Anesthesia for Pediatric Obesity

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Overweight and obesity are increasingly common problems not only in the United States but worldwide. Paralleling the increasing adult prevalence, adolescent and childhood obesity is also on the rise. The Centers for Disease Control and Prevention (CDC) has sponsored data showing that the prevalence of overweight children is 16% (1999–2002 data), representing 9 million adolescents and children in the United States [1]. Consequently, the medical effects of overweight, such as hypertension, type 2 diabetes, and other antecedents of coronary artery disease, are also on the rise in children and adolescents [2]. Pediatric anesthesia specialists are now dealing with perioperative issues previously seen predominantly in their adult counterparts.

The economic impact is profound. The medical expenses of obesity accounted for 9.1% of the total United States medical expenditures, amounting to between $80 and $90 billion [3]. These expenditures do not consider the additional indirect costs attributable to obesity. With so many children and adolescents heading toward an overweight adulthood, these costs will no doubt rise as the morbidity rate of these patients increases.

This article discusses the unique anesthetic implications of obesity, with an emphasis on children and adolescents. It also touches on the issues surrounding bariatric surgery in the morbidly obese adolescent population. Adolescent bariatric surgery is moving to the forefront as a treatment modality because weight-loss programs alone are not keeping pace with the growth of the problem. Bariatric surgery offers the potential to achieve the weight reductions necessary to reverse the debilitating and costly comorbidities of obesity.

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Definitions

The common measurement of overweight and obesity is the body mass index (BMI). Calculated as the mass of the patient divided by the square of the patient’s height (kg/m²), BMI is used to delineate overweight and obesity in adults. In adults, a BMI of 25 or greater is considered adult overweight; a BMI of 30 or greater is considered obese; and BMI greater than 40 is considered morbidly obese.

There are limitations to the BMI as a measure. This metric does not account for individual variation in fat and muscle distribution. It also does not account for bone density, body shape, or racial differences. For example, some of our most celebrated and muscular baseball heroes (especially those who used anabolic steroids) often have a BMI greater than 25, but are they considered overweight?

This calculation is also useful in children, but because the BMI in children varies with age and gender, an absolute value may not signify that a given patient is overweight or obese. It is necessary to use an additional tool, a gender-specific BMI-for-age growth chart, as published by the CDC, to make the determination [4]. Using the gender-specific charts (Figs. 1 and 2), the convention in children is to determine the BMI for age. Those children whose measurements are found to be in the 95th percentile or greater are considered overweight. It must be remembered that, in contrast to adults, the BMI number is not the determinant but rather the percentile into which the child’s gender and age fall. As an illustration, a child may have a BMI of 20. This works out to be the 50th percentile for a 15-year-old child, but this number would be greater than the 95th percentile for a seven-year-old child.

Prevalence

It is estimated that 1.1 billion people worldwide are overweight, with 250 million classified as obese [5]. In the United States, an estimated 65% of adults are considered overweight, with 30.4% considered obese according to the National Health and Nutrition Examination Survey (NHANES) of 1999 to 2002 [1]. This represents 60 million obese American adults.

The NHANES found that the prevalence of overweight in children 6 to 19 years of age (4%–7% from the 1960s to the 1980s) has increased dramatically during the last 15 years (Fig. 3). The prevalence now stands at an estimated 16% in children 6 to 19 years of age. This prevalence rate corresponds to approximately 9 million overweight and obese children, which is triple the rate found during the 1980s. More disturbing is that other developed countries, including Canada, the United Kingdom, and Australia, are reporting up to 43% rates of obesity in children [6]. The International Obesity Task Force [7] estimates that as many as 155 million school-aged children worldwide are overweight or obese.
Fig. 1. Body mass index-for-age percentiles in girls, age 2 to 20 years, according to the National Center for Health Statistics. (Data from http://www.cdc.gov/nchs/data/nhanes/growthcharts/set3/chart%2016.pdf. Accessed February 24, 2005.)
Published May 30, 2000.
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

Fig. 2. Body mass index-for-age percentiles in boys, age 2 to 20 years, according to the National Center for Health Statistics. (Data from http://www.cdc.gov/nchs/data/nhanes/growthcharts/set3/chart%2015.pdf. Accessed February 24, 2005.)
Although the NHANES data do not show a difference between children and adolescent age groups overall, there are differences between ethnicity and gender for certain age groups. Mexican American children are more likely to be overweight (23%) than non-Hispanic Black (21%) and white (14%) children. Among males, it appears that the prevalence among Mexican American males is the highest (27.5%), and non-Hispanic Black females have the highest prevalence among females at 26.6% [8].

At the present author’s institution, the prevalence of obesity in patients undergoing surgery has also risen during the last 5 years [9]. In a review of the A. I. duPont Hospital for Children anesthesiology medical records database from 1999 to 2003, the ages, weights, and heights of 40,772 cases were extracted. Of these cases, 18,409 patients were age 6 years or older, and of these patients, 15,275 had complete data fields (83%). From 1999 to 2003, the overall prevalence of overweight in the population of children older than 6 years has risen from 13% to 16%, which represents a 23% change. The overall prevalence of overweight in the male population has risen by 29%, and overall prevalence for females has risen by 19%.

The breakdown by age and gender are shown in Fig. 4. The rate of rise of obesity has differed between the age groups at the present author’s institution. Adolescent females (ages 12–19 years) were found to show a rise in obesity of 13%, with a prevalence of almost 15%. Female children (ages 6–11 years) had a greater rate of increase of 25.78%, with a prevalence of almost 17%. Male adolescents and children have shown the greatest rise in prevalence, with male children having the steepest rise of 31.56% and a current prevalence of 17.33%.
Most disturbing is that the prevalence of overweight and obese children is greater than the adolescents who usually are associated with obesity.

There is strong evidence that overweight children develop into overweight adolescents and adults [10–12]. If present trends continue, it appears we will have an increasing cohort of overweight patients in the future.

**Causes**

The causes of obesity are numerous and interrelated. The simplistic reason is that overweight and obesity are caused by consuming too many calories while not engaging in enough activities that result in energy expenditure. However, heredity, metabolism, behavior, environment, culture, and socioeconomic status affect the balance of intake and expenditure. Because the genetic makeup of individuals is fixed and not readily amenable to treatment, cultural, behavioral, and environmental changes are the focuses of treatment.

It has been estimated that less than 10% of the causes of obesity have a unique medical cause. Five percent of children may have neurologic damage, endocrine dysfunction, or hereditary disease. Several rare syndromes associated with obesity, such as Laurence-Moon-Biedal, Fröhlich’s, Cushing’s, and most notably, Prader-Willi syndromes, account for only 1% of cases [6].

Several single gene disorders have been shown to result in the early onset of profound obesity. Leptin, an adipocytokine, is secreted from adipose cells and acts in the hypothalamus to control satiety and energy balance. Congenital leptin deficiency or mutations in the leptin receptors have been described that cause an
intense drive to eat with no negative feedback mechanism [13]. Most obese patients do not have such mutations, but such findings provide fertile ground for future study and, perhaps, treatments.

The precursors of obesity may start with an individual’s genetic makeup, and it is no surprise that overweight children tend to have overweight parents. How much of this is because of nature or nurture is difficult to tell. It has been found that nutritional balance during the prenatal period, early infancy, and early childhood may be particularly important for later obesity development and has been the source of considerable study [14]. Although a direct relationship between birth weight and BMI has been shown [15,16], a recent study has also found that infants who are small for gestational age and have rapid weight gain in early infancy are prone to develop central obesity [15].

Breast feeding and its duration have been shown to be inversely associated with the development of overweight [17]. Formula feeding, likewise, has been associated with an increased likelihood of overweight. Although numerous confounding variables are involved, some studies have examined how the development of taste preference in utero and early infancy may affect later food preferences. According to the hypothesis, maternal food preferences may be transmitted through amniotic fluid and breast milk [18].

Pressed for time, children in developed countries eat “on the fly.” The easy access to fast food, with its high sugar and fat content (and, thus, calorically dense makeup) and salty flavor that encourages consumption of a sugary drink, is a recipe for future overweight. Therefore, a high relative caloric intake with inadequate energy expenditure results in the accumulation of energy storage in the form of fat. What makes the problem an epidemic is profound, widespread cultural perpetuation of poor habits and food choices, unfortunate genetic predispositions, and economic factors.

Although genetic predisposition is a factor, it is probably not a strong reason for the incredible rise in rates of obesity, because genetic factors have not changed significantly, nor is the genetic makeup of a patient amenable to treatment. It is more likely that children with particular genetic predispositions have run headlong into behavior and environments that favor weight gain.

Pathophysiology related to obesity

Because the population of children coming to surgery is increasingly overweight, it is important that pediatric anesthesiologists are aware of the spectrum of physiologic derangement that may be present. Fortunately, most children with obesity do not have all of the longstanding medical issues of their obese adult counterparts, because most do not present until later in life. However, if the children have been obese for several years, especially if they trend into the morbidly obese range, the longstanding medical issues may become evident (Box 1).
Respiratory issues

The pulmonary function and respiratory mechanics of obese patients are altered by 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. Pulmonary function studies in obese patients typically show a restrictive pattern with decreases in functional residual capacity, expiratory reserve volume, vital capacity, and inspiratory capacity [19]. These changes have also been observed in obese children. In addition, reductions in the forced expiratory reserve volume in 1 second (ie, FEV₁), the forced expiratory flow between 25% and 75% of vital capacity (ie, FEF₂₅₋₇₅), and the diffusing capacity of lung for carbon monoxide (ie, DLCO) have been noted [20].

Overweight patients also may have elements of obstructive pulmonary disease. Overweight children and adolescents have a higher incidence of asthma and exercise-induced asthma than do normal children [21]. There is a distinct positive correlation between increasing BMI and asthma incidence and severity [22]. The prevalence of asthma is greater among obese females than obese males [23]. Of 48 patients with extreme overweight (BMI ≥ 40) presenting to one specialty clinic, 35 (73%) had small airway disease by pulmonary function testing or were receiving asthma treatment [24].

Sleep-disordered breathing and outright sleep apnea are well-recognized problems in adults and have been found to be quite prevalent with increasing BMI in children. From 15% [24] to 33% [25] of overweight children with

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**Box 1. Partial list of complications of longstanding obesity**

- Certain malignancies (eg, breast, pancreatic, endometrial, prostate, and colon types)
- Cholecystitis
- Congestive heart failure
- Coronary artery disease
- Gallstones
- Gout
- Hypercholesterolemia
- Hyperinsulinemia
- Hypertension
- Insulin resistance and glucose intolerance
- Obstructive sleep apnea
- Osteoarthritis
- Psychological disorders
- Reactive airway disease
- Stroke
- Type 2 diabetes
BMI ≥ 40 in recent studies had sleep-disordered breathing or sleep apnea [25]. These abnormal sleep patterns lead to nighttime oxygen desaturation, respiratory acidosis, pulmonary hypertension, polycythemia, and ultimately, directly to heart failure (the so-called Pickwickian syndrome). It has been suggested that adenotonsillar hypertrophy should be managed aggressively in this population to lessen the cardiorespiratory effects [26].

At rest, obese patients have twice the atelectasis of normal patients [27]. This is generally believed to be because of the increased closing volume that results in air trapping and shunting in this area that is perfused but not ventilated. The resultant pulmonary shunt worsens hypoxia, especially in the recumbent position, because the mass of the abdominal wall and intra-abdominal contents exert pressure on the diaphragm.

**Cardiovascular issues**

Obesity has been associated with the development of the classic cardiovascular risk factors of hypertension, dyslipidemia, insulin resistance, type 2 diabetes, left ventricular hypertrophy, and the previously mentioned pulmonary hypertension. With children and adolescents developing obesity earlier, the longstanding perpetuation of these risk factors will almost invariably lead to significant cardiac morbidity in adulthood.

In a recent review of obesity-related hypertension by Sorof and Daniels [28], the prevalence of hypertension was shown to increase with increasing BMI. The mechanisms of hypertension in obesity currently point to sympathetic nervous system hyperactivity, insulin resistance, and abnormalities in vascular structure and function. Higher resting heart rate and heart rate and blood pressure variability have been shown to be present in obese hypertensive adolescents compared with normal adolescents. These findings have been shown to be associated with relative over-activity of the sympathetic nervous system activity compared with parasympathetic activity [29]. Physical training in obese children reduces the ratio of sympathetic to parasympathetic activity [30]. Increases in the systolic blood pressure have been associated with insulin resistance and increases in visceral fat in obese patients. Insulin has renal sodium retention effects that may contribute to blood volume overload. Obese children have been shown to have lower arterial compliance and lower distensibility of arterial vasculature compared with nonobese children [31]. Weight loss in this population is associated with reversal of these changes.

In obese patients, both the cardiac output and the blood volume are increased, largely because adipose tissue is well vascularized. It is estimated that the cardiac output increases 0.1 L/min for each kilogram of adipose tissue. The increased CO is because of a resultant increased stroke volume as the resting heart rate in obese patients is normal to low.

With increasing overweight, oxygen consumption and carbon dioxide production are increased. The increased oxygen demand increases the workload of the heart. Indeed, most obese patients are at risk for significant hypertension.
In overweight adolescents, the left ventricular mass has been shown to be larger, and the mass increases in right ventricular pressure in some patients [24]. With these changes and the elevated need for oxygen, severely overweight adolescents are potentially at risk for myocardial strain.

In severely obese adolescents (BMI ≥40), cardiac deconditioning is seen. When these patients underwent graded exercise stress testing, it was found that fewer than half of them were able to achieve the anaerobic threshold [24]. Obesity cardiomyopathy is the result of severe and long-term obesity and a risk for progressive heart failure and sudden cardiac death [32].

Endocrinology issues

In adults, type 2 (noninsulin-dependent) diabetes has long been associated with obesity. An increasing percentage of obese adolescents has type 2 diabetes. What is more disturbing is that some of these patients with classic type 2 diabetes are becoming insulin-dependent.

Insulin resistance is also common and is associated with the metabolic syndrome of insulin resistance, hyperlipidemia, and hypertension. Of interest is that recent literature has noted that visceral accumulation of adipose tissue plays an important role in the development of insulin resistance and compensatory hyperinsulinism. These mechanisms have been shown to be related to the development of hypertension in children, as mentioned above [28]. Serum insulin has been closely related to systolic blood pressure in obese children, and hyperleptinemia and increased visceral fat are also associated, even when there is no family history of hypertension [33].

Pharmacology as it relates to obesity

There are two problems associated with the dosing of medications in children and adolescents with obesity. First, there is a paucity of information specifically on the pharmacokinetics and pharmacodynamics of many common drugs in obese children, and the conclusions are largely drawn from adult literature. Second, the available literature often contains conflicting results for the same agents, depending on the age and degree of obesity studied. The available literature is lacking or contradictory regarding the nature of protein binding in the obese population. There is some literature suggesting that hepatic metabolism is altered in obesity, with no consistent reviews [34]. Pediatric anesthesiologists are accustomed to dealing with the age-related differences in dosing regimens, but body composition adds a new dimension. What are available in the literature are individual studies of certain drugs of interest.

As with all pharmacologic agents, the main 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. The body composition of children varies significantly with age, and
the body composition of overweight children is different from normal children. It would be simplistic to assume that an obese patient is simply a lean patient that has an extra adipose tissue compartment. The discussion of body composition in patients with obesity includes various terms such as total body weight (TBW), ideal body weight (IBW) and lean body mass (LBM). The IBW is not the same as the LBM. Most obese patients have increased adipose tissue combined with an increase in LBM [35]. Indeed, 20% to 40% of an obese patient’s increase in TBW can be attributed to an increase in LBM [6].

It is generally expected, however, that medications that are highly lipophilic will show significant increases in the volume of distribution in obese patients compared with normal weight patients. These medications include barbiturates and certain benzodiazepines. This is not always the case, because it has been shown that propranolol, although highly lipid soluble, has a decreased volume of distribution, suggesting other factors are at play [34]. Less lipophilic or watersoluble agents are expected to show very little change in the volume of distribution [36].

Thiopental and midazolam are examples of medications that are very lipophilic and show an increased volume of distribution in obese patients. It is, therefore, recommended to administer the dosage according to the patient’s TBW. Propofol, however, is a lipophilic drug that does not show an increased volume of distribution in obese patients. The total body clearance and steady-state volume of distribution have been correlated to the TBW. It is appropriate to initially administer the dose of propofol according to the IBW, but the dose for a steady-state continuous infusion should be based on the TBW. Although propofol is lipophilic, the accumulation may be less because adipose tissue has relatively poor perfusion, and a significant portion of propofol is metabolized outside the liver [37].

Polar and hydrophilic neuromuscular blocking agents such as vecuronium and rocuronium have been used and studied in the obese population, and both agents have been shown to distribute to the lean tissues. Recovery of twitch has been prolonged when these doses of these medications have been set according to TBW, and the recommendation is to administer dosages according to IBW [38]. Cisatracurium and atracurium have presented a more confusing picture. Both medications have been touted not to be prolonged in obesity, ostensibly because they are eliminated independently of organ systems. However, more recent literature has shown that cisatracurium has a prolonged duration of action when given according to TBW [39]. Succinylcholine has been shown to have a similar potency in obese as well as normal adolescents, and the dose should be based on the TBW and not the LBM or IBW [40].

The narcotics fentanyl and sufentanil show an increased volume of distribution, with the dose of the medication distributing to both adipose tissue and the lean body mass. The dose should be based on the TBW [41,42]. Remifentanil differs from these other narcotics not only because of its rapid elimination but also because it has a smaller volume of distribution in obese patients [43].
Isoflurane, sevoflurane, and desflurane have all been used successfully in obese patients. Isoflurane, although a well-known and safe agent, has shown a prolonged recovery compared with sevoflurane and desflurane [44]. Sevoflurane has also been shown to have a slower elimination than desflurane. Sevoflurane has also been shown to result in increases in fluoride concentrations in obese patients compared with nonobese patients [45]. Desflurane has been shown to have significantly faster uptake and recovery characteristics with none of the potential side effects of sevoflurane. Desflurane has also been shown to have a very consistent recovery profile in adult obese bariatric patients.

Bariatric surgery in adolescents

Bariatric medicine refers to treatments associated with weight loss. Bariatric surgery represents a series of invasive procedures that are designed to treat morbid obesity. Although more than 100,000 adult bariatric operations are performed each year in the United States and Canada [46], only recently are centers considering extending this treatment modality to the morbidly obese adolescent population.

Adolescent bariatric surgery may be considered drastic by some practitioners; however, the rationale for proceeding with these procedures has been well considered. Overall, weight-loss programs for adolescents have had limited success. The benefits of weight-loss surgery may be realized before the long-term medical and psychologic effects of obesity take hold. These procedures offer the patient the opportunity to prevent the serious comorbidities associated with obesity [47]. Type 2 diabetes, obstructive sleep apnea, pseudotumor cerebri, and the antecedents of heart disease can be cured or significantly ameliorated with bariatric surgery in young adults. Long-term studies are still needed to be certain that adolescents will obtain sustainable benefits from the procedures.

The surgical procedures are classified as either malabsorptive or restrictive. The malabsorptive procedures, including the jeunoileal and biliopancreatic bypass, result in a relative dumping syndrome and are not currently used as much for bariatric surgery. Restrictive procedures such as vertical banded gastroplasty and gastric banding are used more commonly, with the current gold standard being the laparoscopic Roux-en-Y gastric bypass (RYGB) that is performed most often [48]. The RYGB involves the resection of all but 15 to 30 mL of the stomach volume and anastomosing this to the proximal jejunum, thus bypassing a great portion of the stomach and the entire duodenum (Fig. 5).

The criteria for acceptance into a bariatric program will vary with the institution, as exemplified in the report by Inge and colleagues [47] in Cincinnati. Generally, candidates should have a documented failure of a weight-loss program. They should have a BMI greater than 40 or greater than 35 if there are significant comorbidities. They must pass rigorous psychologic testing and have none of the factors that preclude surgery, for example, family factors, such as inability for long-term follow-up, and cognitive disability.
There are early and late complications of bariatric surgery. The early complications include gastrointestinal leakage, bleeding, wound infections, minor pulmonary complications, and severe complications such as pulmonary embolism and deep vein thrombosis. The late complications include stomal stenosis, bowel obstruction, and incisional and internal hernia formations. Other late complications are related to subsequent nutritional and metabolic derangements such as ulcers, cholelithiasis, and iron deficiency [48].

Anesthetic management

Preoperative

Heavy premedication has traditionally been contraindicated in patients with obesity because of the risk of respiratory depression. Intramuscular medications are also contraindicated because of the difficulty in reliably accessing the muscular site. When adipose tissue receives medication, it has variable kinetics. Venous access is often difficult in this population, necessitating attempts at central access. The use of transillumination of the veins, as in infants, and medications such as topical amethocaine that cause venodilation in addition to numbing of the skin have been advocated in pediatric and in obese patients [6].

Preoperative concern about gastroesophageal reflux has long been associated with obesity. Early studies have shown that obesity was associated with increased gastric fluid and a lower gastric pH level [49]. This view was believed to be associated with a greater likelihood of vomiting and aspiration during the induction of anesthesia and a higher risk of aspiration pneumonia postoperatively.
Recent work has challenged this view. Retrospective examination of large numbers of patients has shown no incidences of acid aspiration in obese children [50]. Further studies have even shown that obese patients have a lower incidence of combined high volume/low pH gastric fluid than lean patients do [51]. Finally, Maltby and colleagues [52] have shown that obese patients, when given 300 mL of clear liquids, had normal gastric emptying. This result, of course, was in patients who did not have pre-existing reflux disease. The crux of the recent literature would suggest that obese patients without reflux disease can follow the same fasting guidelines as nonobese patients.

**Intraoperative issues**

Routine intraoperative monitoring can often be difficult in patients with morbid obesity. Artifactually low voltages caused by excessive tissue impedance can complicate electrocardiographic monitoring [53]. Similarly, excess soft tissue thickness can make pulse oximetry unreliable. Alternative sites such as the nose, lip, or smallest finger have been advocated to improve the reliability of this monitor [5].

Accurate pulse oximetric data are not trivial in this population because it has been shown that obese patients have decreased tissue oxygen tensions compared with nonobese patients. Subcutaneous oxygen tension has been measured in these two groups at an arterial oxygen tension of 150 and 300 mmHg. Whereas the nonobese population showed a steep rise in subcutaneous oxygen tension, the obese group started at 20 mmHg lower and had a flatter response to increased oxygen (Fig. 6). Although arterial oxygen tension may be adequate, the lower...
tissue oxygenation may predispose obese patients to wound infection during the postoperative period [54].

Noninvasive blood pressure monitoring has been fraught with inaccuracies, often because of the unavailability of an appropriately sized cuff. Undersized cuffs are known to falsely elevate readings, although the configuration of the arm may also affect readings. Obese patients tend to have conically shaped upper arms in comparison with the cylindrical shape of nonobese patients’ arms, and an appropriate cuff sometimes does not fit properly. Use of the forearm has been shown to improve reproducibility, although it has also been shown to overestimate arterial pressure [55,56]. Recently, other noninvasive devices that monitor the blood pressure based on continuous radial artery compression have been tested. These devices (Vasotrach, Medware, Maitland, FL) have been shown to correlate well with invasive recordings [57]. Certainly, there are some researchers who advocate invasive monitoring except for the shortest of cases.

Neuromuscular blockade monitoring, like ECG, suffers from a similar excessive soft tissue impedance fate. Percutaneous needle electrodes may offer some improvement in the reliability of this monitoring modality [58], although the present author is not aware of widespread use of this technique.

End tidal CO₂ monitoring is not always accurate in morbidly obese patients. Decreases in functional residual capacity (FRC), ventilation-perfusion mismatch, and the dead space to tidal volume changes with obesity are cited as factors. A recent study has shown that transcutaneous (TC)-CO₂ monitoring is more accurate than end-tidal (ET)-CO₂ in morbidly obese patients undergoing gastric bypass surgery [59]. The absolute difference between the TC-CO₂ and the PaCO₂ was 0.2 kPa versus a difference of 0.7 kPa between the ET-CO₂ and the PaCO₂ ($P \leq .0001$). The drawbacks of TC-CO₂ are a monitoring 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.

Positioning issues

Under anesthesia, positioning affects the cardiorespiratory dynamics of obese patients more than other perioperative conditions. Attention to this detail is essential for conducting procedures safely. The recent review by Brodsky [60] examines this problem in obese patients. To generalize broadly, the supine position and any head-down position are tolerated relatively poorly, whereas any head-up, prone, or lateral decubitus position is better tolerated.

Although most operations are performed with the patient in the supine position, this position is essentially contraindicated in the obese patient. The supine position results in increases in the venous return, pulmonary blood flow, cardiac output, and arterial blood pressure because of normal vascular redistribution. From a pulmonary standpoint, the abdominal contents cause decreased diaphragmatic excursion and alterations in lung volumes. These changes are exaggerated with anesthetics and muscle relaxants. In obese patients, the adipose panniculus exerts extra excessive weight on vascular and pulmonary
structures. Although the cardiac indices are somewhat improved in the supine position in normal patients, the excess weight causes obese patients to decompensate. These changes increase with increasing BMI. If the supine position is combined with the Trendelenburg position, the physical dynamics are further compromised.

If a procedure is to be performed with the patient in the supine position, it is recommended that the patient be allowed to be head-up at 30° to 45°. This head-up modification allows for good pulmonary dynamics and preserves cardiac function, and often, this is the position the patient sleeps in at home. The prone position is well tolerated as long as the abdomen is free. In this position, the diaphragm is unloaded, which improves the FRC, and pulmonary compliance and cardiovascular function are preserved.

Perioperative outcomes

There are limited and often conflicting data regarding outcomes in obese children after surgery. One report [6] from a single hospital in England has noted that 9.56% of obese children had an adverse event, in contrast with a 5.89% rate of complications in adult obese patients. This would suggest that there is an increased perioperative risk in obese children.

Recent literature from the adult obese population suggests otherwise. In a prospective study by Dindo and colleagues [61] of 6336 adult patients (808 obese and 239 morbidly obese), a morbidity grading system was used to stratify outcome. This study has shown that rates of morbidity and mortality do not differ between obese and nonobese patients, nor is there a difference in the length of hospital stay [61]. There was a difference found in the incidence of minor surgical site infection for open abdominal cases. Another recent study by Klasen and colleagues [62] has examined 1962 patients with BMI greater than 30 and an equal number of controls. The authors found that there was no significant association between a higher BMI and outcomes for patients who underwent noncardiac surgery. Their conclusion was that obesity alone is not an independent risk factor of perioperative morbidity and mortality.

Other studies have specifically investigated postoperative pulmonary outcomes. In a small study of 161 obese patients, pulmonary function tests were measured at baseline, after the patient received premedication, and at 1 and 3 hours after extubation. The authors found progressive reductions in the spirometric values associated with increasing BMI [63]. The worst results were obtained with patients with morbid obesity and abdominal incisions. In another small study comparing morbidly obese patients with normal patients, preoperative CT scans were compared with scans performed soon after extubation and 24 hours later. The morbidly obese group had more significant baseline atelectasis, with continued atelectasis after anesthesia, and they still had the changes 24 hours after the surgery [27]. The changes were largely resolved in the non-obese, normal group at 24 hours.
Investigations have begun into the perioperative outcomes of children and adolescents. A recent abstract presented at the Pediatric Anesthesiology national meeting has presented data collected on 1246 children younger than 12 years old who presented for dental surgery. Of these children, 183 had BMIs greater than the 95th percentile for BMI. No differences were found between the obese and nonobese groups in terms of the incidence of laryngospasm, difficulty in starting intravenous lines, intraoperative or postoperative emesis, intraoperative or postoperative oxygen desaturation, or ICU admission [64]. This abstract also suggests that obesity is a recognized problem but that outcomes are necessarily poor. It may be that widespread concerns about obesity trigger precautionary actions perioperatively that result in improved outcomes.

Summary

Obesity and overweight are health problems of epidemic proportions worldwide. Childhood and adolescent obesity are associated with the onset of adult cardiovascular and endocrine problems at earlier ages. Dietary modifications alone have not been successful in slowing the rising incidence of obesity. Bariatric surgery in adolescents may provide the start to long-term improvements in the quality of life, psychosocial status, and physical well being for these patients. Although obese patients have been traditionally believed to be at very high-risk during the perioperative period, recent investigations in adults and children are challenging this view. Recent reviews attest to the concern and interest in the health and well being of the obese population undergoing surgery [6,48,57,65]. Further research and experience will determine whether this modality will be effective in the long run.

References


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