Management of Three Uncommon but Potentially Detrimental Anesthesia Emergencies; Amniotic Fluid Embolism, Local Anesthetic toxicity and Intraoperative Myocardial Infarction

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Title: Management of uncommon but potentially detrimental anesthesia emergencies; amniotic fluid embolism, local anesthetic toxicity and intraoperative myocardial infarction.

Problem:

Operating room emergencies can pose serious threats to the patient as well as all the staff members that are in direct and indirect care of that patient. The precarious position in which the anesthetized patient is in, lends for detrimental outcomes when complications arises. Of interest to the authors of this paper are three uncommon yet potentially deleterious emergencies. These are: Amniotic fluid embolism, Local Anesthetic Toxicity and Intraoperative Myocardial infarction.

While the incidence of some of these emergencies may be as low as 0.01%, as is the case of local anesthetic toxicity, the mortality and morbidity associated with them are exponentially higher (Goyal, 2012). As expected, taking into account the infrequency of some these emergencies and the vast array of imperative information that needs to be understood to safely practice anesthesia, authors of this paper believe that a more in depth understanding of these emergencies is needed in addition to what was present in the classroom. It would behoove any practicing anesthesia provider to have in their arsenal of knowledge a comprehensive understanding of theses emergencies and how to safely and effectively manage them.

It is the goal of the authors of this paper to thoroughly review the literature for the latest and most germane information on these topics and create an effective teaching module. A concise but information dense paper and presentation will then be synthesized and presented to the members of the Junior Anesthesia class at Adventist University of Health Sciences. The focus of the presentation and paper will be identifying and diagnosing the emergencies as well as

providing the best evidence based treatment for managing them. Additional information will also be provided for steps that can be taken to prevent the emergencies whenever possible. Finally, to assess and evaluate the effectiveness of the literature review and presentation a pre and Post-test covering varying depths of the emergencies will be administered.

The importance of this project and the justification as to why it needs to be done cannot be overstated. The fact that the incidences of these emergencies are relatively low does not negate the significant negative impact they can potentially have on someone's life. For example, according to records from the American Society of Anesthesiologists Closed Claims Database between 1980 and 2000 one third of claims for death and brain damage after regional anesthesia were accredited to local anesthetic toxicity (Didier, 2010). That is a telling example of the dire importance of understanding and gaining the tools to manage local anesthetic toxicity and other related emergencies.

Review of literature:

A detailed literature review was conducted over a period of weeks and numerous peer reviewed journal articles were read and analyzed and the most recent and strong research based articles selected. Databases such as Science Direct, Ebsco Host, Ovid, PubMed, Medline, and CINAHL which are reputable medical databases were systematically dissected and those articles deemed paramount were chosen to form the basis for this project.

Local Anesthetic Toxicity

Before delving into the issue of local anesthetic systemic toxicity (LAST) it would be most beneficial to give a brief overview of local anesthetics and their functions. Basically speaking, local anesthetics are weak basic drugs that reversibly block the conduction of electrical impulses along nerve fibers. Local anesthetics are able to carry out their function by

antagonizing voltage gated sodium channels located at the unmyelinated gaps between Schwann cells known as the *nodes of Ranvier*. This antagonizing of the receptors prevents proper functioning of the voltage gated sodium channels and hence prevents depolarization from occurring. Without depolarization the action potential cannot be propagated along the length of the nerve and neuronal communication ceases (Nagelhout, 2013).

Berrio Valencia and Silva (2013) holds that local anesthetic systemic toxicity (LAST) is one of if not the most feared complications of regional anesthesia. The significant undesirable impact on the central nervous system and the cardiovascular system and the possibility of causing a refractory cardiorespiratory arrest gives credence to those claims. Prevention is the main goal when dealing with LAST. However, prompt recognition and early supportive treatment is of utmost importance. According to Valencia and Silva, neurological toxicity is somewhat more common than cardiac toxicity occurring in 89% of reported cases compared to 55% for cardiac. Common signs of neurologic toxicity includes: intractable seizures, agitation and complete loss of consciousness with autonomic dysfunction. Cardiac toxicity present in the form of obstinate: severe bradycardia, hypotension, tachyarrhythmia, conduction defects, wide QRS intervals, ST segment changes, ventricular fibrillation or asystole (Valencia, 2013).

In a detailed literature review conducted by Toledo (2011) the genesis of lipid therapy as a treatment for local anesthetic toxicity was studied. It was determined that LAST occurred at a rate of 4/10000. Despite the fact that this is a minute fraction, some of the possible consequences speak volumes. Symptoms of local anesthetic toxicity can begin with vague signs such as lightheadedness to tingling around the mouth to complete loss of consciousness and eventually cardiopulmonary collapse requiring resuscitation and other supportive measures. Notably, resuscitation is often prolonged when LAST is involved as the drugs duration of action dictates

the duration of the cardiopulmonary arrest and hence the success of the resuscitative efforts. In 1998 Weinberg proposed that lipid emulsion can be used as the first line of treatment for the cardio toxic effects of LAST. This proposal was made after repeated animal studies showed the undeniable benefits of lipid emulsion in treating LAST. Surprisingly, even in current times the mechanism of action is not fully understood. Some have postulated that the local anesthetic is neutralized by the lipid emulsion or that the lipid emulsion actually sequesters the local anesthetic. Others hypothesize that lipid emulsion enhances metabolism of the local anesthetic via a mitochondrial mediated process while others argue that lipid emulsion simply increases calcium concentration in myocytes leading to improved contractility. In any case, lipid therapy has been used over the last decade with some success in managing the life-threatening effects of LAST (Toledo, 2011). The specifics of lipid therapy will be outlined and detailed in the PowerPoint presentation.

Beecroft and Davies (2013) conducted a systematic literature review and found that most cases of LAST occur as a result of inadvertent intravascular injection of local anesthetic. This often occurs because the person administering the local anesthetic fails to aspirate prior to injecting the drug. Additional means for LAST to occur include absorption from the site of injection when those sites have large blood vessels in close proximity. Distribution of local anesthetic to organs with a high blood supply also accounts for some of the incidences of LAST. The rate of absorption of local anesthetics was noted to be the least when administered via the intrathecal or subcutaneous routes and greatest when administered intercostal (Beecroft, 2013).

In a meta-analysis conducted by Mulroy (2003) the systemic and cardiovascular effects of LAST were examined and conclusions were drawn on the incidences and the best preventative measures. As mentioned before the most common occurrence of LAST occurs with unintentional

injection of a local anesthetic into a vein but there have been numerous reports of intra-arterial injections as well. Intra-arterial injections are usually associated with regional anesthetic techniques involving the neck and are typically characterized by profound rapid onset of symptoms even with small amounts of injected local anesthetics. Fortunately due to the rapid flow of blood in the arterial circulation the drug is often speedily removed especially from cerebral areas. Prevention of unintentional injection of local anesthetics and the negative sequelae can be accomplished by aspirating prior to injection, incremental injection of smaller doses at a time, dose limitation to recommended maximum safe dose and the use of assistive technology such as ultrasound and peripheral nerve stimulators (Mulroy, 2003).

Amniotic Fluid Embolism

Amniotic Fluid Embolism (AFE) is not a common condition, but it can certainly become a fatal obstetric syndrome that is exclusively related to pregnancy. It presents most frequently during labor or immediately in the post-partum period. Sudden cardiovascular collapse, altered mental status with respiratory compromise, fetal distress and the development of intravascular disseminated coagulopathy are the most common clinical presentations. Nevertheless non-classical presentations may also befall, and the clinician must constantly consider the probability of AFE when dealing with an obstetric patient that is not progressing as expected.

The pathophysiology of AFE is poorly understood and there are many proposals that aim to justify the entry pathways and the catastrophic effects on maternal circulation. After amniotic fluid goes in the maternal circulation a series of humoral, hemodynamic and coagulopathic changes follow leading to the signs and symptoms of amniotic fluid embolism syndrome. In the

past, AFE was associated with a mortality rate as high as 80%; nowadays according to recent literature, mortality rates have declined to 40-20 % with some statistics as low as 13% (Tuffnell, 2011).

Abenhaim et al., (2008) piloted a population-based cohort study by using data from the Healthcare Cost and Utilization Project and the Nationwide Inpatient Sample (NIS) containing all patient-level clinical information. A 3-step analysis was conducted to help examine the incidence and fatality outcomes derived from AFE. Findings suggested an occurrence of 7.7 cases per 100,000 deliveries with a 21.6% fatality rate. Potential risk factors associated with AFE were determined to be advanced maternal age and placental abnormalities such as placenta previa and placental abruption. Forceps or vacuum assisted cesarean deliveries have also demonstrated an increase in the risk of AFE. The ability to immediately deliver effective resuscitation support after recognizing the insult was the number one determining factor to survive an AFE event.

Mato (2008) conducted a case report where several theories for the pathophysiology of AFE were discussed. Embolization of amniotic fluid, the presence of bradykinin, leukotrienes, tryptase, complement activation, and antigen-antibody response were determined to be closely related in the pathogenesis process. Compromised cardiovascular system, respiratory failure, neurologic symptoms, hypotension and disseminated intravascular coagulation (DIC) were defined to be the hallmark signs and symptoms of AFE. The catastrophic outcomes consequent from these symptoms has directed to the implementations of several actions and therapies to help diagnose the fatal syndrome. When fetal heart rate is compromised, emergency delivery has to be accomplished after carefully securing the patient's airway. Hysterectomy usually follows, secondary to DIC and increased blood loss. Recombinant factor VIIa is generally the treatment

to help achieve hemostasis. Increased pulmonary vasculature due to pulmonary embolism was successfully accomplished with nitric oxide administration. The study highlights the positive results that the vasodilatory properties of nitric oxide exert on the pulmonary hypertension.

According to Dean et al., (2012), AFE even when rare, should always be considered in the development of any obstetrical emergency that involves any of the above mentioned symptoms followed by precipitated hemodynamic instability. Anaphylactoid syndrome of pregnancy is the other name given to AFE since the entry of amniotic fluid, which contains higher concentrations of vasoactive and procoagulant factors, into maternal circulation, triggers the activation of all inflammatory mediators that will cause either a humoral or immunologic response. All these factors that cause a disruption in the coagulation cascade are typically responsible for the common prevalence of DIC during AFE.

Management of AFE in general, relies on the early diagnosis and rapid aggressive hemodynamic support. These measures include ACLS protocol follow up, correction of coagulopathy and immediate cesarean section to improve neonatal outcome and prevent fetal neurologic damage. TEE is also found to be a powerful tool to guide vasopressor therapy and promote adequate fluid resuscitation. Additional invasive approaches like extracorporeal membrane oxygenation, uterine embolization, cardiopulmonary bypass and exchange transfusions are proven to be practical by improving morbidity in the obstetrical emergency. Again, nitric oxide accompanied by other aerosolized prostacyclin administration helps by acting as direct vasodilators on the AFE related vasoconstriction.

The prognosis of amniotic fluid embolism can always be improved with the early diagnosis and prompt intervention to correct hemodynamics. However, despite of new approaches and therapies, morbidity among survivors is still significant. Awareness between

clinicians and anesthesia providers is crucial in the progression of the incident and in the avoidance of all catastrophic events that can take place if adequate management of the emergency it is not attained. (Conde-Agudelo & Romero, 2009).

Intraoperative Myocardial Infarction

Perioperative myocardial ischemia continues to be a major contributor of mortality and morbidity in patients after non-cardiac related surgeries with mortality rates up to 25% (Landesberg, 2003). Current literature estimates incidence ranges from 1-17%. However, this figure can be an underestimation because it does not put into account silent or unrecognized intraoperative ischemia (Singh & Antognini, 2011).

If an intraoperative MI is to occur, it will most likely peak during emergence and early postoperative period (Landesberg, 2003). General or regional anesthesia is not a risk factor even for high risk cardiac patients when administered without complications. However, postoperative stress especially during emergence is what causes ischemia, infarction and mortality (Landesberg, 2003). This postoperative myocardial ischemia is usually seen as ST depression and less likely ST elevation, is mostly silent (non-Q wave) and occurs up to 24 -48 hours after surgery (Landesberg, 2003).

Although myocardial ischemia is well understood in non- perioperative settings, the pathophysiology in the operating room is not always explicit (Singh & Antognini, 2011). Coronary perfusion pressure which can be estimated by the difference in the diastolic blood pressure and the left ventricle end diastolic pressure is an important factor in oxygen delivery (Singh & Antognini, 2011). This and the oxygen carrying capacity of blood, determine oxygen delivery to the myocardium. Ischemia results in case oxygen demand by the myocardium exceeds what is required. Usually, in the normal heart, increased need for oxygen is regulated by

coronary vasodilatation that increases oxygen delivery. In coronary heart disease, this ability is compromised (Singh & Antognini, 2011).

Acute myocardial ischemia occurs when an unstable atherosclerotic plaque ruptures causing a thrombus that blocks a coronary vessel hence blood supply to a particular portion of the heart muscle. Interestingly, there is no correlation between severity of preoperative coronary blockage or plaque size and the possibility of getting a perioperative myocardial infarction (Singh & Antognini, 2011). Factors such as intraoperative hypotension, increased sympathetic activity especially tachycardia and hypertension have been shown to increased risk of perioperative myocardial ischemia (Singh & Antogninin, 2011). Attenuation of these conditions especially during emergence is an important step in reducing incidences of ischemia (Li, Wang, Wu, Li & Xie, 2013).

Recognition of risk factors during preoperative period is paramount. According to the ACC/AHA 2007 perioperative guidelines for non-cardiac surgeries, cardiac risk increases with : age, cardiac conditions such as past MI, angina, decompensated heart failure, significant arrhythmias, high grade valve disease, comorbidities such as peripheral vascular disease, CVA, diabetes, renal impairment, chronic pulmonary disease and poor exercise tolerance (Fleisher, Beckman, Brown, Calkins, Chaikof & Fleischmann, 2007). This guideline gives a systematic approach to identify high cardiac risk patients and allows the anesthesia provider opportunity to seek optimal cardiac condition prior to surgery hence reduce risk of cardiac related mortality and morbidity (Fleisher et. al, 2007). In a Chinese retrospective study analyzing 117,856 patients undergoing non-cardiac surgeries over 9 years, perioperative myocardial ischemia frequently occurred in male patients over 60 who had such risk factors as hypertension, diabetes and dyslipidemia. In the same study, 77% of patients with hemodynamic instability intraoperatively

especially with blood pressure labiality and increased heart rate suffered from myocardial ischemia or infarction within 72 hours of surgery (Li, Wang, Wu, Li & Xie, 2013).

In the operating room classic MI symptoms are masked by general anesthesia. Even with readily available monitors, it may not always be possible to detect ischemia (Singh & Antogninin, 2011). Myocardial ischemia should always be suspected in patients that are hemodynamically unstable with cardiac risks (Singh & Antogninin, 2011). Suspicion should also be raised with arrhythmia, conduction abnormalities, unexplained tachycardia, bradycardia and elevation of cardiac filling pressures (Chu & Fuller, 2012).

Routine use of multiple leads to detect ST and T wave changes on the EKG can enhance detection. In a study by London et. al, leads 2 and V5 increased detection of ST changes by 80% while using leads 2, V4 and V5 increased sensitivity by 96% (Singh & Antogninin, 2011). Computerized analysis by the monitors is more sensitive than visual inspection but this was dependant on proper lead placement, preoperative EKG changes and default settings (Singh & Antogninin, 2011). Left ventricular wall abnormalities seen on the transesophageal echocardiogram are more foretelling of myocardial infarction than using EKG and can be used for diagnosis in the OR (Singh & Antogninin, 2011). In addition to wall abnormalities, new onset mitral regurgitation is indicative of myocardial ischemia (Chu & Fuller, 2012).

Ischemia or infarction intraoperatively before incision by the surgeon should be indication to delay the case until the patient is stable (Singh & Antogninin, 2011). If surgery is in progress, inform the surgeon because surgery should be expedited while the anesthesia provider stabilizes the patient by improving coronary blood flow and oxygen delivery while reducing oxygen demand (Singh & Antogninin, 2011).

After myocardial ischemia/infarction is identified, oxygen demand should be decreased by; use of pain control and beta blockers to slow the heart rate and increasing supply by increasing FIO2 to 100%,. Beta blockers should be held for bradycardia or hypotension. Diastolic blood pressure should be maintained to improve coronary perfusion pressure. Nitroglycerin can be used to achieve this as long as the patient is not hypotensive (Chu & Fuller, 2012). Treat hypotension or hypertension accordingly. Consider placing an arterial line and central line, check labs including CK/ troponins and treat anemia with packed red blood cells (Chu & Fuller, 2012). If hemodynamics are stable and surgical bleeding is acceptable, a post op cardiac consult, statins, ACE inhibitors and aspirin can be started after surgery (Singh & Antogninin, 2011). If the patient is hemodynamically unstable, blood pressure support with vasopessors and assessment/ placement of intra-aortic balloon pump is indicated. If the patient has an ST elevated myocardial infarction then cardiac catheterization is preferred if coagulation is acceptable (Singh & Antogninin, 2011).

The anesthesia provider plays in important role in reducing cardiac related mortality and morbidity. His or her actions during the preoperative and intraoperative period have repercussion long after the patient leaves the operating table. Prevention of perioperative myocardial events begins with understanding the pathophysiology of myocardial ischemia, good preoperative assessment to evaluate cardiac risk, use of sensitive diagnostic tools to identify the event and reduction of intraoperative cardiac stressors especially during emergence. Intraoperative hypotension, increased heart rate and hypertension during emergence have been shown to be detrimental to the myocardium especially in patient with increased cardiac risk and should be avoided.

Project description:

After identifying the three uncommon but potentially detrimental anesthesia related emergencies a methodical literature review was conducted by all the members of this group. Only those resources and articles that boast the strongest level of research and that were conducted by individual qualified to lead in a research study were selected. Additional efforts were made to include the most recent information into the project to add more credence to the information to be presented.

As per the perception of the authors of this paper, the problem as stated above was the lack of experience and inadequate exposure to the aforementioned anesthesia related emergencies. The goal is to provide in a simple systematic way, information that can assist the junior nurse anesthesia student at Adventist University of Health Sciences in understanding, identifying, managing and possibly preventing these anesthesia related emergencies. The information will be presented in the form of an interactive PowerPoint lecture where various prompts and visuals aids will be incorporated to facilitate the learning process.

The PowerPoint presentation will involve strategically placed questions on key points with possibly a reward for correctly answering the questions. This method will be employed in an attempt to engage the audience catch and maintain their attention and create an environment that is more of a social gathering while presenting invaluable information that will equip them with the tools needed to deal with the anesthesia emergencies being discussed.

A trifold poster will then be designed and created with a detailed summary of the three emergencies being studied. A brief background of the emergency will appear at the top of each column of the trifold poster. Information to be incorporated in the background include: brief history, relative incidence and mortality and morbidity associated with the emergency. Below the section on background the classic signs and symptoms will be included and possibly a schematic

diagram for eliminating differential diagnoses and identifying the specific emergency will be incorporated. The best evidence based treatment and management techniques will then appear before the last section on possible methods of preventions.

Still in discussion is whether or not to include a lab simulation before and after the classroom PowerPoint presentation. The final details of that will be discussed and a conclusion made in advance to the proposed date of the presentation. The inclusion of a simulation will add more assurance that the information presented will be understood and retained by the junior anesthesia students.

Evaluation plan:

As mentioned before the project will aim to equip the junior nurse anesthesia student with the knowledge needed to be able to identify and manage as well as possibly prevent the three anesthesia related emergencies that formed the focus of this paper. The best method of evaluating ones knowledge is by testing that knowledge whether by a theoretical type test or by having them put into practice the knowledge that they have via a practical exam.

Taking this into account, exam questions will be formulated to test the knowledge and understanding of the junior anesthesia students in relation to the emergencies. Prior to presenting the information on the PowerPoint pretest questions will be administered to the students. After completion of the pre-test, data will be collected and the questions graded. The PowerPoint presentation will then be presented by the authors of this paper. After the presentation the same pre-test exam will be given to the junior anesthesia students and upon completion data will be collected again and graded. The authors of this paper has decided that an improvement in score of greater than **20%** from pre to post-test will indicate success in increasing the knowledge of the student on the three emergencies.

Additionally, as described above, the inclusion of a simulation lab may also be added to the project to assess and evaluate the effectiveness of the presentation in increasing the knowledge and understanding of the intricacies of these three uncommon anesthesia related emergencies. If included, the simulation lab will probably follow the same format of the pre and post-test. A volunteer junior anesthesia student will be placed in the simulation lab and one of the emergencies played out and the student evaluated on how they identify and manage the emergency. The other junior anesthesia student will watch the simulation from a remote location where their input cannot be ascertained by the volunteer student. After completion of the simulation no debriefing would be given. The PowerPoint lecture will then be given. Using the same volunteer, the same emergency simulation would be run and a thorough evaluation of his/her management and how much it has changed would be noted.

Results and Conclusions:

After completing the implementation of the project and taking into consideration all set goals and the results of the pre and post-test, it is fair to conclude that the project was a success. Although the lab simulation was not included in the evaluation, the results of the pre and post-test affirmed the immense success of the implementation of the project. The authors of this paper originally projected that a 20% increase from pre-test to the post-test would be considered significant and form the basis to conclude that the presentation of the anesthesia related emergencies increased the junior anesthesia student's knowledge about the topics. The average pre-test score was 4.65 correct responses out of 15 with the lowest score being 3 and the highest score being 7 out of 15. This worked out to an average percentage of 31% on the pre-test.

The post-test scores came back and surpassed expectations. The average was 9.61 correct responses out of 15 with the lowest score being 3 and the highest being 12. This resulted

in an average percentage of 64.1%. This was an increase by 5 correct questions and a total percent increase of 106.45%. The standard deviation was calculated to be 1.11 for the pre-test and 1.80 for the post-test This confirmed that the project was a success and the information presented was understood by the junior anesthesia student. The objectives were met and it can be concluded that the presentation built on the existing knowledge of the junior anesthesia student. The authors of this paper hope that the increase in knowledge will be lasting and go to serve the junior anesthesia students throughout the rest of their anesthesia careers.

The current project has many implications for the anesthesia provider in general. Even though operating room emergencies like the ones discussed above do not happen all the time, they comprise a serious threat to the surgical patient population when they do occur. Access to quality healthcare is essential to the health of a community but optimal surgical attention and knowledge by the anesthesia provider is essential for the prevention and management of major operating room crises. Implementation of strategic management tools deals with long-term decision-making process and the ability of the anesthesia provider to respond in a timely manner during catastrophic conditions, therefore, a better understanding of the anesthesia team plays a decisive role in the anticipated outcomes.

The findings in the research shows that despite the distinction in the complexity of the three different operating room emergencies anteriorly discussed, they all require similar approaches to safely manage the circumstances. Being aware and having an extensive understanding of the possible complications, critically analyzing the symptoms and being able to promptly respond with the best appropriate treatment, will guarantee the anesthesia provider as well as the patient, a much better prognosis and a much healthier recovery.

Interestingly, there were two most frequently missed questions in both the pre and post-test. Consistency in failing to answer the questions correctly can be attributed to; poor understanding of the content presented, poor comprehension of the question, or poor construction of the question. Perhaps better construction of the questions would lead to even better scores in the post test in the future. Overall, the students appeared to have good background understanding of the subject matter in all three topics. This made it easier to add to their existing knowledge as evidenced by both the pre and post-test.

The project was deemed a success as the information presented was well understood by the junior anesthesia student. The objectives were met and it can be concluded that the presentation built on the existing knowledge of the junior anesthesia student.

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