كلية الطب
قسم التخدير والرعاية المركزة

Cardiac Arrest In Pediatric Anesthesia

An Essay

Submitted For Partial Fulfillment Of Master Degree In Anesthesia

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Cardiac Arrest In Pediatric Anesthesia

توقف القلب المصاحب للتخدير فى الأطفال

رسالة مقدمة للحصول على درجة الماجيستير فى التخدير

من الطبيب / محمد سراج الدين إسماعيل محمد

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work and his guidance and meticulous revision for the whole work.

LIST OF ABBREVIATION

POCA = Pediatric perioperative cardiac arrest.

ASA = American society of anesthesiologist.

MAC = Minimum alveolar concentration.

LMA = Laryngeal mask airway.

MH = Malignant hyperthermia.

URI = Upper respiratory infection.

ETS = Environmental tobacco smoke.

LEAN = Lidocaine, Epinephrine, Atropine, Naloxone.

VF = Ventricular fibrillation.

VT = Ventricular tachycardia.

SVT = Supraventricular tachycardia.

CPR = Cardiopulmonary resuscitation.

CCM = Closed cardiac massage.

OCM = Open cardiac massage.

ECMO = Extracorporeal membrane oxygenation.

PALS = Pediatric advanced life support.

AV = Atrio-ventricular.

PEA = Pulseless electrical activity.

EMD = Electromechanical dissociation.

AEDs = Automatic external defibrillators.

CNS = Central nervous system.

ROSC = Return of spontaneous circulation.

SIRS = Systemic inflammatory response syndrome.

LV = Left ventricle.

ATP = Adenosine tri-phosphate.

ABC = Airway, Breathing & Circulation.

ARDS = Acute respiratory distress syndrome.

AMP = Adenosine mono-phosphate.

MODS = Multiple organ dysfunction syndrome.

Introduction

Pediatric anesthesia has progressed rapidly throughout the years. From the first recorded case of pediatric anesthesia in ١٨٤٢ to the latest advancements in training , technology, medicine and equipment in the last decades of this century.

Today, pediatric anesthesia has grown to include new anesthetic agents, more advanced technology and sophisticated equipment, and special training that provides education in all aspects of pediatric anesthesia ***(Steward, ١٩٩٢)***

Advances in pediatric anesthesia practice such as sub-specialization, introduction of new drugs and better monitoring may have changed the liability profile of pediatric anesthesia practice. Pediatric malpractice claims from the ١٩٧٠s and early ١٩٨٠s showed a high proportion related to respiratory complications (inadequate ventilation) with ٤٥% of complications thought to be preventable ***(Jimenez et al., ٢٠٠٥)***

Despite advances in pediatric anesthesia, unexpected cardiac arrests still occur. The risk of anesthesia related cardiac arrest appears to be inversely proportional to age, with our youngest patients at the highest risk. Of all cases of cardiac arrest submitted to the Perioperative Cardiac Arrest (POCA) Registry, ٥٥% were less than one of age. Any relation between age and risk results in large measure from the impact of underlying patient disease ***(Morray et al., ٢٠٠٠)***

Outcomes for anesthetized children have improved over the past ٥٠ years. As reflected in the decrease in anesthesia-related mortality rate from ١٤ deaths per ١٠,٠٠٠ anesthetics in the ١٩٥٤ study of Beecher and todd to ٠.٢, ٠.٣٦, and ٠.٣٦ deaths per ١٠,٠٠٠ anesthetics in recent series from France, Canada and the United States. Several series of outpatient anesthetics in healthy children have shown mortality of zero ***(Keenan and Boyan, ٢٠٠١).***

Etiology of Cardiac Arrest in Pediatric Anesthesia

Along with a decline in the incidence of anesthesia-related cardiac arrest has come a change in the profi١e of causes of arrest. Forty years ago, airway obstruction and aspiration were more frequent, often from the lack of use or inappropriate use of endotracheal tubes. With increased use of muscle relaxants, inadequate ventilation became a relatively more common respiratory complication than airway obstruction or aspiration. In the last decade, respiratory complications have become relatively less common and cardiovascular complications more common ***(Cheney, ١٩٩٢)***.

Cardiovascular and respiratory factors are the major causes of cardiopulmonary arrest in the pediatric population during anesthesia**.** In ***(١٩٧٥) Salem et al.,*** reported that hypovolemia, preoperative anemia, pharmacologic toxicity (succinylcholine, potassium), hypoventilation and airway obstruction were the major cardiovascular and respiratory causes of anesthesia-related cardiac arrest in the pediatric population. The etiology of cardiac arrest in the pediatric patient has changed over the past ٢٠ years as practice has evolved in the care of these patients. The Pediatric Closed Claims Study in ١٩٩٣ showed respiratory events were the most common category accounting for ٤٣% of claims with inadequate ventilation seen in half of the respiratory events. The typical profile in this category of inadequate ventilation were healthy, non-obese children breathing halothane spontaneously whose arrest was preceded by hypotension or bradycardia. These children were difficult to resuscitate successfully, ٧٠% died and ٣٠% had permanent central nervous system impairment. Pulse oximetry was used in ٧% of the Closed Claim cases and capnometry in ٥% ***(Morray et al., ١٩٩٣)***

Recently the Pediatric Perioperative Cardiac Arrest (POCA) Registry has provided some new data that out of ١,٠٨٩,٢٠٠ anesthetics, there were ١٥٠ cardiac arrests which were deemed anesthesia related (١.٤/١٠,٠٠٠). Several points are relevant in analysis of this data ***(Morray et al., ٢٠٠٠)***

First, an increased incidence of cardiovascular causes (٣٢%) have differed from the Pediatric Closed Claims Study in ١٩٩٣ where only ١٣% were from cardiovascular causes. This may have some basis in the fact that using chest compression was necessary as entry criteria for the (POCA) Registry or the fact that the use of pulse oximetry in ٩٨% and capnography in ٨٦% of cases may be more effective in preventing respiratory than cardiovascular incidents before arrests occur. Most of the cardiac arrests (٨٢%) occurred during induction or maintenance of anesthesia. Bradycardia (٥٤%), hypotension (٤٩%), abnormality of SpO٢ (٤٦%) or inability to measure blood pressure (٢٥%) were the most common antecedent events ***(Olsson and Hallen, ١٩٩٨)***

Second, infants are at increased risk. Infants <l-year accounted for ٥٥% of the anesthesia related cardiac arrests. Several pediatric studies have confirmed that infants <١ -year have the highest anesthetic risk and that mortality is inversely proportional to age with the highest risk in the <١ month of age group. This may be notably related to a higher American Society of Anesthesiologists (ASA) Physical Status (PS) Classification with underlying patient disease (particularly congenital heart disease) but also to cardiovascular depression by inhalational agents ***(Cohen et al., ١٩٩٠)***

Infants <٣٠ days of age the MAC of halothane is ٨٧%, as compared with children ١-٦ months of age MAC of ١.٠٨ With isoflurane, the MAC for preterm infants (<٣٢ weeks)is ١.٢٨, ٣٢-٣٧ weeks is ١.٤١, and for term (٠-١ month) ١.٦٠, with ١-٦ months being ١.٨٧. Only sevoflurane appears to be different with the MAC being constant at ٣.٢-٣.٣% for neonates and infants less than one month, decreasing to ٣% at ١-٦ months, and ٢.٥-٢.٨% for ٧ months - ١٢ years ***(Lerman et al., ١٩٩٤).***

Table (١): Comparison between MAC of different inhalational agents at different age of child ***(Lerman et al., ١٩٩٤)***

Age of child	MAC of holothone	MAC of isoflurane	MAC of sevoflurane
<٣٠ days	٨٧%	١.٦٠%	٣.٢-٣.٣%
١- ٦ months	١.٠٨%	١.٨٧%	٣%
٧ months- ١٢years	١.٣٠%	٢.٢%	٢.٥-٢.٨%

Recent studies showed that sevoflurane has less myocardial depressant action and less potential for producing bradycardia than halothane in infants. Sevoflurane may also be safer for use in children with congenital heart disease, another high risk area. In comparison with children receiving halothane, the halothane treated patients experienced twice as many episodes of severe hypotension as those who received sevoflurane. Recurrences of hypotension occurred despite increased vasopressor use in the halothane as compared to the sevoflurane treated patients. Risk of hypotension was increased in children less than one year of age compared with older children. Patients with preoperative cyanosis had a higher incidence of developing severe desaturation with halothane ***(Russell et al., ٢٠٠١)***

Third, ٣٣% of all anesthesia related cardiac arrests occurred in previously healthy ASA grading I and II patients mostly medication-related errors (٦٤%). Fifty percent of the arrests caused by halothane cardiovascular depression which seen at inspired concentrations of ٢% or less with the median age being ٦ months. Controlled ventilation may accelerate the rise in halothane concentration associated with prolonged exposure to higher concentrations due to difficult intravenous access. Four cases of arrest occurred following probable intravascular injection of local anesthetics. These occurred during combined halothane and caudal anesthesia with injection of ٠.٢٥% bupivacaine with ١/٢٠٠,٠٠٠ epinephrine despite negative test dose and aspiration. They occurred when both needles and catheters were used to deliver the medication. All had ventricular arrhythmias but were successfully resuscitated without injury ***(Linda and Loma, ٢٠٠٣).***