s00134-020-06266-1
11. Nascimento JCR, Neto EBL, da Silva EL, et al. Analysis of the hemostatic therapy in liver transplantation guided by rotational thromboelastometry or conventional laboratory tests. *Eur J Gastroenterol Hepatol*. 2020;32(11):1452-1457. doi:10.1097/MEG.0000000000001660
12. Kandeel A-R, Abdalla U, Abouelella M, et al. Rotational thormboelastolmetry guided transfusion practice in living donor liver transplantation, a retrospective comparative study. *Egypt J Anaesth*. 2018;34(2):55-59. doi:10.1016/j.egja.2018.03.004
13. St-Onge S, Lemoine É, Bouhout I, et al. Evaluation of the real-world impact of rotational thromboelastometry-guided transfusion protocol in patients undergoing proximal aortic surgery. *J Thorac Cardiovasc Surg*. 2019;157(3):1045-1054.e4. doi:10.1016/j.jtcvs.2018.07.043
14. Khalaf-Adel, E, Alavi, M, Alizadeh-Ghavidel, A, Akbar Pourfathollah, A. Comparison of standard coagulation testing with thromboelastometry tests in cardiac surgery. *J Cardiovasc Thorac Res*. 2019;11(4). https://doi.org/10.15171/jcvtr.2019.48
15. Jackson GN, Ashpole KJ, Yentis SM. The TEG vs the ROTEM thromboelastography/thromboelastometry systems. *Anaesthesia*. 2009;64(2):212-215. doi:10.1111/j.1365-2044.2008.05752.x

Mentor: Peter Slivinski, DNP, CRNA

Nurse Anesthetists and the Atropine, Ondansetron, Ketorolac (A-OK) Protocol

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Introduction

Amniotic fluid embolism (AFE) is a rare but devastating complication of pregnancy that is hypothesized to result from the entry of amniotic fluid into maternal circulation. The cardiovascular, pulmonary, and hematologic systems are frequently affected with maternal and neonatal mortality rates as high as 11%-44% and 21%-50%, respectively. Due to its rarity, research into the pathophysiologic mechanisms, supporting data, and available treatment options are incomplete. The atropine, ondansetron, ketorolac (A-OK) protocol, developed by Leighton[1], is a novel treatment regimen based on the platelet activation theory of AFE. Leighton developed the A-OK protocol to manage the cardiopulmonary and hemodynamic complications associated

with AFE. While there are case reports describing successful outcomes with the use of the proposed treatment regimen[2–4], scientific research explaining its efficacy is insufficient. First proposed in 2009, it is unknown how widespread the knowledge of the A-OK protocol is among the certified registered nurse anesthetist (CRNA) community. Thus, a survey conducted among CRNAs practicing obstetric anesthesia assessed their knowledge and perception of, and experience with using the A-OK protocol for AFE management.

Methods

An internet-based survey was distributed to 3,000 randomly selected CRNAs from the American Association of Nurse Anesthesiologists (AANA) database who self-identified as providing obstetric anesthesia services. The survey was available from October 20, 2021, to November 17, 2021, for this group. The survey was also made available to CRNAs who provide obstetric anesthesia services on the "CRNAs and SRNAs" private Facebook group. The survey was available from November 27, 2021, to December 6, 2021, for this group. The responses were analyzed, and frequency charts and cross-tabulation tables were constructed to assess correlational relationships among the provided data.

Results

A total of 174 survey responses met criteria for further analysis. Most respondents (82.76%, n = 144) had heard of the A-OK protocol. The protocol is generally well-known across all seven AANA regions of the United States and tends to be more well-known among newer CRNAs. Of the 26 out of 144 CRNAs that have used the protocol, the majority (17/26) reported improvement in patient condition after using the protocol and none reported worsening condition. All CRNAs who have used the protocol report that they would use it again, and the vast majority of CRNAs who have heard of it but hadn't used it (90.68%, 107/118) would use it in a suspected case of AFE. Most CRNAs who have heard of the A-OK protocol (84.72%, 122/144) would like to see more research on this topic.

Discussion

The response rate for this survey (3.8% for the AANA distribution, and indeterminate for the Facebook group) was a limiting factor in this study. According to the latest data received from the AANA Research and Quality Division, 8,750 members self-identified as obstetric CRNAs (email communication, March 2, 2021). Thus, 174 responses are less than the estimated 370 needed for a representative sample size. Nonetheless, the results of this survey indicate that knowledge of the A-OK protocol has spread widely in the obstetric CRNA community and that it is generally well-received. Still, more efforts to improve awareness are warranted and research is needed to confirm the physiologic mechanism through which the protocol works to support AFE management guidelines and/or algorithms. The researchers recommend future focused ethnography studies into A-OK experiences and the formation of a database dedicated to tracking A-OK utilization in suspected cases of AFE and the outcomes.

References

1. Leighton BL. Amniotic fluid embolism. Oral presentation at: Obstetric Anaesthesia Society of Asia and Oceania and Society for Obstetric Anesthesia and Perinatology Joint Symposium; April 2009; Washington, D.C.
2. Copper PL, Otto MP, Leighton BL. Successful management of cardiac arrest from a:mniotic fluid embolism with ondansetron, metoclopramide, atropine, and ketorolac: A case report. The Society for Obstetric Anesthesia and Perinatology 45th Annual Meeting April 24-28, 2013, San Juan, PR. Abstract S 47.
3. Rezai S, Hughes AC, Larsen TB, Fuller PN, Henderson CE. Atypical amniotic fluid embolism managed with a novel therapeutic regimen. *Case Rep Obstet Gynecol*. Published online December 21, 2017:1-6. doi:10.1155/2017/8458375
4. Parfitt S, Roth CK. A novel approach to amniotic fluid embolism treatment through use of the atropine, ondansetron, and ketorolac protocol. *J Obstet Gynecol Neonatal Nurs*. 2019;48(3):S164-S165. doi:10.1016/j.jogn.2019.04.272

Mentor: Vicki Callan, PhD, CRNA, CHSE

Editorial

I've been a Disney fan for many years and recently I saw a documentary on the history of the Disney organization. The punch line at the end was, "Remember – this all started with a mouse!" It made me realize that this journal started with just a staple.

When I was teaching at Georgetown, which had a two phase – academic and clinical curriculum, I wanted to create some means of helping the students retain their academic science knowledge during their clinical months so they would not have to cram for the board exam. So our faculty came up with the idea of requiring a case report each semester which would require discussing in writing an anesthetic the students administered and pull from their science background how the science applied to that experience.

When these reports started to come in, I saw the students' enthusiasm jump off the pages. It was exciting for me also as a teacher; it was like hearing the students say, "Look Mr. Vee, see what I can do!" The papers not only showed me enthusiasm, but they were well written. So well written I wanted the students to share their papers with their classmates. So, I photocopied all their reports for each member of the class. The very moment I hit the stapler on the first stack of papers it hit me – this is a little journal. Over time we dressed up the cover and title and invited other schools to join us in this publishing venture. After a few years we went online and overseas. The rest is history.

If I was the spark that got this going it was Julie Pearson and Vicki Callan who added the fuel and did they ever. It's been fun watching CRNAs who published in this journal when they were students return as faculty and mentor a new generation of authors. Congratulations to everyone, and it all started with a staple!

Sincerely,

Ron Van Nest, JD, CRNA, CAPT, NC, USN (Ret)
Founding Editor

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 ºC, 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