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Anesthesia Implications of Pediatric Obesity

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ANESTHESIA IMPLICATIONS OF PEDIATRIC OBESITY

by

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Abstract

Title: Anesthesia implications of pediatric obesity

Background: Pediatric obesity is becoming an epidemic nationally and internationally. It poses several challenges to anesthesia providers because of the comorbidities associated with it. Anesthesia challenges posed by a 3-year-old obese patient led this author to do an independent study on pediatric obesity and anesthesia management.

Purpose: The purpose of this independent study is to review the current literature, epidemiology, comorbidities and practice recommendation regarding the anesthetic management of pediatric obese patients.

Process: A comprehensive literature review was conducted utilizing the University of North Dakota's Harley. E. French library website. Current literatures was searched using the key words 'pediatric anesthesia' and 'obesity'. Search engines such as PubMed, ClinicalKey and CINAHL were used. Journals were extensively reviewed for relevant information.

Results: The findings presented in the study are based on the published literatures in the year range of 2005-2012. This paper will evaluate what the literature states about the prevalence and the pathophysiology of childhood obesity and provides suggestions on pre-anesthetic evaluation, airway management, dosage of anesthetic drugs, and postoperative care.

Implications: Perioperative respiratory events seem more frequent in overweight and obese children. So anesthetist should anticipate and be prepared to optimize the anesthetic management of this high-risk population. Increasing number of pediatric obese surgical population demands more researches in areas of pharmacology, preoperative and intraoperative management.

Keywords: *pediatric, obesity, anesthesia, management*

Childhood obesity is increasing substantially in industrialized nations, which poses multiple medical and social issues. Worldwide obesity has more than doubled since 1980, and approximately 43 million children under the age of five were overweight in 2010 (Owen & John, 2012). According to statistics, in United States the incidence of obesity in 6-11 year-olds increased by 54 % in the last three decades and approximately one third of patients presenting to pediatric day surgery units are overweight or obese (Middlebrooks & Winters, 2011). Obesity is a systemic disease process that alters the physical and mental health of the pediatric patient. Because of comorbidities associated with obesity, the intra-operative and post-operative course is challenging to anesthesia care providers. Respiratory complications, airway management difficulties, prolonged post anesthesia care unit (PACU) stays and postoperative nausea and vomiting (PONV) are more common with an elevated body mass index (BMI). Because of these consequent challenges, obese pediatric population demands more planning, consultations, management and time.

Case Report

A 3 year old, 41 kg (BMI 35.3), 106 cm male presented for dental restoration with a diagnosis of dental caries. The patient did not have any previous surgical history and no known family history of problems with anesthesia. His medical history included respiratory distress as newborn, Chorioamnionitis and Genu Valgum. Airway evaluation revealed a Mallampati score of lll, TMJ > 3 fingerbreadths, short and thick neck with full range of motion. No allergies and no routine medication consumption reported. Pre-operative vitals signs as follows: BP-117/53, Pulse-106, RR-16, Temp-36.2 C and SpO2-97% on room air. Pre-operative laboratory values showed hemoglobin level of 12.1 grams per deciliter (g/dl) and hematocrit of 34.9 % g/dl.

The patient was transported to the operating suite and assisted on the operating room table. After applying non-invasive monitors such as ECG, blood pressure cuff, and pulse

oximetry, an inhalation induction began which consisted of N2O 7L/min, O2 3L/min, and sevoflurane 8% via facemask. Immediately his oxygen saturation dropped to 92 % with one person Bag Mask Ventilation (BMV); so two-person airway masking technique was initiated for proper pre-oxygenation. A 22 gauge intravenous (IV) catheter inserted. Phenylephrine spray was administered to both nares and Fentanyl 50 mcg administered intravenously. Direct laryngoscopy was performed with a number 2 Macintosh blade and a grade 2 Cochrane Lehane view obtained. A 5.0 mm uncuffed nasal RAE tube (a specialized endotracheal tube tube designed for oral or ENT surgeries) was introduced to his left nare in to the oropharynx. The vocal cords were then re-exposed by direct laryngoscopy. With the help of a pediatric McGill forceps the endotracheal tube was advanced through the cord with medium difficulty on the second attempt. Bilateral breath sounds were auscultated and an ETCO2 wave form obtained. Respiration were controlled by mechanical ventilation using a volume control mode. Dexamethasone 4 mg and Ondansetron 4 mg were intravenously administered. Mechanical ventilation was challenged during the intra-operative period. The ventilator was alarming due to high airway pressure that made the anesthetist to change the ventilation mode to pressure control. It did take care of high pressure, but tidal volume was inadequate. So his oxygen saturation began to drop to 91-92 %. Further changes were made to ensure adequate minute volume by decreasing the tidal volume and increasing the respiratory rate; that maintained oxygen saturation in the 93-96 % range throughout the case.

At the end of the surgery, the patient exhibited an adequate tidal volume and respiratory rate. Oropharynx suctioned and extubated in the operating room without complication and transferred to PACU with continuous oxygen delivery via facemask and an oral airway in place. His oxygen saturation dropped to 88 % in PACU and mild stridor was noted. A Jaw-thrust

maneuver was initiated and nasal airway inserted that improved his oxygen saturation to 92 %. Racemic epinephrine 0.5 ml was administered via nebulizer. As the patient recovered from anesthesia, his oxygen saturation improved to 97 %. The patient remained in the PACU until his vital signs were stable. He was then transferred to same day surgery for observation and discharged home later that afternoon.

Discussion

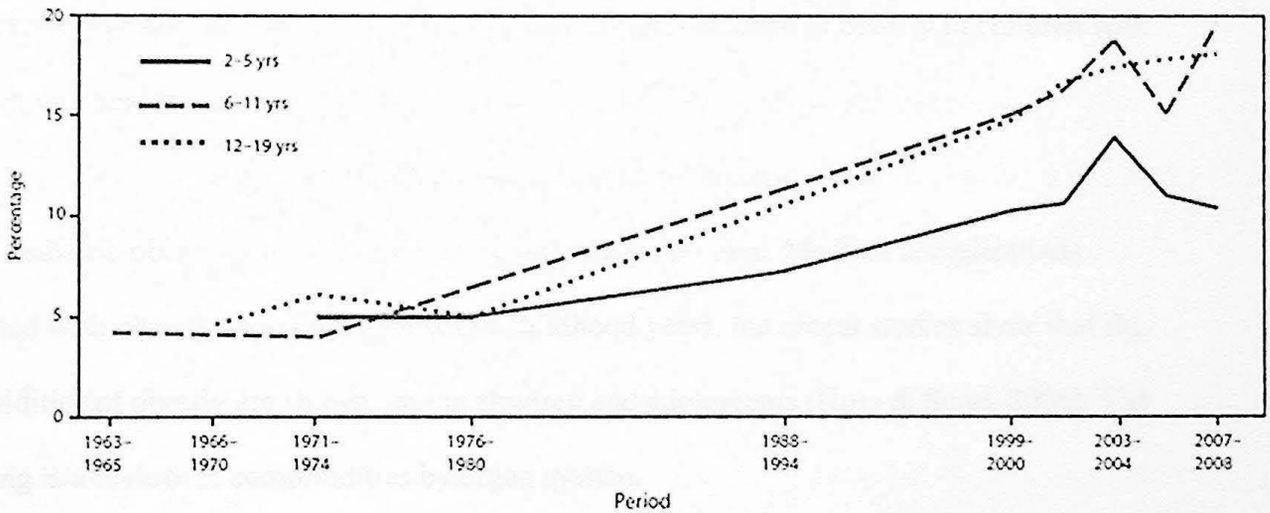
The definition of obesity is different for children compared to adults. Body Mass Index (BMI) is used to measure pediatric obesity and overweight. In pediatrics, BMI is affected by age, gender and puberty (Lin, 2007). According to Centers for Disease Control and Prevention (CDC), for children and adolescents aged 2-19 years, "overweight is defined as a BMI at or above the 85th percentile and lower than the 95th percentile for children of the same age and sex" and "obesity is defined as a BMI at or above the 95th percentile for children of same age and sex"(Centers for Disease Control, 2012). According to research studies, there is a 70% to 80% chance that overweight children will develop in to overweight adolescents and adults (Brenn, 2005). Obese adults poses anesthesia challenges due to the comorbidities associated with obesity, such as hypertension, insulin resistance, coronary artery disease and metabolic syndrome. The same is true with the pediatric obese population if they have long-standing obesity. A thorough understanding of the pathophysiology and anesthetic management is necessary to guide the anesthetist to provide quality and safe care for obese children.

Demographics

Approximately 17 % of children and adolescents aged between 2-19 years are obese in the United States. According to the 2011-2012 statistical data retrieved from CDC, there are significant age and racial disparities in obesity prevalence among children and adolescents. Obesity prevalence was higher among Hispanics (22.4%) and non-Hispanic black youth (20.2%)

than non-Hispanic white youth (14.1%) in 2011-2012. The prevalence of obesity was lower in non-Hispanic Asian youth (8.6%) than in youth who were non-Hispanic white, non-Hispanic black or Hispanic. In 2011-2012, 8.4 % of 2-to-5 year olds, 17.7 % of 6-to-11 year olds and 20.5 % of 12-to-19 year olds had obesity. The figure below shows the prevalence of obesity among children and adolescents by age group, in the United States during 1964-2008. Changes in obesity prevalence from 1960s show a rapid increase in 1980s and 1990s. Among children and teenagers, the obesity prevalence increased to triple fold (from 5% to 15%).

Figure 1



Note. Prevalence of obesity among children and adolescents by age group in the United States. Adapted from " CDC Grand Rounds: Childhood Obesity in the United States" (2011). *Morbidity and Mortality Weekly Report (MMWR), 60(2), P-42.*

Childhood obesity is suggested to be more prevalent in children from low socioeconomic status (Ogden, Carroll, Kit & Flegan, 2014). When compared to the data collected in 2003, there is no drastic change in increasing childhood obesity in 2012, yet the prevalence of childhood obesity remains high.

Epidemiology

The causes of pediatric obesity are various, which include: excessive calorie consumption, endocrine dysfunction, genetic predisposition, poor food habits or choices, and several single gene disorders. In a majority of cases, overweight and obesity are due to the consumption of too many calories and the lack of physical activities. In approximately 5 -10 % of the cases, a medical or genetic problem is associated with childhood overweight and obesity. Several rare syndromes are associated with obesity such as Lauence-Moon-Biedal, Frohlich's, Cushing's and Prader-Willi syndromes. Some single gene disorders such as congenital leptin deficiency or mutations in the leptin receptors 'cause an intense drive to eat with no negative feedback mechanism' (Brenn, 2005). There is also a high incidence of obesity in children with leukemia who undergo chemotherapy.

Pathophysiology related to obesity

Pediatric obesity is a multiorgan affecting disease process. Medical complications associated with obesity were rarely shown in childhood years, but recent studies show that the comorbidities of obesity are shown among children and adolescents (Ross & Scott, 2006). The following is a review of comorbidities by organ system.

Respiratory - Obesity causes changes to the pediatric airway and pulmonary function due to the amount of adipose tissue and its distribution. Chest wall compliance is reduced, and the chest wall musculature is often unable to fully produce anterior excursion. The increased disposition of fat tissue in the pharynx, tongue, and around the larynx results in narrowing of the airways. This eventually results in the development of obstructive sleep apnea (OSA). Pediatric obesity is the strongest predictor of OSA and presents in approximately in 13-59 % of obese children compared to 1-2 % of normal weight children (Lin, 2007). Severe OSA increases the risk of postoperative respiratory depression and airway obstruction. Children with OSA have

diminished ventilatory response to CO2 and increased sensitivity to opioids. Even though pulmonary studies are not common with pediatric obese patients, it is observed as a restrictive respiratory pattern with decreased functional residual capacity (FRC), expiratory reserve volume (ERV), vital capacity, and inspiratory capacity similar to the obese adults. Evidences indicate decreased forced expiratory reserve volume in I second (FEV1), the forced expiratory flow between 25 % and 75% of vital capacity (FEF25-75); and decreased diffusing capacity of lung for carbon monoxide (DLCO) with obesity (Brenn, 2005). A resulting high closing volume may results in atelectasis, air trapping, intra pulmonary right to left shunting and possible hypoxemia (Mortensen, Lenz, Abildstrom & Lauritsen, 2011). It is still uncertain if there is a correlation between obesity and the incidence or severity of asthma as some studies argue that there is a positive correlation and some opposes. In one study approximately 30 % obese children suffered from asthma (Smith, Meldrum & Brennan, 2002). Furthermore, obese children are more prone to upper airway infections than non-obese children (Mortensen et al., 2011).

Cardiac- In adults, obesity has been associated with the development of many cardiovascular risk factors such as hypertension, dyslipidemia, left ventricular hypertrophy and pulmonary hypertension. Childhood obesity along with above said risk factors will lead in to an increased cardiac morbidity in early adulthood. Hypertension is more frequent in obese children (increases with increasing BMI) than their non-obese peers (Lin, 2007). The mechanisms of developing hypertension with obesity are associated with sympathetic nervous system hyperactivity, insulin resistance and abnormalities in vascular structure and function (Brenn, 2005). Hypertriglyceridemia and low levels of high-density lipoprotein (HDL) and cholesterol are present in obese children. Cardiac output (CO) and blood volume are higher in obese children. Cardiac output increase is estimated as 0.1 L/min for each kilogram of adipose tissue.

Increased CO is mainly due to an increase in stroke volume. Increases in blood pressure have been associated with insulin resistance and increases in visceral fat in obese patients. Lower arterial compliance and lower distensibility of arterial vasculature is more often present with obese children (Brenn, 2005). Oxygen consumption and carbon dioxide production are increased with obesity. Increased oxygen demand increases the workload of the heart, which eventually will lead to left ventricular hypertrophy (LVH) and myocardial strain. It is estimated that up to 41 % of obese children develops left ventricular hypertrophy (Lin, 2007).

Endocrine -Obesity will cause an imbalance between insulin secretion and sensitivity. Because of that it is a risk factor for developing diabetes mellitus type 2 and insulin resistance. Both total body fat and visceral body fat contribute to decreased insulin sensitivity and increased fasting insulin levels. According to current statistics, the rise in the diagnosis of diabetes mellitus type 2 in children parallels the rise in pediatric obesity (Lin, 2007). The pre operative history of polyuria, polydipsia, headaches, fatigue, acanthosis nigrans, candida vulvovaginitis and recent weight loss raises the suspicion for diabetes. Acanthosis nigricans is one of the high-risk indicators for the presence of metabolic syndrome. Pediatric obese population, who presents for surgery in a state of acute illness and stress, can develop ketoacidosis that can complicate intraoperative and postoperative management (Lin, 2007).

Hepatic- In United States, 6% of overweight and 10% of obese children have elevated liver enzymes and the presence of nonalcoholic fatty liver disease (NAFLD), which in obese children is under diagnosed (Lin, 2007). NAFLD, which occurs secondary to hyperinsulinemia and its inhibitory effect on the oxidation of free fatty acids, that accumulates in the liver. Literature indicates that obese children diagnosed with diabetes mellitus type 2 may also have undiagnosed liver disease. The clinical implications of liver disease include altered drug

pharmokinectics caused by liver and renal insufficiency, coagulopathy, portal hypertension, pulmonary arteriovenous shunts, gastrointestinal varices and other sequelae of end-stage liver disease (Lin, 2007).

Neurological and Psychological issues- Obesity and weight gain are risk factors in developing idiopathic intracranial hypertension (IIH) or pseudo motor cerebri. Anesthetists should be aware of psychological issues of pediatric obesity and should be sensitive about it. Many of the obese children will show psychological maladjustment. Psychological stresses develop from poor body image, low self esteem, depression, school activity performance and learning difficulties. Some studies showed general anxiety, separation anxiety and social phobias are frequent in overweight children (Villa G et al, 2004).

Musculoskeletal- Orthopedic conditions associated with obesity include scoliosis, slipped capital femoral epiphysis, Blount's disease and fractures. Overweight children experience more fractures, musculoskeletal discomfort and develop lower extremity malalignment than their normal-weight peers (Lin, 2007). The following table is a summary of comorbidities associated with obesity.

Table 1

Affected organ system	Obesity related comorbidity
Respiratory system	Bronchial hyperactivity Asthma High incidence of upper airway infections Obstructive sleep apnea
Cardiovascular	Hypertension Left ventricular hypertrophy (in Adolescents)
Endocrine	Metabolic syndrome Dyslipidemia (hyperlipidemia and hypercholesterolemia)

Gastrointestinal	Polycystic Ovarian Syndrome Gastro esophageal reflux Asymptomatic steatosis hepatis
Neurological/Psychological	Pseudotumor cerebri Low self esteem Poor school performance
Orthopedic	Slipped femoral epiphysis

Note. Comorbidities associated with childhood obesity. Adapted from " Anesthetizing the obese child," by A. Mortensen, K. Lenz, H. Abildstrom and T.L.B. Lauritsen, 2011, *Pediatric Anesthesia, 21, p.627.*

Pharmacology related to obesity

There is a lack of pharmokinectic studies in obese children. Much of the information is gathered from studies done in the adult population. Calculation of the optimal drug doses for induction and maintenance of anesthesia are based on patient's total body weight (TBW), ideal body weight (IBW), and lean body weight (LBW). In regards to all pharmacological agents, the factors that affect drug uptake and distribution are body composition, plasma-protein binding, regional blood flow and the relative maturation of organ systems to modify and then excrete the medication (Brenn, 2005). The body composition of obese children are different than non-obese children, as obese patients have increased adipose tissue along with an increase in LBM. Lipophilic medications such as barbiturates and certain benzodiazepines will show significant increases in the volume of distribution in obese patients. Therefore, it is recommended to administer the dosage according to the patient's TBW. Propofol is an exception; even though it is lipophilic accumulation is less due to poor perfusion in adipose tissue. Hence, initial dose of Propofol should be based on IBW, and then a continuous infusion should be based on TBW. Hydrophilic neuromuscular blocking agents are recommended to administer based on IBW as

they distribute more to the lean tissues. The only drug, which is studied pharmacokinetically in obese children, is succinylcholine. Since succinylcholine has been shown to have same potency in obese and normal weight population, dosage should based on TBW. Fentanyl and Sufentanil have increased volume of distribution, so the doses should be based on TBW. Remifentanil shows a smaller volume of distribution and rapid elimination too (Mortensen et al., 2011).

Table 2

Drug	Induction dose based	Maintenance dose based on
Thiopental	LBW	TBW
Propofol	LBW	LBW
Synthetic opioids (Fentanyl, Alfentanil, Sufentanil)	TBW	IBW
Morphine	IBW	LBW
Remifentanil	LBW	IBW
Nondepolarizing NMBs	IBW	
Succinylcholine	TBW	
Suggammadex	TBW	

Note. Dosage of intravenous anesthetics in obese children .TBW, total body weight; LBW, lean body weight; IBW, ideal body weight. Adapted from " Anesthetizing the obese child," by A. Mortensen, K. Lenz, H. Abildstrom and T.L.B. Lauritsen, 2011, *Pediatric Anesthesia, 21, p.627.*

When it comes to volatile agents, more hemodynamic stability and less airway irritability is identified with sevoflurane. Desflurane has quick uptake and rapid elimination when compared to sevoflurane due to its lower blood-lipid solubility. According to the studies done on adult

obese population, desflurane has been shown to have a very consistent recovery profile (Brenn, 2005). Recovery is prolonged with isoflurane as it shows higher blood-lipid solubility. Literature recommends using sevoflurane as the inhalational agent of choice in obese children, however no studies have been performed in obese children to support that. Monitoring the depth of anesthesia by subjective (hemodynamic changes and autonomic responses) and objective methods (Bispectral index (BIS), EEG and evoked potential monitoring) could be useful in titrating anesthetics in obese children.

Regarding regional anesthesia, obese adults have smaller epidural and CSF volumes. Since there are no studies conducted in the obese pediatric population, one can assume the above said is the same in obese children also. Caution should be taken regarding the dosages of local anesthetics (Mortensen et al., 2011).

Anesthesia care of obese pediatric patients

As obesity results in multi-organ dysfunction, there is a profound implication of pediatric obesity to the anesthetists. Studies on the perioperative complications of childhood overweight and obesity are less compared to adult obese population. Some retrospective studies on pediatric obesity showed, there is an association between high BMI and certain perioperative issues. Some common complications are difficult direct laryngoscopy, mask ventilation, and increased likelihood of developing perioperative bronchospasm (Nafiu et al., 2007). By proper planning and implementation of anesthesia care, one can prevent pre-operative, intra-operative and post-operative complications in this population.

Preoperative Management

In anesthesia, ASA classification remains the widely accepted physical status assessment, which is used to determine the perioperative risk evaluation, resource allocation and

reimbursement for anesthesia services. Compared to the obese adult population, there is a nonlinear relationship between BMI and ASA status. In other words, in the obese adult group, obesity is considered a risk factor and they are therefore given a higher ASA status .Whereas in the pediatric obese groups, obesity is not considered a risk factor. According to a retrospective study conducted in Michigan, 35.3 % of obese children and 20.6 % of morbidly obese children were classified as healthy or ASA 1 (Nafiu et al., 2007). Since there is a lack of studies done on perioperative complications associated with pediatric obesity, it is difficult to estimate the relationship between ASA classification and obesity in the pediatric population.

When looking at airway evaluation, adult Mallampatti classification does not correlate completely with pediatric airway. The anesthesia provider should rely on his/her physical assessment, chart review, and history and physical assessment for predicting a difficult airway in children. Any reports of recent illness, breathing problems and congenital abnormalities are further questioned with parents and other caregivers. Highest prevalence of difficult intubations in pediatric patients happens in cardiac, oral and maxillofacial surgeries which is approximately 40 %(Belanger & Kossick, 2015).

The pre-operative investigation work up should be according to the obese child's health status and surgical procedure. A thorough history and physical examination will help the anesthesia provider to determine if further work up is needed. If a child's room air oxygenation is less than 96%, further investigation of pulmonary disease or obstructive sleep apnea syndrome is warranted. Laboratory testing of a complete blood count may reveal polycythemia, which is suggestive of chronic hypoxemia and possible cardiac issues. In severe obstructive sleep apnea syndrome patients, pre-operative consultation with surgery, cardiology, and pulmonary services. Additional labs such as ABG, chest radiograph, and EKG are also recommended in this patient

population. Polysomnography is the gold standard to diagnose obstructive sleep apnea (Lin, 2007).

Premedication is contraindicated in obese patients due to the risk of respiratory depression. Intramuscular medications are also contraindicated as increased adipose tissue can decrease the accessibility to the muscular tissue. In some instances venous access is difficult in this population. The anesthesia provider should be prepared with equipment such as ultrasound, vein transillumintor or topical medicines, which cause numbness and venodilation. Another concern associated with obesity is gastroesophageal reflux disease. In the pediatric population, recent studies have shown no increased incidence of gastric fluid aspiration in obese children unless they have pre-existing reflux disease. Hence, literature recommends that obese children can follow the regular fasting guidelines as nonobese patients (Brenn, 2005).

In this case report, the patient was not given any premedication, he was not anxious and was very cooperative with providers. His airway evaluation showed a Mallampatti score of lll. After discussion with the anesthesiologist the anesthetist plan was made to do induction of anesthesia via the inhalational method. We anticipated some difficulty in starting an intravenous catheter due to increased adipose tissue. An adult reservoir bag was used in place of the pediatric reservoir bag due to the patient's weight.

Intraoperative Management

Obese children are prone to have more airway related complications compared to their non-obese peers. Due to higher oxygen consumption and less oxygen reserve, children develop hypoxemia faster than adults and obese children are more prone to develop intraoperative hypoxemia. Children are at higher risk for developing upper airway collapse during sedation and general anesthesia. Induction of anesthesia either will be either inhalation or intravenous

depending on several factors such as previous anesthesia history, patient cooperation, age, airway examination and risk of aspiration. Overall aspiration risk is small in children even if they are obese but may increase in certain surgeries such as, dental restoration surgeries due to the amount of blood swallowed during surgery (Ross & Scott, 2006). The risk of difficult mask ventilation and intubation is greater in obese children especially those who have coexisting diseases such as obstructive sleep apnea, craniofacial abnormalities and neurological issues. Having a second trained anesthesia provider in the room will be helpful if a difficult airway is anticipated. Combining jaw thrust and chin lift maneuvers with CPAP of 10 cm H2O reduces upper airway collapse in spontaneously breathing anesthetized non-obese children. Positive end expiratory pressure (PEEP) prevents atelectasis of lung tissue and improves ventilation. Studies have shown mixed results regarding the difficulty level of direct laryngoscopy in the obese pediatric population. No studies have been conducted so far in regards to the benefits of preoxygenation, positioning, the choice of endotracheal intubation, LMA, use of RSI or ventilation strategies in obese children compared to non obese children (Mortensen et al., 2011). In the pediatric population airway examination is not always possible with patients' cooperation. For this reason, awake fibro optic intubations are not a feasible option. Equipments such as the fibrooptic scope, Glidoscope, laryngeal mask intubators, oral and nasal airways, light wand devices or other technologically advanced airway devices should be readily available. The Glidoscope has been shown to improve the laryngoscopic view in the difficult airway pediatric patient (Belanger & Kossick, 2015).

Familiarity with difficult airway management is important and an appropriately sized LMA should be readily available as part of the difficult airway algorithm (Lin, 2007). As with laryngeal mask airway (LMA), choosing size according to the TBW significantly increases the

oropharyngeal leak pressure and gives better ventilation conditions in overweight children. Preoxygenating for at least 3 or 4 minutes prior to induction will prevent hypoxemia, which occurs in obese children as decreased FRC, and increased metabolic rate will cause rapid desaturation during hypoventilation and apnea. An oral airway helps to relieve some of the upper airway obstruction due to the redundant tissue. The anesthesia provider will determine which muscle relaxant to use for intubation. Succinylcholine may be the best choice due to its rapid onset. Intermediate muscle relaxants such as Cisatracurium may be used in the maintenance phase.

Positioning- Under anesthesia, positioning can alter cardiorespiratory dynamics in patients, which occurs more in obese patients. The goal of positioning is to decrease intra-abdominal pressure, decrease abdominal pressure on the diaphragm, enable adequate chest wall and lung expansion, and allow for adequate venous return of blood volume. Studies have shown that supine and head down positions are less tolerated compared to head-up, prone or lateral decubitus position in the obese adult population. In the supine position, abdominal contents cause decreased diaphragmatic excursion and results in altered lung volumes. These changes are exaggerated with anesthetics and muscle relaxants. In obese patients, the adipose panniculus exerts excessive weight on vascular and pulmonary structures. If the supine position is combined with the tredelenberg position, the physical dynamics are further compromised. It is recommended that if a procedure is performed in the supine position, the head of the patient should be elevated to 30-45 degrees. This will allow good pulmonary dynamics and protect cardiac function. And most probably this may be an obese patients' natural sleeping position at home. The prone position is well tolerated as long as the abdomen is not compressed. Moreover, in the prone position the diaphragmatic excursion is better, which improves FRC, and pulmonary

compliance and cardiovascular function are preserved. Pressure point padding is necessary to avoid pressure necrosis and nerve damage, especially if surgery lasts longer than one hour (Brenn, 2005). Some of the suggestions for airway management of the obese children are positioning 25 degree head up in older children, preoxygenation for 3 minutes, mask ventilation with PEEP of 10 c H2O, stomach desufflation, and be prepare with difficult intubation equipment (Mortensen et al, 2011).

In morbidly obese patients routine intra-operative monitoring may be challenging. Electrocardiac monitoring can show many artifacts because of excessive tissue impedance. For this same reason pulse oximetry can shows unreliable readings. Also, in obese patients subcutaneous oxygen tension is decreased compared to non obese patients. For better spirometry, the nose or smallest finger have been advocated. Noninvasive blood pressure monitoring has shown inaccuracies mainly due to an inappropriately sized cuff. Undersized cuffs have known to falsely elevate the pressure readings. Obese patients tend to have conically shaped upper arms in comparison with the cylindrical shape of nonobese arms. Thus, an appropriate sized cuff sometimes does not fit properly on the upper arm of an obese patient. The forearm can be used for measurement, but occasionally shows increased arterial pressures. Some new devices based on continuous radial artery compression such as Vasotrach, Medware, Maitland, FL have shown accuracy with noninvasive readings (Brenn, 2005).

End tidal CO_2 monitoring is not always accurate in the obese population due to decreases in FRC, ventilation-perfusion mismatch, and the dead space to tidal volume changes. Some studies suggest that transcutaneous CO_2 monitoring is more accurate than end tidal CO_2 in morbidly obese patients (Brenn, 2005). The drawbacks of transcutaneous CO_2 monitoring are warm up time, risk of improper placement and calibration issues. In sick patients tissue

perfusion, edema and the use of vasoconstrictors may limit the value of this technology (Brenn, 2005).

According to the case presented in this paper, the intra-op period was challenging. As literature indicated, problems were anticipated during the course of the procedure. A glideslope was available in the room; however, the anesthesiologist was able to intubate nasally on the second attempt with cricoid pressure. The increased amount of soft tissue may have contributed to the first time-failed attempt. A reverse tredelenberg position or utilizing a wedge pillow-positioning device could have increased the chance of successful intubation on the first attempt. During the intra-operative period, a slight decrease in saturation was noted. PEEP was added to improve oxygen saturation. Literature suggests that addition of PEEP will enhance oxygenation in the event of arterial hypoxemia. It also prevents airway closures, atelectasis and desaturation (Owen & John, 2012). The patient did receive antiemetics during the intra-operative period as postoperative nausea and vomiting (PONV) is one of the most common complications of anesthesia in children. An increased risk for PONV in children is associated with surgeries such as tonsillectomy, adenoidectomy, oral surgeries, ENT and laparoscopic procedures (Pawar, 2012).

Postoperative Management

Certain extubation criteria should be met prior to extubating obese children especially those who have coexisting obstructive sleep apnea. Verification of complete reversal of paralysis agents (train of four (TOF) ratio to 0.9), adequate ventilation and oxygenation (appropriate tidal volume and respiratory rate), pain control, body position tilted upright to 25 degrees or higher, oxygenation and intact airway reflexes should be met prior to extubation. Difficult airway patients should extubated awake (Lin, 2007).

There is an increased risk of postoperative upper airway obstruction in obese children. Maintaining an unobstructed airway after extubation is essential. Supplemental oxygenation and pulse oximetry should be continued until room air saturation remains greater than 92%. If the child is CPAP dependent before surgery, it should be continued post operatively. CPAP will reduce pulmonary atelectasis and oxygenation. If the obese child has OSAS, literature recommends avoiding tonsillectomies and laparoscopic procedures as outpatient surgeries. Those children need at least a 23-hour observation in the post-operative period (Lin, 2007).

There are no studies conducted about the postoperative analgesia management in obese children. Controlled analgesia based on IBW and respiratory monitoring is recommended in obese children to avoid postoperative depression. Control of nausea and vomiting is important for all children; the use of multi-modal antiemetics will need to be considered, even though there is no substantial evidence that obese children are at high risk for postoperative nausea and vomiting (PONV) (Owen & John, 2012).

In this case study, the child was extubated following the dental procedure, once the criteria were met for extubation. An oral airway was placed and supplemental oxygen administered via facemask. In PACU, oxygen saturations decreased to 88 %, a nasal airway was placed and monitoring continued until patient awake completely and met satisfactory oxygen level (above 92%).

Regional technique

Regional anesthesia is technically challenging in obese children due to obscure anatomical landmarks, increased depth to neurovascular sites, poor patient cooperation, anxiety and positioning. Most pediatric neuraxial blocks are therefore placed after the patient is under general anesthesia. The use of fluoroscopy, nerve stimulators and ultrasound-guided techniques

will improve the success of blocks in this anatomically challenging population. Drug doses of local anesthetics should be adjusted in obese patients as the spinal and epidural space is decreased because of fat tissue and increased abdominal pressure. Local anesthetic spread and block height are unpredictable (Lin, 2007).

Complications

Certain perioperative complications are more frequent in overweight and obese children than their normal counterparts. Perioperative morbidity in obese children is mainly related to airway and ventilation. There are not many retrospective studies conducted so far, but three published studies have shown various and different results about complications associated with pediatric obesity and anesthesia. One study revealed there is a significantly greater risk of intraoperative oxygen desaturation (SpO2 less than 85 %) (2 % Vs. 0.19%) and unexpected hospitalization (2% vs. 0.19%) in obese children undergoing anesthesia (Veyckemans, 2008). A retrospective study conducted on pediatric obese population (n=6094) revealed difficult airway, upper airway obstruction in the PACU and PACU stay longer than 3 hours were more common in overweight and obese children compared to non obese children (Nafiu et al,. 2007). Another database showed obese children (n=2025) had a greater frequency of difficult mask ventilation (7.4% vs. 2.2%), difficult laryngoscopy (1.3 % vs. 0.4%) and postoperative airway obstruction (1.6% vs. 0.07%), bronchospasm and critical respiratory events (Tait, Voepel-Lewis, Burke, Kostrzewa &Lewis, 2008). There is another study, which was conducted on obese children who underwent dental restoration procedures. The results indicated minor respiratory events in obese children compared to non obese children (Setzer & Saade, 2007). Since the study was conducted only on patients undergoing dental procedures, the physiologic impact may be less. More

prospective studies are required on children undergoing various surgical procedures in order to understand perioperative complications associated with pediatric obesity.

Summary

Pediatric obesity is increasing and its impact on pediatric anesthesiology practice is extensive as anesthetists and anesthesiologists are likely to see a corresponding increase in the proportion of these patients who present for anesthesia and surgery. Obese children are not healthy children, these patients present a challenge to the anesthesia providers. This independent study paper discusses the comorbidities associated with pediatric obesity, and current review of literatures regarding the perioperative, intraoperative and postoperative anesthetic management of pediatric obese population. There is still scarcity for current literature and definite practice guidelines about the anesthesia management of obese pediatric patients. As it is mentioned in the body of this paper, many recommendations are made from studies based on adult obese patient groups. More studies are needed about pharmacology, pre, intra, and post op anesthesia management of pediatric obese patients in order to provide a more specific anesthetic and prevent complications.

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Appendix

Anesthesia Implications of Pediatric Obesity

Jency Jacob, SRNA

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Introduction

- Pediatric obesity has become a growing and alarming trend in United States.
- Operational definition of childhood obesity by CDC, (for children of the same sex & age)
  - -BMI > 85th percentile and < 95th percentile = **overweight**
  - -BMI at or above 95th percentile = **Obesity**
- One third of children presenting to pediatric day surgery units are overweight or obese (Middlebrooks & Winters, 2011).
- Anesthesia and surgery may entail considerable risk for obese children

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Prevalence & Epidemiology

- Approximately 17 % of children & adolescents aged between 2-19 years are obese
- Obesity is higher in Hispanics(22.4%) and non-Hispanic black youth(20.2 %)
- As per 2011-2012 statistical data, 8.4% of 2-5 year olds, 17.7 % of 6-11 year olds and 20.5 % of 12-19 year olds had obesity

Source: CDC. (2012). Basics About Childhood Obesity. Retrieved on 08 mar 2015 from http://www.cdc.gov/obesity/childhood/basics.html

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Epidemiology

- **Causes**
  - -Excessive calorie consumption (90 %)
  - -Genetic predisposition
  - -endocrine dysfunction
  - -single gene disorders (congenital leptin deficiency)
- Obesity is associated with Prader-Willi, Cushing's and Bardet-Biedl syndrome

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Pathophysiology cont.

- **Cardiovascular**- HTN (20-30%), increase in CO & SV, LVH(in adolescents), hyperlipidemia, hypercholesterolemia
- **Gastrointestinal**- GERD, asymptomatic nonalcoholic fatty liver disease(NAFLD)
- **Endocrine**- Metabolic syndrome, insulin resistance, Polycystic ovarian syndrome
- **Neurological/Psychological**- Pseudomotor cerebri, low self esteem, poor school performance
- **Orthopedic**- Slipped femoral epiphysis

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Pathophysiology cont.

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Case Information

- Surgical Procedure: Dental Restoration &SSC
- Age: 3 year
- Weight: 41 kg (BMI- 35.3)
- Gender: Male
- ASA: 1

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Pre-operative Evaluation

- Past Medical Hx: Respiratory distress as newborn, Genu Valgum
- No surgical history
- Pre-op vital signs: BP- 117/55, Pulse- 106, RR-16, SpO2-97 % on room air.
- Lab: Hemoglobin/Hematocrit- 12.1/34.9 %
- Airway evaluation: Mallampati- II

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Anesthetic Course

- Inhalation induction: 70% N2O/3 L O2/8% sevoflurane
  - -Oxygen desaturation to 91-92 %
  - -Two person BMV with oral airway in place
  - -IV insertion (2 attempts)
- Technique- Intubated with a 5 mm uncuffed nasal RAE tube using a no. 2 Macintosh blade and Magill forceps (2 attempts). Grade 2 Cochrane Lehane view.
- Drugs used in the peri-operative period: Fentanyl 50 mcgs, Dexamethasone 4 mg and Ondansetron 4 mg.

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Intraoperative & PACU issues

- Decreased O2 saturation in the perioperative course
- Challenging mechanical ventilation(volume controlled->pressure controlled + PEEP)
- Following transfer to PACU the patient had developed stridor and oxygen saturation dropped to 88 %
- Administration of racemic epi, applying a jaw-thrust maneuver and placing a nasal airway improved patient's oxygenation
- The patient was kept in observation until vital signs were stable, and discharged home the same day.

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Anesthesia care of obese pediatric patients- Review of Literature

- Obesity is a systemic disease and associated with many comorbidities→ challenges to anesthesia providers.
- There is still scarcity of literature regarding specific anesthetic management in pediatric obesity.
- Current literature suggestions are mainly based on studies done in obese adult patients

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Discussion

- Common perioperative complications of pediatric obesity are: (results from retrospective studies)
  - -intraoperative oxygen desaturation (2 % Vs. 0.19%) (Setzer & Sadde, 2007)
  - -difficult mask ventilation (7.4 % Vs. 2.2 %)
  - -difficult laryngoscopy (1.3 % Vs. 0.4 %)(Tait et al, 2008)
  - -post-operative airway obstruction (1.6 % Vs. 0.07 %)(Nafiu et al, 2007)
  - -longer stay in PACU due to bronchospasm or other critical respiratory events (Setzer & Sadde, 2007)

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Discussion

Preoperative Management

- A thorough pre-op evaluation is mandated which includes chart review, physical assessment, airway assessment, recent illness and breathing problems
- A BMI percentile chart is useful to know whether the child is overweight or obese (BMI changes with age)
- Enquire about tolerance to exercise, medications including herbs or special meds taken to lose weight
- A preoperative fasting blood sugar is recommended-to rule out undiagnosed DM (Mortensen et al, 2011)

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Discussion

- A room air oxygen saturation < 96 % warrants further investigation of pulmonary disease or obstructive sleep apnea syndrome
- Avoid heavy premedication
- Be prepared with equipment such as glidescope, appropriate intubating LMAs, oral/ nasal airways, difficult airway cart, ultrasound or vein transilluminator(for IV start).

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Discussion

Intra operative Management

- Induction of anesthesia can be inhalational or intravenous
- Have another trained anesthesia professional in the room if difficult airway is anticipated
- Pre oxygenate with 100% FiO2 for at least 3-4 minutes
- Optimize patient positioning for intubation- ramping up
- Combine jaw thrust & chin lift maneuver with CPAP of 10 cm H2O – reduce upper airway collapse during induction, prevent atelectasis

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Discussion

Intra operative management cont.....

- Positioning 25 degree head up in obese children→ good pulmonary dynamics, Protect cardiac function
- Desufflate stomach if applicable
- Prevent nerve injury by appropriate pressure point padding
- Use appropriate sized BP cuffs for accuracy
- Consider inserting an A-line for invasive procedures

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Discussion

Pharmacokinetics

- Pharmacokinetic studies in children are less
- The body composition of obese children are different from non-obese children - increased adipose tissue, increase in lean body mass(LBW) = can affect the volume of distribution (Vd) of several drugs
- Sevoflurane considered ideal in pediatrics due to less airway irritability & more hemodynamic stability (Brenn ,2005).

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Discussion

- Dosage recommendations of intravenous anesthetics in obese children (Mortensen et al, 2011)

Drug	Induction dose based on	Maintenance dose based on
Thiopental	LBW	
Propofol	LBW	TBW
Opioids (Fentanyl, Alfentanil, Sufentanil)	TBW	LBW
Morphine	IBW	IBW
Remifentanil	LBW	LBW
Succinylcholine	TBW	
Sugammadex	TBW	

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Discussion

Post operative Management

- Adequate ventilation & oxygenation, intact airway reflexes, complete reversal of paralysis agents should be met prior to extubation
- Maintain body position tilted upright to 25 degrees or higher
- Difficult airway- should extubate awake
- Supplemental oxygen delivery and pulse oximetry should continue till SpO2 > 92 %
- If patient is CPAP dependent before surgery, continue in the post operative period

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Discussion

- In obese children with obstructive sleep apnea syndrome(OSAS), avoid tonsillectomies and laparoscopic surgeries as outpatient- need at least 23 hour observational period (Lin, 2007).
- Avoid postoperative respiratory depression-controlled analgesia
- Consider multi-modal antiemetics depending on the type of surgeries – no substantial evidence that obese children have increased incidence of PONV (Owen & John, 2012).

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Discussion

Regional Technique

- Anatomically challenging – obscure landmarks, lack of co-operation, increased depth to neurovascular sites
- Use of fluoroscopy, nerve stimulators and ultra-sound guided technique will increase success
- Local anesthetic spread and block height are unpredictable
- Drug doses of local anesthetics should be adjusted as spinal and epidural space is decreased in obese patients (Lin, 2007).

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Recommendations

- Airway & Ventilation management- Caution should be exercised
- Keep in mind about the risk factors associated with obesity
- Anticipate, recognize and treat complications that may disproportionately occur in obese children - optimize their anesthetic care
- More large-scale prospective studies needed in future in regards of pharmacokinetics, perioperative management and outcome of obese children

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Conclusion

- Pediatric obesity is a recognized epidemic
- Precautionary actions and literature recommendations discussed in this presentation will improve perioperative outcomes and patient safety
  - Be proactive !!

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Thank You
Are There Any Questions?

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