

REVIEW ARTICLE

Obese Adolescents and the Implications for Anesthesiologists

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Obese adolescents are not just smaller versions of adults even though they may have similar weights. Too often, their perioperative management is based on information extrapolated from adult studies without considering their distinct pathophysiology. As a prime example, obese adults demonstrate restrictive lung physiology due to fat deposition compromising their diaphragm function and chest wall compliance. Obese adolescents have restrictive factors too, but they also demonstrate obstructive airway symptoms and increased airway resistance because their lung capacity grows faster than the airway caliber—a mismatch known as “airway dysanapsis.”¹

We review the major physiologic changes associated with obesity in adolescents, together with the precautions needed to avoid complications in their perioperative care.

Background

Childhood obesity has become an epidemic, with the prevalence increasing from 4% in 1975 to 18% in 2016. Approximately 30% of pediatric patients now presenting for surgery are found to be overweight or obese. Notably, the prevalence of obesity in adolescents is increasing at a faster rate than in other age groups.^{1,2}

By definition, adolescents are children in the process of becoming adults. Their physiology is different from both children and adults, characterized by dramatic growth and change that varies by the individual. Puberty starts at varying ages with hormone surges causing growth spurts, increased muscle mass, sexual organ maturation and menstruation. In obese adolescents, puberty may occur earlier because increased serum leptin causes gonadotropin-releasing hormone secretion, and these adolescents can have additional comorbidities including hypertension and obstructive sleep apnea (OSA). These variations make obese adolescents difficult to study in a standardized way.

Obesity in Adolescents

Obesity in adults is based on body mass index, with over 30 kg/m² defined as obesity and over 40, severe obesity. However, this classification cannot be easily applied to adolescents due to variations in growth trajectory around puberty onset. Most sources use age- and sex-specific BMI percentiles relative to other adolescents of the same age and sex. Obesity in pediatrics is considered a BMI that exceeds the 95th percentile and severe obesity, exceeding the 99th percentile when matched for age and sex.²

Respiratory System

Adolescents undergo increases in truncal height and rib diameter resulting in rapid increases in lung capacities and volumes. Airway dysanapsis describes the mismatched growth between faster-growing lung parenchyma and slower-growing airway caliber, producing an abnormal forced expiratory volume in 1 second—to-forced vital capacity ratio. Adipose tissue macrophages are also thought to produce inflammatory mediators that act on the respiratory system and trigger bronchial hyperreactivity and airway obstruction. Obese adolescents' dysregulated immune systems can put them at higher risk for reactive airway disease and postoperative infections. Consequently, they may have both mechanical and inflammatory processes affecting their lung function with reduced responses to inhaled corticosteroids.¹

Nearly 80% of obese children have reported OSA and, if left untreated, this can lead to further cardiovascular (CV) complications such as left ventricular (LV) dysfunction and pulmonary hypertension. Unsurprisingly, there is an increased relative risk for perioperative respiratory adverse events including oxygen desaturation, difficult mask ventilation, airway obstruction and bronchospasm.³

Cardiovascular System

Similar to obese adults, obese adolescents may have abnormal cardiac function and structure due to adipose tissue accumulation promoting blood vessel angiogenesis. These changes lead to increases in cardiac output, diastolic filling pressures, LV wall stress, myocardial mass and LV stiffening. If untreated, this can cause left ventricular

hypertrophy, diastolic dysfunction and heart failure. Obesity in children is significantly associated with left ventricular hypertrophy (14% in obese vs. 3% in nonobese groups).⁴

Studies have shown that weight loss may reverse LV geometry and diastolic dysfunction in obese adolescents. The clinical relevance of these results remains unclear due to lack of standardized definitions of diastolic dysfunction in children and few studies investigating cardiac physiology in obese adolescents, but it highlights the importance of early intervention.⁵

Metabolic Changes

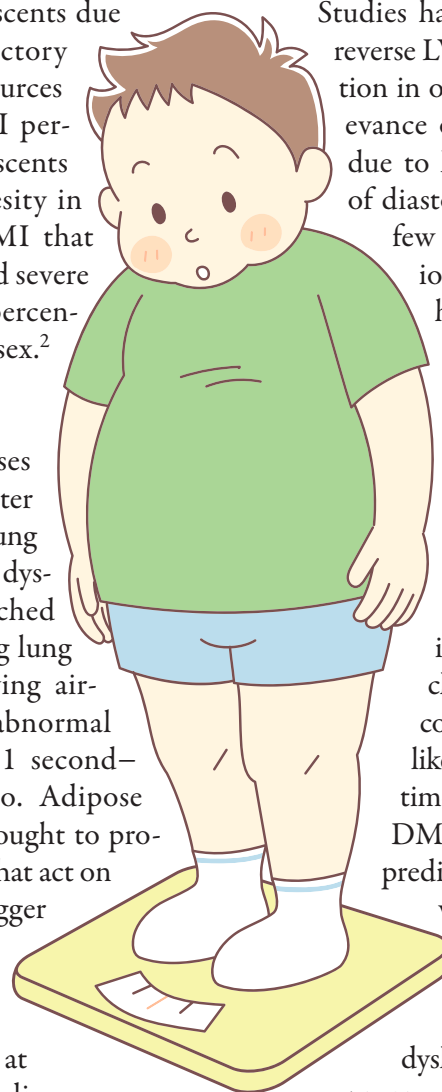
“Metabolic syndrome” (MetS) is a term for a cluster of risk factors for CV disease and diabetes mellitus (DM) including obesity, hypertension, elevated triglycerides, low high-density lipoprotein cholesterol and elevated fasting glucose. Patients with MetS are twice as likely to develop CV disease and five times more likely to develop type 2 DM. Childhood obesity is a significant predictor of MetS later in adulthood, with disease severity increasing with degree of obesity. If DM is diagnosed during adolescence, associated complications such as dyslipidemia and hypertension often progress more rapidly than when DM appears in adulthood.

Like CV changes, MetS can be reversed in adolescence more readily than in adulthood. In 2016, the Teen-Longitudinal Assessment of Bariatric Surgery study analyzed obese adolescents up to three years after bariatric surgery and found that 95% had remission of DM and 80% had resolution of hypertension postoperatively. Conversely, adults who underwent bariatric surgery had only 50% to 70% remission of DM and 40% for hypertension.⁶

Intraoperative Care

Airway and Respiratory Considerations

Compared with their normal-weight counterparts, obese adolescents experience significantly more intraoperative desaturation, difficult mask ventilation, and difficult laryngoscopy requiring multiple attempts. Obesity-related factors include excessive adipose tissue causing pharyngeal collapse, large tongue, tonsillar hypertrophy obstructing laryngoscopy views, and



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limited neck extension. There is greater risk for bronchospasm and laryngospasm, particularly following general endotracheal anesthesia.³

No current guidelines caution against laryngeal mask airway (LMA) use in obese adolescents. One study observed significantly longer LMA placement times compared with endotracheal tube placement in obese children, but this did not result in significant differences in overall complications. Of note, LMA sizes based on total body weight (TBW) instead of ideal body weight (IBW) or lean body weight were observed to have better ventilating conditions with fewer leaks. Recommendations for airway management include adequate preoxygenation, continuous positive airway pressure (CPAP) of higher than 10 cm H₂O, head-up positioning during induction, and using TBW when choosing LMA sizes.³

Pharmacologic Considerations

A major obstacle in managing obese adolescents is calculating optimal drug doses. As expected, obesity can affect drug absorption, metabolism and elimination. Dosing recommendations typically are based on TBW, which is reasonable for normal-weight subjects whose TBW, IBW and lean body weight are similar. Using IBW for obese patients may result in underdosing. Adolescents are additionally complex because variable organ maturation rates and body composition changes (total blood volume, volume of distribution) can alter drug clearance, elimination half-life and peak plasma concentration.

Lipophilic drugs have a higher volume of distribution than hydrophilic drugs in obese patients and should be dosed according to TBW. There is concern that dosing propofol (a lipophilic drug) according to TBW could lead to overdosing in adolescents. Some recommend using lean body weight to titrate propofol for both induction and maintenance in obese adolescents, along with quantitative electroencephalogram, until better guidelines are established. Hydrophilic drugs such as morphine should be dosed based on IBW in obese patients, yet this lower dose may still cause respiratory depression in patients with OSA and increased opioid sensitivity. Obese patients have increased pseudocholinesterase levels and extracellular fluid, which necessitates larger succinylcholine doses based on TBW to ensure adequate paralysis and optimal intubating conditions. Rocuronium is weakly lipophilic and was noted to have increased duration of action when using TBW, so dosing should be cautiously based on IBW to avoid prolonged paralysis.^{3,7}

Overall, there is a lack of evidence-based age- and weight-appropriate guidelines for obese adolescents, and dosing is often extrapolated

from adult studies. One study found that overweight children had a significantly higher risk for receiving medication doses outside the recommended ranges (30%-70% more likely). Unfortunately, they are 3.5 times more likely to receive an overdose of morphine and nearly twice as likely to receive inadequate doses of succinylcholine and neostigmine.⁸



The perioperative setting may provide an opportunity to educate overweight adolescents and their families about the additional risks of anesthesia and surgery in this context, and to encourage lifestyle changes.

Postoperative Care

In a retrospective study that matched pediatric patients by age and sex, obesity was found to be independently associated with a sevenfold increase in postoperative adverse respiratory events, including upper airway obstruction and respiratory depression. Obese pediatric patients had longer anesthesia recovery times (more than three hours) and were more likely to be admitted for the same procedures. Severe obesity is associated with a threefold increased rate of unplanned hospital admission and increased length of stay. Some authors recommend overnight hospitalization for all obese children after airway procedures such as tonsillectomy.^{3,9}

Conclusion

Despite their youth, obese adolescents are at risk for the same comorbidities that affect obese adults. Unfortunately, there are few guidelines

for their management other than the common-sense recommendations below:

- Perform a comprehensive preoperative assessment with referral, if needed, for optimization of coexisting medical issues.
- Prepare for possible difficult IV line placement and/or airway management.
- Preoxygenate with head of the bed elevated and CPAP if tolerated.
- Consider the impact of the patient's weight on drug dosages.
- Reduce opioid use with multimodal analgesia.
- Completely reverse neuromuscular blockade.
- Monitor oxygenation and ventilation postoperatively, with a low threshold for prolonged observation or admission.

The term "oblivobesity" was introduced recently to reflect the failure of parents to recognize their child's obesity and the health risks associated with it, although this can also be used to describe physicians who don't recognize the complexities of this particular group.¹⁰ The perioperative setting may provide an opportunity to educate overweight adolescents and their families about the additional risks of anesthesia and surgery in this context, and to encourage lifestyle changes. It remains to be seen if new treatment modalities, such as glucagon-like peptide-1 agonists, will reduce the prevalence of obesity in children and adolescents.

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Sibert is a member of the Anesthesiology News editorial advisory board.