Evaluation of the variability of anesthetic practice in a single institution

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EVALUATION OF THE VARIABILITY OF ANESTHETIC PRACTICE IN A SINGLE INSTITUTION

by

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JOSHUA D. LEE

ABSTRACT

Anesthetics are provided to millions of patients every year in the United States mostly by anesthesiologists. However, there is a lack of literature or documentation on how anesthetics are administered by various anesthesia providers. In order to have a better understanding on the pattern, we performed retrospective chart review on anesthetic practice for surgical atrial septal defect repair procedures performed in Boston Children’s Hospital. Our collected data included: premedication, anesthesia induction methods, anesthesia maintenance methods, choice of vasoactive agents, analgesics, and intravenous accesses, extubation in the operating room, postoperative sedation, and choice of antiemetics and postoperative nausea and vomiting. In addition, the studied patients were divided into two groups based on the institutional initiation of the Fast-track protocol: before and after the implementation of the Fast-track protocol (the Non-fast-track group and the Fast-track group).

Some results fell under expectation; for example, in the Non-fast-track group, all patients who were induced intravenously were older than 10 years old, and received propofol for induction, which is the most popular choice of intravenous induction drug. The Fast-track group showed a similar trend; 80% of all intravenously induced patients were 10 years or older and induced with propofol. Also, in both groups, anesthesia was maintained with the combination of IV and volatile anesthetics. An anticipated change in
practice pattern was seen in the Fast-track group for the choice of analgesics and postoperative sedation for non-extubated patients; acetaminophen was introduced as an adjunct to other analgesics, and propofol infusion was introduced as a standard drug of postoperative sedation for non-extubated patients, both of which are part of the Fast-track protocol. Interestingly, however, overall intraoperative opioid doses did not show any change. The variation in the choice of intravenous access showed difference before and after the Fast-track implementation; in the Non-fast-track group, extra jugular vein was accessed as the most popular choice, whereas in the Fast-track group, central venous line was the most popular choice. Also, the incidence of postoperative nausea and vomiting was notably lower in patients who were not given anti-emetics after the Fast-track protocol implementation. This calls for a need for a future research on what part of the Fast-track protocol could have resulted this improvement without intraoperative administration of regular anti-emetics. Overall, our results provide future directions for researches on anesthetic practice that may help improve patient safety and efficiency beyond the practice in Boston Children’s Hospital.
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LIST OF ABBREVIATIONS

ASD .......................................................... Atrial Septal Defect
CNS .......................................................... Central Nervous System
CPB .......................................................... Cardiopulmonary Bypass
IV .............................................................. Intravenous
OR ............................................................ Operating Room
PONV ......................................................... Postoperative Nausea and Vomiting
PPI ............................................................. Parent Present Induction
INTRODUCTION

Background and Purpose

There is a lack of literature or documentation on how anesthetics are applied in the operating rooms by various practitioners. Understanding how anesthetics are administered may provide useful information on pros and cons of current practice as well as directions for further research in both clinical settings and laboratories. Therefore, we collected data of anesthetic regimens in a medically homogenous population retrospectively, and aim to study variation in anesthetic practice in Boston Children’s Hospital.

Practice of Anesthesia

Anesthesia is a medical intervention during which a physician gives a patient a drug called anesthetic (“Anesthesia,” n.d.). The purpose of anesthesia is to reduce or prevent pain and provide immobile field to facilitate surgical procedure (“Anesthesia,” n.d.). Four main types of anesthesia are sedation, local, regional, and general anesthesia (“Anesthesia,” n.d.). The choice of the anesthesia type depends on many factors, including the procedure the patient receives and his or her current health (“Anesthesia,” n.d.). In this study, the procedures of interest utilize general anesthesia.

General Anesthesia
In general anesthesia, the patient is put into a deep “sleep” in order to avoid pain and recollection during the surgery. The patient is not aware of what is happening around him or her, and does not feel pain during medical procedures (“General anesthesia,” n.d.).

General anesthesia is commonly produced by a combination of intravenous and inhaled drugs. During general anesthesia, the brain does not respond or is less responsive to pain signals or surgical manipulation (Mayo Clinic Staff, 2013). While the patient is unconscious, the body’s vital functions are monitored, and breathing is often assisted or controlled (Mayo Clinic Staff, 2013). Some conditions that may lead physicians to recommend general anesthesia for procedures include - lengthy procedure, anticipation of significant blood loss, exposure of the body to a cold environment, and impaired respiration during surgeries such as chest or upper abdominal surgeries (Mayo Clinic Staff, 2013).

Safety of General Anesthesia

The practice of general anesthesia has become significantly safer with the development of newer drugs and monitoring system, and training systems. Now the focus in anesthesia practice shifted toward improving quality in patients rather than just focusing on severe complications. These include controlling postoperative nausea and vomiting, and postoperative pain. Therefore, it is important to understand how anesthetics are delivered to patients. The literature is rather lacking in this aspect. Recent study demonstrates that there was a difference in the outcomes among anesthesia practitioners (Glance LG et al., 2015). It is critical to understand how variable the practice pattern is.
Premedication Prior to General Anesthesia

The purpose of premedication administered to children is to reduce anxiety during various phases of the perioperative period. Midazolam is a relatively short-acting benzodiazepine and is most commonly used via oral route in children (Cox, Nemish, Ewen, & Crowe, 2006). Particularly, past studies have shown that premedication with oral midazolam reduces anxiety at separation from parents and at the induction of anesthesia (Cox, et al., 2006).

Adequate sedation provided by premedication prior to anesthesia, followed by premedication, will not only relax patients for procedures, but will also make them more receptive to future anesthetics (Stark, 1958). Sedatives presumably prevent “stress reaction.” In addition, premedication often causes temporary amnesia for a few hours in children, allowing them to forget the visit (Stark, 1958).

Induction

Induction is the first step of general anesthesia during which anesthetics are administered to the patient to produce unconsciousness. Induction is largely done either intravenously or inhalationally (Hemming Jr., 2010). In adult patients, almost always intravenous induction is performed because of their acceptance to intravenous catheter insertion. Although it is commonly perceived that intravenous induction is a more reliable and safe method, in pediatrics the choice of induction method is dependent on many factors such as easiness of obtaining intravenous access without stress. Children
undergoing surgery may experience fears of separation from their parents at the time of induction. The avoidance of preoperative sedative for them often gives children the distress at the time of separation as they are surrounded by masked strangers at the beginning of anesthesia (Larosa-Nash, Murphy, Wade, & Clasby, 1995). In order to minimize this distress experienced by patients, hospitals have implemented parent-present anesthesia induction programs, possibly improving the surgical experience for many children and families (Larosa-Nash, et al., 1995).

**Inhalation Induction**

Inhaled anesthetics are useful for the induction of anesthesia in pediatric anesthesia, where IV access is commonly absent (Hemmings Jr., 2010). Prior to the introduction of IV anesthetics, inhalation of gases such as nitrous oxide, ether, and chloroform, often resulted in slow, unpleasant and occasionally dangerous inductions (Hemmings Jr., 2010).

Sevoflurane is currently the most popular anesthetic agent in North America for inhalation induction because of its low pungency and low risk of respiratory irritation. It has an intermediate solubility in blood and tissues, and does not cause respiratory irritation, circulatory stimulation, or hepatotoxicity. However, it may be associated with seizure-like activity, and postoperative agitation (Eger II, 2004).

**IV Induction**
Introduction of hollow needles, syringes, and IV fluid therapy, which provided direct access to the bloodstream for the rapid administration of drugs, led to the introduction of rapidly acting anesthetics using intravenous drugs (Hemmings Jr., 2010). The concept of “balanced anesthesia,” introduced in 1926, describes a combination of premedication (sedatives), local anesthesia, and systemic anesthetic drugs to reduce the dose of each agent and thereby improve safety (Hemmings Jr., 2010). This concept has evolved to a practice that is widely used today - the combination of various IV drugs including hypnotics, analgesics, sedatives, and muscle relaxants, often with inhaled anesthetics (Hemmings Jr., 2010). Appropriate IV drugs are selected based on the anesthetic side goals for each patient as dictated by the procedure and patient-specific pathophysiological conditions (Hemmings Jr., 2010).

Common intravenous anesthetics include etomidate, midazolam, propofol, ketamine, and opioid agents (Eger II, 2004). The ideal IV anesthetic agent has a rapid onset of action as well as a quick clearance from the bloodstream and CNS, facilitating control of the anesthetic state (Eger II, 2004). The ideal agent also protects vital tissues, does not affect circulatory system or cause adverse effects, is inexpensive, and has desirable pharmacologic effects such as an antiemetic effect (Eger II, 2004). Propofol is the most popular choice of IV induction agent for many reasons. It has a very rapid onset of action, as it distributes to CNS and tissues fast (Eger II, 2004). Unconsciousness is produced within one arm-brain circulation time, which refers to the time it takes for the drug to travel from the injection site to the brain (Eger II, 2004). Propofol is also rapidly and extensively metabolized in the liver and also extrahepatically, leading to a high rate
of total body clearance (Eger II, 2004). It is known to have a direct anti-emetic effect, although the mechanism remains unknown (Eger II, 2004). It is euphorigenic, but does not have residual psychotic effects unlike ketamine (Eger II, 2004). In past studies, patients have shown preference of IV induction due to aforementioned advantages and association with less claustrophobia. More patients who were given propofol (90%) were willing to receive the same induction again, than those who were given sevoflurane (50%) (Eger II, 2004). On the other hand, children preferred an inhalation induction due to a fear of needles (Eger II, 2004).

**Endotracheal Intubation**

During an endotracheal intubation, a tube is placed into the trachea through the mouth or the nose. After intubation, patient is placed on a breathing machine (“Endotracheal intubation,” n.d.). Endotracheal tubes are intubated for several reasons that are not mutually exclusive - to secure an airway for the administration of anesthetic agents, to provide airway protection, or to provide positive-pressure mechanical ventilation (Ortega, Connor, Rodriguez, & Spencer, 2014). In addition to the main risks of bleeding and infection, other potential risks include: trauma to the larynx, thyroid gland, vocal cords, and trachea or esophagus, puncture or perforation of body parts in the chest cavity, which may lead to lung collapse (“Endotracheal intubation,” n.d.).

**Maintenance**
On the contrary to advantages of IV anesthetics during induction period, they are not commonly used during maintenance period of general anesthesia for several reasons (Eger II, 2004). Administration of multiple doses by IV injection or continuous infusion may result in drug accumulation and delays in recovery from anesthesia, and the cost of IV drugs, compared to that of inhaled drugs, is higher (Eger II, 2004). In addition, the use of inhaled anesthetics for maintenance of anesthesia allows a greater control of the depth of anesthesia because of the presence of medical devices designed to monitor the concentration of the inhaled anesthetic agent delivered to the patient (Eger II, 2004). Past studies showed that patients who were given propofol for maintenance of anesthesia showed higher percentage of purposeful movement, an indication for a shallow depth of anesthesia that can interfere and delay surgery, than those who were given isoflurane or desflurane, inhaled anesthetic agents (Ashworth J, 1998).

Inhaled anesthetic agents include nitrous oxide and halogenated agents, which include desflurane, isoflurane, and sevoflurane in current use. Following the success of halothane, the first fluorinated inhaled anesthetic, isoflurane, desflurane, and sevoflurane, which have more characteristics of the ideal inhaled anesthetic agent than halothane, were developed and introduced (Eger II, 2004). Major characteristics of the ideal inhaled anesthetic agent include ample potency, low solubility in blood and tissues, resistance to physical and metabolic degradation, and a protective effect in and lack of injury to vital tissues (Eger II, 2004).

**Emergence**
Emergence from general anesthesia refers to liberation of the patient from the state of anesthesia. Ideally, the patient should be free from effects of anesthetics and only analgesia needs to be continued (Bhaskar, 2013). The ideal emergence happens in a short-time, is smooth and free from side-effects. Side-effects may be the results of residual effects of anesthesia and altered physiology related to airway, respiration, autonomic, metabolic and endocrine functions (Bhaskar, 2013). The site of action and the emergence mechanism of general anesthesia are still not completely clear (Bhaskar, 2013) but gradually being elucidated (Benveniste & Volkow, 2013).

**Endotracheal Extubation**

Endotracheal extubation is the removal of an endotracheal tube from the trachea, and is commonly performed in operating rooms, but it can be performed in postanesthesia care units, and intensive care units (Ortega, et al., 2014). Although extubation-related problems are usually minor, serious complications such as cardiovascular stress, pulmonary aspiration, hypoxemia, and even death may arise. Therefore, a plan for airway management is required to minimize the risks of complications related to extubation (Ortega, et al., 2014). When the clinical conditions that required mechanical ventilation or airway protection with an endotracheal tube are no longer present, endotracheal extubation is indicated (Ortega, et al., 2014). However, endotracheal extubation is contraindicated in patients with impaired protective airway reflexes or inability to maintain adequate spontaneous respiration. Also, the presence of cardiovascular
instability, metabolic derangements, or hypothermia can also lead to a contraindication to endotracheal extubation (Ortega, et al., 2014).

**Postoperative Care**

Following anesthesia emergence, most of patients are extubated in the operating room and postoperative care is provided in the recovery room and continues throughout the recovery period. Main concerns are airway clearance, pain control, mental status, and cardiovascular stability (Johnson, 2013). Other important concerns include preventing urinary retention, and constipation (Johnson, 2013). However, patients who undergo cardiac surgical procedures may or may not be extubated in the operating room based on their clinical status. In our institution, Boston Children’s Hospital, all the patients following cardiac surgery on cardiopulmonary bypass will be recovered in the intensive care unit. Appropriateness of extubation in the operating room is assessed on an individual basis.

**Heart Embryology & Atrial Septal Defect (ASD)**

In the early embryo heart, the atria contain a common chamber (“Ostium Secundum Atrial Septal Defects,” 2013). As the atria enlarges the septum primum forms and grows toward the developing atrioventricular canal area, which later gets divided by the superior and inferior endocardial cushions (“Ostium Secundum Atrial Septal Defects,” 2013). These cushions fuse and bend with their convexity toward the atria, thereby approaching the down-growing septum primum (“Ostium Secundum Atrial
Septal Defects,” 2013). This process continually narrows the passageway between the atria, which is defined as the ostium primum (“Ostium Secundum Atrial Septal Defects,” 2013).

Before the ostium primum completely closes, a central perforation appears in septum primum, allowing continuous unrestricted flow from the right atrium to the left atrium (“Ostium Secundum Atrial Septal Defects,” 2013). This perforation, the second opening in the septum primum, is called ostium secundum (“Ostium Secundum Atrial Septal Defects,” 2013). As the atria expand, a fold is produced passively within the atria just to the right of septum primum, and is called septum secundum (“Ostium Secundum Atrial Septal Defects,” 2013). The leading edge of septum secundum is concave in shape and is called the foramen ovale. It overlays the ostium secundum but does not interfere with blood flow from right to left through ostium secundum (“Ostium Secundum Atrial Septal Defects,” 2013). After birth, with onset of pulmonary blood flow and elevation of left atrial pressure, the septum primum is pushed against the septum secundum, closing the ostium secundum (“Ostium Secundum Atrial Septal Defects,” 2013). The septum primum and the septum secundum fuse to close the foramen ovale. In two-thirds of individuals, complete closure occurs (“Ostium Secundum Atrial Septal Defects,” 2013).

Atrial septal defect (ASD) refers to a hole in the septum that separates left and right atria, of the heart. This defect allows oxygen-rich blood to leak into the oxygen-poor blood chambers (“Atrial Septal Defect (ASD),” 2015). ASD occurs when an abnormal formation of this wall results in a hole that remains after birth (“Atrial septal defect (ASD),” n.d.). When blood flows through this shunt between the two upper chambers,
pressure in the lungs builds up, and over time, less oxygen will be delivered to the body ("Atrial septal defect (ASD),” n.d.). Although small ASDs often cause very few problems and may not be discovered until much later in life, large ASD’s can cause many problems ("Atrial septal defect (ASD),” n.d.). Some symptoms that occur at any time after birth include dyspnea, frequent respiratory infections in children, heart palpitations, and shortness of breath with activity ("Atrial septal defect (ASD),” n.d.).

**ASD Types**

**Ostium Secundum Atrial Septal Defect**

A secundum atrial septal defect results from inadequate formation of the septum secundum, not covering the ostium secundum completely. In more frequent cases, the ostium secundum is excessively large because of increased resorption so that septum secundum cannot cover it. ("Ostium Secundum Atrial Septal Defects,” 2013)
Ostium Primum Atrial Septal Defect

During normal fetal development, around 5 weeks’ gestation, the ostium primum is sealed by fusion of the superior and inferior endocardial cushions (“Ostium Primum Atrial Septal Defects,” 2015). Failure to do so results in an ostium primum ASD (“Ostium Primum Atrial Septal Defects,” 2015). Because the endocardial cushions also contribute to the complete formation of 2 separate AV valves and the inlet interventricular septum, primum ASDs are commonly associated with malformations of
these structures such as cleft mitral valve (“Ostium Primum Atrial Septal Defects,” 2015).

**ASD Sinus Venosus**

Sinus venosus ASDs refer to defects that involve the area of the atrial septum derived from the sinus venosus (Marshalko, 2001). Most common defects occur at the junction of the superior vena cava and the right atrium, as well as at the junction of the inferior vena cava and the right atrium (Marshalko, 2001). Typically, the right upper pulmonary veins enter the left atrium superiorly and to the left of the atrial septum and sinus venosus region (Marshalko, 2001). A defect of the superior sinus venosus may direct the flow from these veins toward the right atrium through the sinus venosus defect (Marshalko, 2001). Often, some of pulmonary veins may be anomalously located and drain to the right atrium rather than the left atrium as well (Marshalko, 2001).
Figure 2. An Illustration of Sinus Venosus ASD (Marshalko, 2001).

**Coronary Sinus Atrial Septal Defects**

Coronary sinus ASDs refer to defects located in the portion of the atrial septum that includes the coronary sinus orifice (“Coronary Sinus Atrial Septal Defects,” 2013). At least a portion of the common wall that separates the coronary sinus and the left atrium is absent (“Coronary Sinus Atrial Septal Defects,” 2013). The defect in the wall on the left atrial side is continuous with the orifice of the coronary sinus opening on the right atrial side of the septum, and causes interatrial shunting (“Coronary Sinus Atrial Septal Defects,” 2013). These defects are often associated with a persistent left superior vena cava (SVC) that drains into the coronary sinus; they may also be associated with complex congenital heart lesions. Isolated coronary sinus ASDs are associated with a low rate of
morbidity and mortality. Less than 1% of ASD cases are of the coronary sinus type (“Coronary Sinus Atrial Septal Defects,” 2013).

**ASD Repair Procedures**

ASDs can be closed by a catheter procedure in the interventional laboratory or surgically in the operating room. In the catheter based approach, a catheter is guided through a blood vessel into the heart, where an umbrella-shaped device (ASD device) is then passed through the catheter into the defect, preventing blood flow through the opening (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.).

Surgery is required if the defect is large or there is not an adequate rim to stabilize the ASD device (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.). The operation of surgical ASD repair is performed under general anesthesia (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.). The surgeon first makes a vertical incision in the chest, opens the breastbone, and exposes the heart (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.). Then, cardiopulmonary bypass redirects blood from the heart to a machine, which does the job of the heart and lungs during the operation (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.). The surgeon then opens the heart, and identifies the defect (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.). Small defects are directly stitched-closed, while a large defect is patched with a small piece of pericardium that is cut in the size and shape of the defect (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.). After the defect is repaired, the surgeon shuts down the bypass machine, and the heart
starts beating again (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.).
The procedure is concluded as the surgeon closes the breastbone and chest incision, and applies bandages to the incision site (“Atrial Septal Defect (ASD) Repair, Heart and Vascular Care,” n.d.).

In our study, primum ASD is excluded because it also often involves mitral valve operation, which could alter the practice in the postoperative period in our institution compared with other types of ASD and introduce a source of additional confounding factors. The ASD repair procedures for secundum ASD and sinus venous ASD were included in our study. The procedure for coronary sinus ASD was absent in our series that were reviewed.

**Intravenous Accesses**

Venous access is a basic yet critical component of patient care during surgical procedures (Cheung, Baerlocher, Asch, & Myers, 2009). Safe and reliable venous access is an important issue in clinical care, and understanding the options and giving adequate counseling to patients on appropriate device is increasingly important to physicians (Cheung, et al., 2009). Venous access device must be tailored to each patient’s needs and to the type, duration, and frequency of infusion (Cheung, et al., 2009). Peripheral intravenous lines (PIV) are intended for short-term IV therapy, are inexpensive (Cheung, et al., 2009). Central venous lines (CVL) terminate in the veins within the thorax but are inserted via large veins, and are potentially lifesaving (Cheung, et al., 2009). Some indications for central lines include: administration of IV fluids, medications, or blood
products in large quantities or over a prolonged period of time, administration of medications that are harmful to peripheral veins, long-term access to the central venous system for repeated procedures, and poor or inaccessible peripheral venous access (Cheung, et al., 2009). For centrally inserted catheters, a preferred vein is internal jugular vein (Cheung, et al., 2009). The extra jugular vein is a superficial vein of the neck and can be large and also close to the heart, often accessed with regular IV catheter (Stickle & McFarlane, 1997).

**Postoperative Sedation & Analgesics**

One of goals in the postoperative period is to maintain an optimal level of pain control and sedation for their patients (Liu & Gropper, 2003). There has been evidence showing that the combined administration of sedatives and analgesics may improve controlling the detrimental stress response in critically ill patients (Liu & Gropper, 2003). Some published clinical practice guidelines for sedation and analgesia have been established by several societies (Liu & Gropper, 2003). Fentanyl is a recommended opioid for short term use, and morphine or hydromorphone is for long-term therapy (Liu & Gropper, 2003). Recommended sedation medications for the acutely agitated patients are midazolam or diazepam, while lorazepam is recommended for longer infusions (Liu & Gropper, 2003). Propofol is recommended when rapid awakening is desired (Liu & Gropper, 2003). These are general guidelines, and actual choices of medications are discretion to providers. Patients who undergo surgical ASD closure are often kept
intubated immediately after the repair and may receive sedation and pain medication to allow them to tolerate endotracheal tubes.

**Postoperative Nausea and Vomiting (PONV) Risk Factors**

Researches on PONV have identified multiple independent PONV predictors (Gan, 2006). Well-established PONV risk factors include female gender post-puberty, nonsmoking status, history of PONV or motion sickness, childhood after infancy and younger adulthood, increasing duration of surgery, and use of volatile anesthetics, nitrous oxide, large-dose of neostigmine, or intraoperative or postoperative opioids (Gan, 2006). Also, for pediatric patients, age increases the risk of postoperative vomiting, such that children older than 3 years have shown increased risk of postoperative vomiting than those younger than 3 years (Pierre & Whelan, 2013).
METHODS

A. Extraction of data and case selection

Surgical procedure data in patients with limited co-morbidities were extracted using SurgiNet, a surgical chart review program utilized in Boston Children’s Hospital. The extracted procedures include: surgical ASD repair (below ASD repair), tonsillectomy/ adenoidectomy, MRI imaging, esophagogastroduodenoscopy, direct laryngoscopy and/or bronchoscopy, electrophysiology study, tympanostomy, circumcision, dental rehabilitation, hernia repair, and spine fusion. Among them we chose to analyze ASD repair procedures.

Patients were divided into two groups on the basis of two different time periods, before and after a practice change, which was to implement the “Fast-track” protocol. The Cardiovascular Program, Boston Children’s Hospital has implemented the Fast-track protocol, which began on April 24, 2014. The definition of the Fast-track protocol varies among institutions; in Boston Children’s Hospital, its particular definition is “aiming to extubate patients within four hours after ICU admission, or to extubate in operating rooms.” The Fast-track protocol also includes additional directions for administering medication, such as giving intravenous acetaminophen as an adjunct of analgesics and administration of propofol infusion as a postoperative sedation for patients who are not extubated in the operating rooms. The first group consisted of all ASD repair procedures from September, 2012 to December, 2013 (Non-fast-track group). The second group included all ASD repair procedures from April 24, 2014 to August, 2014 (Fast-track group). Such choice of time periods will allow us to observe the effect of the Fast-track protocol.
protocol on how anesthetics are applied in the operating rooms. The short gap between the two time periods is intended to allow sufficient time for transition so that an established and stable practice can be studied.

**B. Choosing parameters for ASD repair procedures & data collection**

Then, retrospective review of preoperative anesthetic evaluation, anesthetic charts, and postoperative ICU nursing notes was performed for the two groups. Various parameters were chosen for review. Data points collected include: age, sex, weight, premedication, anesthetic regimen during anesthetic induction, maintenance, and emergence, parent present induction, choice of vasoactive agents, analgesics, types of intravenous access types, extubation in the operating room or postoperative sedation, postoperative nausea and vomiting (PONV), intraoperative anti-emetics, and average amount of opioids. Collection of all the data regarding medication was sorted such that timing of medication administration was distinguished among three phases of procedure – before the initiation of cardiopulmonary bypass (pre-CPB), during CPB (intra-CPB), and after the separation from CPB (post-CPB).

**C. Organizing data & analysis**

After collection of data, patients with co-morbidities such as severe respiratory disease, premature at the birth, or trisomy 21 that may significantly alter anesthetic practice were excluded. After grouping the data according to our designated time periods, bar graphs were drawn for studying variation among cases as well as comparison of two
groups. Preoperative anesthetic evaluation was reviewed to search for any pre-existing conditions and complications that would direct us to exclude the cases. Anesthetic charts were reviewed for collecting the majority of anesthetic practice, such as choice of medications, parent present induction, induction methods, maintenance methods, intravenous access and extubation. The ICU nursing notes were reviewed for collecting PONV information.
RESULTS & DISCUSSION

A. Demographics

<table>
<thead>
<tr>
<th></th>
<th>Non-fast-track (n=60)</th>
<th>Fast-track (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>6.53 ± 6.69</td>
<td>5.55 ± 6.88</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>23.76 ± 18.35</td>
<td>22.30 ± 19.97</td>
</tr>
<tr>
<td>M/F</td>
<td>19/41</td>
<td>17/14</td>
</tr>
</tbody>
</table>

Table 1. Demographics of Surgical ASD Repair Procedures.

The Non-fast track group is from 09/2012 to 12/2013. The Fast-track group is from 4/24/2014 to 8/2014.

B. Premedication

Figure 3. Premedication for the Non-fast-track Group.
Figure 4. Premedication for the Fast-track Group.

The two groups showed very similar trends in their choices of premedication. The most popular choice was the administration of two drugs, midazolam and ketamine. The second most popular choice was the administration of midazolam by itself. Ketamine was, however, rarely used by itself. Cases in which no premedication was given were greater in number (12%, 19% of cases, in the Non-fast-track, the Fast-track groups, respectively) than those in which only ketamine was given (2%, 0% of cases in the Non-fast-track, the Fast-track groups, respectively) as a premedication.

This result indicates some variation in choice of medications, and midazolam seems to be a well-established regimen either with combination of ketamine or by itself. Ketamine is a drug that induces amnesia ("Ketamine," n.d.), and the benefit of ketamine administration in combination with midazolam, in comparison with the administration by itself or no administration may be worth studying in the future. Clinically the
combination of midazolam and ketamine tends to provide deep sedation, but it will be interesting to study if consideration of early extubation affects the decision-making of type of premedication. Practitioners chose not to use any premedication drugs in 10-20% of cases, where parent present induction was performed.

C. Induction methods.

Figure 5. Choice of Induction Methods for the Non-fast-track Group.
<table>
<thead>
<tr>
<th>Age</th>
<th>Induction</th>
<th>IV drug</th>
</tr>
</thead>
<tbody>
<tr>
<td>15yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>10yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>17 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>24 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>40 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>16 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>14 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>11 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>19 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>14 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>15 yrs</td>
<td>IV</td>
<td>Propofol</td>
</tr>
</tbody>
</table>

Table 2. Age and IV Drug Choice for Patients Who Were IV-induced within the Non-fast-track Group.

The cases within the Non-fast-track protocol showed a predominance of inhalation induction. Out of total 60 cases, 49 cases were induced with inhalation, and 11 cases were induced with IV induction. Notably, in all of the 11 cases of IV induction, all of the patients were 10 years or older, and were induced with propofol, a popular type of IV induction medication.
Figure 6. Choice of Induction Methods for the Fast-track Group.

Table 3. Age and IV Drug Choice for Patients Who Were IV-induced within the Fast-track Group.

<table>
<thead>
<tr>
<th>Age</th>
<th>Induction</th>
<th>IV drug</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 years</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>15 years</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>13 years</td>
<td>IV</td>
<td>Propofol</td>
</tr>
<tr>
<td>2 years</td>
<td>IV</td>
<td>Fentanyl only</td>
</tr>
<tr>
<td>14 years</td>
<td>IV</td>
<td>Propofol</td>
</tr>
</tbody>
</table>

The Fast-track group showed a very similar result with a predominance of choice of inhalation induction method. Out of total 31 cases, 25 cases were induced with inhalation method while only 5 cases were induced with IV induction. Among the IV-induced cases, in 4 out of 5 cases, propofol was the choice of induction agent and patients were 10 years or older. One IV-induced patient out of the 5 patients was 2 years old and fentanyl was used as the choice of IV drug, following oral administration of midazolam.
and ketamine. The premedication of midazolam and ketamine was likely effective enough to obtain IV access before induction and negate the necessity of inhalational induction.

The result indicates very little variation in anesthesia providers’ practices, most of whom preferred to use inhalation for children under age 10, and little change from the Non-fast-track group to the Fast-track group. These data align with the established fact that children are usually given inhalation induction due to absence of IV access, and therefore fall under expectation. The results of the close observation of the majority of the IV-induced patients who were 10 years old or older and were induced with propofol suggest that this parameter is strongly dictated by patients, and that protocol for induction method is fairly well-established.

D. Parent Present Induction

![Figure 7. Parent Present Induction (PPI) for the Non-fast-track Group.](image)

Figure 7. Parent Present Induction (PPI) for the Non-fast-track Group.
The variation in parent presence at anesthetic induction was studied. The result was very similar in both groups. In majority of cases, 52 out of 60 in the Non-fast-track group and 26 out of 31 in the Fast-track group, parents were not present at the time of induction. We did not study the correlation of parent present induction (PPI) with certain practitioners. It will be worth studying if the usage of PPI is heavily dependent on practitioners.

E. Anesthetic Maintenance
The method for anesthetic maintenance for all cases that utilized IV maintenance was studied for both groups. In all cases for the Non-fast-track group, and in all cases in
the Fast-track group except for one case that remained undocumented, anesthesia was maintained using the simultaneous administration of IV and inhaled anesthetics. None of the cases utilized only IV maintenance.

This result indicates almost no variation. It is fairly well-established that inhaled anesthetic maintenance controls the depth of anesthesia reliably. The results of this study well reflect this fact; in both groups, all of the cases that utilized IV anesthetics except for one case that was not documented also utilized inhaled anesthetics during the maintenance period.

F. Choice of Vasoactive Agents

![Figure 11. The Choice of Vasoactive Agents in the Non-fast-track Group](image)

Figure 11. The Choice of Vasoactive Agents in the Non-fast-track Group
Several kinds of vasoactive agents that were given to patients in either of the two groups include epinephrine, calcium gluconate, ephedrine, phenylephrine, and dopamine. In both groups, calcium gluconate was the most popular choice of vasoactive agent. Phenylephrine was the second most popular choice in both groups.

These results indicate some variation. The search for the reasoning behind these choices may provide a direction of possible future research. The two groups, the Non-fast-track and the Fast-track groups, showed very similar variations in the frequencies of each choice of vasoactive agents. Studying the reasoning behind these similar frequencies of each of vasoactive agents may provide a better understanding on how vasoactive agents are chosen. Further studies may focus on whether the choices are dictated by patients or physicians’ preferences.
G. Choice of Analgesics

Figure 13. Choice of Analgesics in the Non-fast-track Group.

Figure 14. Choice of Analgesics in the Fast-track Group.
Table 4. The Average Amount of Opioids, Fentanyl or Morphine, in Each Group.

<table>
<thead>
<tr>
<th></th>
<th>Non-fast-track (n=60)</th>
<th>Fast-track (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fentanyl (mcg/kg/patient)</td>
<td>18.12 ± 10.72</td>
<td>20.51 ± 18.37</td>
</tr>
<tr>
<td>Morphine (mg/kg/patient)</td>
<td>0.1735 ± 0.0974</td>
<td>0.1559 ± 0.0964</td>
</tr>
</tbody>
</table>

The common choices of analgesics in both groups included fentanyl and morphine. In both groups, a similar trend was seen; fentanyl administration during pre-CPB period and morphine administration during post-CPB were the most prominent choices of analgesics. In the Non-fast-track group, 58 out of 60 total cases (96.7%) were given fentanyl during pre-CPB period, and 39 out of 60 total cases (65%) were given morphine during post-CPB period. In the Fast-track group, 28 out of 31 total cases (90.3%) were given fentanyl during pre-CPB period, and 16 out of 31 total cases (51.6%) were given morphine during the post-CPB period. Total fentanyl and morphine doses were not clinically different between the Non-fast-track group and the Fast-track group. One notable difference between the two groups was also found; acetaminophen administration was seen in the Fast-track group, but not in the Non-fast-track group. This is an expected result, because the use of acetaminophen as a choice of analgesic is a part of the protocol. However, 100% compliance of acetaminophen administration was not achieved, and this may be attributed to the incomplete transition process.
Overall, no significant difference in usage of opioid was seen between before and after the Fast-track protocol implementation despite the institution of intravenous acetoaminophen. Opioids are known to induce some side effects, which include dizziness, nausea, vomiting, constipation, physical dependence, tolerance, and respiratory depression (Benyamin et al., 2008). In this study, we did not evaluate the opioid requirements immediately after ICU admission. It will be critical to evaluate the total opioid requirement during intraoperative and immediate postoperative period. If there is no actual change in opioid administration, re-evaluation of current pain regimens may be indicated.

**H. Choice of Intravenous Accesses**

![Choice of Intravenous Accesses in the Non-Fast-track Group](image)

*Figure 15. Choice of Intravenous Accesses in the Non-Fast-track Group*
The choice of intravenous accesses showed some variation among cases within each group as well as differences in trends between the two groups. The available choices of intravenous accesses included central venous line (CVL), extrajugular catheter (EJ), CVL + EJ, and peripheral intravenous line (PIV). The most popular choice in the Non-fast-track group was EJ, while CVL was the most popular choice in the Fast-track group.

The different trends of variation between the Non-fast-track group and the Fast-track group, characterized by the predominance of EJ by itself before the Fast-track implementation and that of CVL by itself after the Fast-track implementation, lack explanation at this point. The reasoning behind such choices can be studied further, possibly through surveys or interviews with practitioners.
I.  OR Extubation or Post-op Sedation

<table>
<thead>
<tr>
<th></th>
<th>Non-fast-track</th>
<th>Fast-track</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR Extubation</td>
<td>25.00%</td>
<td>17.86%</td>
</tr>
<tr>
<td>No OR Extubation</td>
<td>75.00%</td>
<td>82.14%</td>
</tr>
</tbody>
</table>

Table 5. Percentage of Extubation in Operating Rooms in Both Groups.

![Bar graph](image)

Figure 17. Choice of Postoperative Sedation for Non-extubated Patients in the Non-Fast-track group. gtt=infusion
In majority of cases of both groups, 75.00% in the Non-fast-track group and 82.14% in the Fast-track group, patients were not extubated in operating rooms. Among these patients who remained intubated in operating rooms, the variation in practitioners’ choices of postoperative sedation was studied. The notable difference between the Non-fast-track and the Fast-track groups was that the administration of propofol as a postoperative sedation was more dominant in the Fast-track group than the Non-fast-track group.

Out of 40 patients in the Non-fast-track group who were not extubated in the operating rooms, 28 patients (70%) were given propofol infusion, and 11 patients (27.5%) were not given any infusion.

On the other hand, in the Fast-track group, out of 23 patients who were not extubated in the operating rooms, 21 patients (91.0%) received propofol infusion.
The difference in the percentages of propofol infusion incidents among non-extubated patients between the two groups may be explained by the fact that the Fast-track protocol includes an administration of propofol infusion as a postoperative sedation. The number of cases in which no postoperative sedation was given decreased in number as a result of the practice change. The benefits of this change would require closer studies of follow-ups, and the efficiency of the practice change may be assessed.

J. Postoperative Nausea and Vomiting (PONV)

![Figure 19. Postoperative Nausea and Vomiting in the Non-fast-track Group.](image)
In the Non-fast-track group, 27 patients out of 60 total patients (45%) experienced PONV. In the Fast-track group, 11 out of total 31 patients (35%) experienced PONV.

The results suggest that PONV was more prominent in the Non-fast-track group. Although it may be true that the practice change decreased the PONV frequency, it is difficult to relate this result to a true variation in anesthetic practice. There exist multiple risk factors for PONV as discussed above that could have affected this parameter, other than the true variation in practice. In our chosen population groups, female gender is an example of the established PONV risk factors that could have affected our results by introducing a confounding factor. Because the Non-fast-track group had higher female ratio than did the Fast-track group, our result remains inconclusive.

**K. Intraoperative Anti-emetics**
<table>
<thead>
<tr>
<th></th>
<th>PONV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) Anti-emetics</td>
<td>42.10%</td>
</tr>
<tr>
<td>(-) Anti-emetics</td>
<td>46.34%</td>
</tr>
</tbody>
</table>

Table 6. The Percentage of PONV in Patients Who Were Given Anti-emetics and Those Who Were Not Given Anti-emetics in the Non-fast-track Group.

<table>
<thead>
<tr>
<th></th>
<th>PONV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) Anti-emetics</td>
<td>40.00%</td>
</tr>
<tr>
<td>(-) Anti-emetics</td>
<td>36.00%</td>
</tr>
</tbody>
</table>


Interestingly in both groups, the patients who were given intraoperative anti-emetics showed significantly large numbers of PONV incidents (42.10% in the Non-fast-track group, and 40.00% in the Fast-track group). This may lead us to question the efficacy of the current intraoperative anti-emetic regimen, and further research on more efficient use of anti-emetics.

In addition, the percentage of cases who experienced PONV decreased after the implementation of the Fast-track protocol from 46.34% to 36.00%. Again, the significance of this decrease cannot be decided without further analysis of causes. However, the data suggest that the decrease in PONV after the Fast-track protocol implementation cannot be simply attributed to the use of standard anti-emetics. One possible explanation is the consistent use of propofol infusion. Propofol has been suggested to possess anti-emetic effect without known mechanism. Analysis of a larger
number of patients will likely allow us to understand if the Fast-track-protocol is indeed beneficial for PONV.

L. Limitations

Although we have several useful findings and suggestions on further directions of research, this study has several limitations. This study focuses on anesthetic practice in only one institution, Boston Children’s Hospital. Due to possible discrepancies in protocols or training procedures among different institutions, this study may not be representative of anesthetic practice in a broader medical field in the country.

Another source of misrepresentation may arise from limited number of patients. Because the time periods of our retrospective study are short, stronger descriptions may require longer time periods. Especially, the range of time period for the Fast-track group was shorter than the Non-fast track group because the onset of the practice change in Boston Children’s Hospital was recent, having started on 4/24/2014.

Lastly, another aspect of this study that may be strengthened is the number of procedure types. Our study focused only on the ASD repair procedures for secundum ASD and sinus venosus ASD. Studies on increased numbers of procedures may deliver us a more thorough understanding of current anesthetic practice.
REFERENCES


Ashworth J, S. I. (1998). Comparison of desflurane with isoflurane or propofol in

Atrial Septal Defect (ASD). (2015, January 22). Retrieved from
http://www.heart.org/HEARTORG/Conditions/CongenitalHeartDefects/AboutCongenitalHeartDefects/Atrial-Septal-Defect-ASD_UCM_307021_Article.jsp


Benveniste, H., & Volkow, N. D. (2013). Dopamine-enhancing Medications to
Accelerate Emergence from General Anesthesia: *Anesthesiology, 118*(1), 5–6.
http://doi.org/10.1097/ALN.0b013e318278c8cd

Benyamin, R., Trescot, A. M., Datta, S., Buenaventura, R., Adlaka, R., Sehgal, N., …

Bhaskar, S. B. (2013). Emergence from anaesthesia: Have we got it all smoothened out?


http://doi.org/10.1056/NEJMvcm1300964


VITA

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EDUCATION

Boston University School of Medicine, Boston, MA, September, 2013 - current
• M.S. in Medical Science Program (MAMS) Candidate, Class of 2015
• Relevant courses: Biochemistry, Histology, Physiology, Pathology, Biostatistics, Biomedical Information

University of Pennsylvania, College of Arts and Science, Philadelphia, PA, 2011
• Bachelor of Arts in Biology, Neurobiology Concentration; Chemistry Minor
• Cumulative GPA: 3.47/4.0; Honors in Biology Major, Dean’s List 2007-2008
• Relevant Courses: Biology, Chemistry, Physics, Psychology, Health & Societies, Physiology

EMPLOYMENT

Medical Scribe, May 2012 – July 2013
Scheie Eye Institute, Hospital of the University of Pennsylvania, Philadelphia, PA
• Recorded Dr. Charles Nichols’ eye examinations electronically in patient charts.
• Additional responsibilities: OCT photography, pre-op/post-op instructions, drug instructions, scheduling patients, etc.
• Assisted surgical quality assurance project led by Dr. Thomasine Gorry. Shadowed various ophthalmic surgeries.

PUBLICATION
• Jennifer Larimore, Joshua Lee et al. The Schizophrenia Susceptibility Factor Dysbindin and its Associated Complex Sort Cargoes from Cell Bodies to the Synapse. Mol. Biol. Cell 2011 mbc.E11-07-0592; First Published on October 12, 2011; doi:10.1091/mbc.E11-07-0592

RESEARCH EXPERIENCE

Research Laboratory Assistant, June 2010 – December 2011
Translation Research Laboratories, School of Medicine, University of Pennsylvania, Dr. Konrad Talbot, Philadelphia, PA
• Performed immunohistochemistry and double-immunofluorescence with antigen-retrieval on brain sections
• Investigated the role of dysbindin-1 in the onset of schizophrenia
• Performed tissue sectioning with microtome, image-capturing with camera-equipped microscopes, and data analysis

**Clinical Research Assistant, September 2009 - June 2010**
*Children's Hospital of Philadelphia, Oncology Division, Dr. Sogol Mostoufi-Moab, Philadelphia, PA*
• Entered patient data in electronic database and managed hardcopies of patient charts
• Studied bone conditions of leukemia survivors who were treated with Bone Marrow Transplant, radiotherapy, and chemotherapy

**Lab Assistant, January 2008 – September 2009**
*Pathobiology/Vet Department, University of Pennsylvania, Dr. James B. Lok, Philadelphia, PA*
• Obtained *Strongyloides Stercoralis* strains from dog feces and prepared their cultures
• Applied medication to dogs for adequate maintenance of *Strogyloides Stercoralis*
• Attempted to integrate extrachromosomal arrays into chromosomes of *C. Elegans* worms by UV irradiation

**HEALTH & SERVICE EXPERIENCE**

**Hospice Volunteer, July 2010 – May 2013**
*Penn/ Wissahickon Hospice, Philadelphia, PA*
• Support patients with conversations, reading, and assistance in games and art classes; provide families with positive reinforcement

**Clinical Volunteer, July 2011 – January 2012**
*University City Hospitality Coalition (UCHC), Philadelphia, PA*
• Assist medical students and physicians organize free clinics held weekly at a church
• Measure blood glucose level and blood pressure; maintain patient charts

**Lead Volunteer, March 2011 – May 2012**
*Fitness for Life, Spruce Christian School, Philadelphia, PA*
• Lecture school children basics of healthy habits in eating, stretching, and exercising, and organize games and sports

**LEADERSHIP/ ADDITIONAL EXPERIENCE**

**President/ Lead Guitarist, September 2007 - December 2011**
*Kapacity, a student-oriented rock band, University of Pennsylvania*
• Organize scheduling of practices and perform concerts during school semester; participate in annual Korean Culture Show
External Vice President, September 2009 – May 2010
Koreans At Penn (KAP), University of Pennsylvania
  • Organized campus events, board meetings, and represented KAP in student meetings

COMPUTER & LANGUAGE SKILLS
  • Fluent in English and Korean. Familiar with Excel, Power Point, Word, Image Pro, Photoshop