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Anaesthesia for the obese child

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Definition and classification

No single definition of obesity in childhood and adolescence has gained international approval. The body mass index (BMI) alone – body weight (kg) divided by height (m^2) – does not describe whether a child is normal in size, overweight or obese. Normal values for BMI vary with age, sex and pubertal status in a nonlinear manner. Instead, the BMI percentages based on the standard deviation within the population are used, which describe the percentage distribution of the BMI in terms of sex and regional origin.

Consensus committees have recommended that children and adolescents be considered overweight if the BMI exceeds the 85th percentile, and obese if the BMI exceeds the 95th percentile, or exceeds 30 at any age.

Classification of obesity

- Class 2 obesity is defined as having a BMI ≥ 120% of the 95th percentile or BMI ≥ 35.
- Class 3 obesity is defined as having a BMI ≥ 140% of the 95th percentile or BMI ≥ 40.

Childhood obesity 'tracks' to adolescent and adult obesity, with increased risk of mortality in adulthood.[1]

Context: Childhood obesity in South Africa

Childhood obesity is one of the most serious public health challenges of the 21st century. This largely preventable disease is associated with a higher risk of premature death and disability in adulthood.

In 2012, the South African National Health and Nutrition Examination Survey concluded that 'interventions are needed to address the dual problems of chronic undernutrition (stunting) and the rapidly rising trend of overweight and obesity in children in South Africa'.[2] Over a 10-year period – 1994 to 2004 – the number of overweight children in RSA increased from 1.2% to 13%, and obese children increased from 0.2% to 3.3%.[2] This is congruous with global trends. The increase was noted to be more prevalent in low- and middle-income groups, and in urbanised populations. Researchers attributed the increase to a decline in physical activity and diets rich in refined fats, oils and carbohydrates.

Causes (and correlations) of childhood obesity

More than 90% are primary, and are caused by a mismatch between calorie consumption and energy expenditure.

- Certain dietary habits are associated with obesity – skipping breakfast, eating solids before six months of age, eating while watching TV, fewer family meals. Exclusive breastfeeding in the first six months of life is associated with a lower risk for obesity.
- Diet – fast food, sweetened drinks, less fruit/dairy/vegetables.
- A low level of physical activity – the daily recommendation is 60 minutes of moderate–vigorous physical activity.
- Social and physical environmental factors – urban, ethnicity, socioeconomic status.
- Environmental – prenatal exposure: maternal diabetes mellitus (DM), maternal smoking, high maternal adiposity and birth by caesarean section are associated with childhood obesity.[3]
- Genetic – rare single gene defects affecting the leptin-melanocortin regulating pathway. Syndromes associated with obesity include Prader-Willi, Bardet-Biedl, Alstrom, WAGR (11p deletion syndrome), Down's, Beckwith Wiedemann, MOMO.
- Endocrine – Cushing's syndrome, hypothyroidism, growth hormone deficiency, pseudohypoparathyroidism.
- Medications – steroids, atypical antipsychotics (risperidone, clozapine).
- Children with intellectual impairment and autism spectrum disorder are at increased risk of obesity.

Multisystemic involvement

Obesity is a multisystemic disease, with few organ systems spared.

The prevalence and severity of asthma are increased – some studies show up to 30% of obese children have asthma.[4] Up to 59% have obstructive sleep apnoea (OSA), and risk postoperative respiratory depression and airway obstruction. Important features to elicit on history include snoring, observed apnoea,

Table I: Organ systems and obesity-related complications

Affected organ system	Obesity-related comorbidity
Respiratory[6]	Asthma, bronchial hyperreactivity ↓ lung volumes: ↓FRC ↓vital capacity ↓ forced expiratory volume ↓ diffusion capacity: ↓ alveolar surface:lung volume ratio ↓ total pulmonary compliance: ↓ auxiliary respiratory muscle strength ↑ work of breathing ↑ upper airway obstruction ↑ obstructive sleep apnoea (OSA) (13–59%) ↑ lower airway obstruction ↑ atelectasis → lower reserve, increased tendency to desaturation
Cardiovascular[5]	OSA → RV hypertrophy/strain/cor pulmonale ↑ hypertension ↑ blood volume ↑ stroke volume ↑ cardiac output → LVH
GIT	GORD, hepatic steatosis
Neurological	Idiopathic intracranial hypertension with headaches, tinnitus, visual loss
Orthopaedic	Slipped upper femoral epiphysis (SUFE), Blount's disease (adolescent type), enhanced skeletal maturation
Endocrine	Metabolic syndrome, diabetes mellitus (DM), dyslipidaemia, polycystic ovarian syndrome
Psychological/social	Poor school performance, low self-esteem, anxiety, depression, bullying, social withdrawal[3]

daytime somnolence, poor school performance and a family history of OSA. Children with severe OSA often display increased sensitivity to both the respiratory depressant and analgesic effects of opiates. Cautious dosing with close observation is necessary to achieve a balance between effective analgesia and oversedation/respiratory depression or apnoea.

Obese children have increased heart size, heart mass and chamber size, as well as increased resting stroke volumes and cardiac output compared to their lean counterparts. This is driven by the excess in lean body mass, which is significantly more metabolically active than adipose tissue. These changes are related to the severity and duration of obesity.[5] There are trends of systolic and diastolic dysfunction that are cause for concern, but clinically significant myocardial dysfunction is atypical.

A summary of organ systems involved in the pathophysiology of obesity is displayed in Table I.

Pharmacokinetics: drugs and dosing

Drug dosing can be challenging in this patient population. The distribution of lipophilic drugs is variable – some have an increased volume of distribution (e.g. fentanyl), while others do not. It is recommended that dosing scalars such as ideal body weight and lean body mass should be used, but these can be tedious and confusing. Hydrophilic drugs should generally be dosed on ideal body weight – dosing on total body weight would result in overdosing. When using TIVA/TCI anaesthesia be mindful that offset relies on drug redistribution. Elimination is usually prolonged, except for remifentanil.

Isoflurane maintenance increases the recovery time when compared to sevoflurane and desflurane in obese adults.[4] The same may be true for isoflurane in obese children. Suggested drug dosing is shown in Table II.

Table II: Suggested drug dosing in obese children (Dr.Meera Kurup, personal communication)

Drug	Induction dose	Maintenance dose
Antibiotics	TBW	
Thiopentone	LBW	
Propofol	LBW	TBW
Fentanyl (↑VD)	TBW	Titrate to effect
Remifentanil, alfentanil	LBW	LBW
NMBA	IBW	LBW
Suxamethonium	TBW	
Sugammadex	TBW	LBW
Lignocaine	LBW	
Paracetamol	LBW	
LMW heparin	ABW	
Neostigmine	ABW (max 5 mg)	
Ibuprofen	LBW	
Morphine	IBW	
Phenytoin	TBW (max 2 g)	IBW
Ondansetron	TBW	

TBW – total body weight, IBW – ideal body weight, ABW – adjust body weight, LBW – lean body weight; VD = volume of distribution

Management

Interdisciplinary care is the cornerstone of management.[7] This involves dietician/nutritionist, biokineticist/physiotherapist, psychological support, groups, etc. It is useful for this to occur in a specialist paediatric setting. The lifestyle, diet and attitude of the whole family unit must be considered. A thorough assessment of comorbidities must be undertaken. Transitional care from paediatric to adult services is critically important – adolescents are a very vulnerable population in our system, especially during this period of transition.

- First-line interventions include a structured diet and exercise. Low calorie and very low calorie diets are utilised, but have raised questions around sustainability. Behaviour modification includes setting realistic short- and long-term weight loss goals, keeping a record, identifying high risk situations and avoiding them, rewards, and developing a support network. Exercise increases the chances of long-term weight loss. Only one-third of children sustain weight loss over time with first-line measures.

Medical management

- Orlistat – an enteric lipase inhibitor – prevents the breakdown of fat during the digestive process. It can be used in children > 10 years old. Side-effects lead to poor compliance. The National Institute for Clinical Excellence (NICE) guidelines recommend only if more than 12 years old AND the presence of physical comorbidity/severe psychological comorbidity.[6]
- Metformin – off label use.

Surgical management

When compared to adults, adolescents who undergo bariatric surgery report similar weight loss, but better resolution of weight-related health comorbidities.[1] Surgeries have proven safe in adolescents, resulting in sustainable long-term weight loss and improved comorbidities associated with obesity. Surgery results in remission of type 2 DM, prediabetes, hypertension, dyslipidaemia, kidney dysfunction in 65–95% in some studies.[8] Safety is a key concern, with small studies showing acceptable complication rates.[9] Larger studies and longer follow up is needed to provide more robust data.

Eligibility for bariatric surgery

The NICE guidelines are fairly conservative and have strict criteria for performing bariatric surgery in children (< 18 years).[6] In contrast, the American College of Surgeons is advocating for earlier bariatric surgeries as a preventative measure.

According to the NICE guidelines, bariatric surgery is contra-indicated in cognitively impaired patients, which may preclude behavioural adaptation. Limited studies, however, show promising outcomes. This raises ethical questions around denying patients who cannot consent/assent to these surgeries, which can promote healthier and possibly longer lives.

The three most commonly performed adolescent bariatric procedures are the Roux-en-Y Gastric Bypass (RYGB), vertical sleeve gastrectomy (VSG), and adjustable gastric band (AGB).[8] All procedures are performed laparoscopically, and produce weight loss by one of three mechanisms: malabsorption, restriction (AGB or VSG), and combined (RYGB). The AGB uses a device restricted by the FDA for use only in patients aged 18 years and older. VSG has become the most popular procedure for weight loss in both adults and adolescents. This involves the removal of most (80–90%) of the greater curvature of the stomach, leaving a tubular remnant stomach about 10% to 15% of its original size. RYBG is the most complex, restrictive and malabsorptive. Although it is most effective, it also carries the highest risk. Newer procedures on the horizon offer the potential for less invasive surgeries, which carry less risk.

Adolescents with a BMI greater than or equal to 35 kg/m^2 with severe comorbidity, such as type 2 DM, moderate to severe OSA, benign intracranial hypertension, or nonalcoholic steatohepatitis, are considered candidates. Those with a BMI greater than or equal to 40 kg/m^2 and less severe comorbidities have also been considered candidates for bariatric surgery. In general, previous guidelines have suggested that patients should attain Tanner stage IV or 95% of linear growth (based on bone age) prior to undergoing bariatric surgery. However, there is no evidence to suggest that Tanner staging and linear growth should be used as exclusion criteria. Vertical growth may even improve post bariatric surgery.

Obese children are at higher risk of complications due to co-morbidities than those who develop obesity in adulthood. Advocates for early surgery promote the shift from weight/age-based criteria to comorbidity-based criteria, which may result in the prevention of morbidity and premature death.

Concerns for anaesthesia

- Procedural sedation and analgesia – certain procedures may be more challenging due to body habitus. Increased respiratory adverse events have been associated with more sedation failures and inability to complete procedures.
- General anaesthesia – these children are at higher anaesthetic risk. Vigilance should be exercised, and appropriate pre-operative counselling should occur.
- Preoperative workup should include cardiology review, endo-crinology assessment, sleep study and psychology evaluation where indicated.

Preoperative concerns and planning

- These patients encounter a lot of stigma and bias. Remain non-judgemental and make every effort to preserve dignity.
- Patients with syndromes require full assessment of the involved organ systems.
- Investigations include a preoperative fasting glucose, which may detect undiagnosed DM. Check blood pressure. Where cardiac disease is suspected/likely, an ECG and echocardiography may be indicated.
- Sleep studies may be necessary to diagnose and determine the severity of OSA, and to guide management and optimisation preoperatively.
- Patients post-bariatric surgery are at high risk for vitamin A, D and ferritin deficiencies, as well as deficiencies in micronutrients B_1, B_{12} and folic acid. Assess for complications of deficiency and optimise where possible.
- Anxiety may require premedication. An alpha agonist (clonidine/dexmedetomidine) or NMDA receptor antagonist (ketamine) is preferred.

Planning

- Standard fasting guidelines apply. There is no evidence of higher residual gastric volumes.
- Special operating tables may be required.
- Surgery may be more technically challenging, with the potential for increased surgical complications and increased bleeding. Plan and counsel accordingly.
- Lifting/moving/positioning patients – do not put staff at risk for injury.

Intraoperative concerns: The ABCDEG approach

A: Airway, analgesia and awareness

Airway

- Be prepared for a potentially difficult intubation – equipment and experienced anaesthetist available. Videolaryngoscopy is routinely used in some centres.
- Positioning helps: 'ramp' + augmented sniff position useful. Head up 25°.
- Increased risk for desaturation perioperatively. Preoxygenate with 3 minutes of normal tidal volume breathing.[4]
- Increased difficulty with bag mask ventilation. Mask ventilate with PEEP 10 cm H_2O (prevents atelectasis).
- The combination of OSA and ↑ BMI increases the incidence of laryngospasm by a factor of 4.
- Choose LMA according to total body weight.[4]
- Consider providing oxygenation via nasal cannulae during intubation attempts. Some consider LMA insertion while optimising for intubation.
- A surgical rescue airway may be potentially difficult due to obscured landmarks.
- Deflate the stomach with nasogastric suction where necessary.

Analgesia

- There is increased sensitivity to opioids. Patients may only require one-third to one-fifth of the dose for sufficient analgesia. Low-opiate anaesthetic technique, with the proviso that good analgesia is ensured. Exercise caution with opiates, but it is almost impossible to avoid.
- Regional anaesthesia is strongly recommended, including the use of catheter techniques. Visualising muscles and fascial planes may be challenging.[10]

Awareness

- Obese patients are disproportionately at risk for awareness, predominantly during induction. The recommendation is to give an additional induction agent if there is a delay in commencing effective maintenance anaesthesia.[11]
- Recommend depth of anaesthesia monitoring if TIVA/TCI anaesthetic technique.

B: Breathing/respiratory

- ↑ Perioperative respiratory adverse events (PRAE).
- ↑ Sensitivity to opiates (apnoea).
- Ventilation strategy may require adjustment to compensate for ↑ chest wall resistance.
- Supine and head down positions are tolerated poorly.

C: Vascular access

- IV access may be challenging. The use of ultrasound is recommended.

C: Cardiac

- Be cognisant of subclinical pulmonary hypertension and RV strain, which could lead to right ventricular failure.
- Anaesthetic management would be dictated by cardiac pathology and reserve.

D: DVT and dosing

- Prevention of venous thromboembolism with pharmaceutical and non-pharmaceutical strategies. This includes optimal analgesia to enable early mobilisation.
- Depth of anaesthesia monitoring is recommended.
- Neuromuscular paralysis monitoring is recommended.

E: Environment and ergonomics

- Environment: patients are prone to hypothermia – monitor, prevent and manage accordingly.
- Ergonomics: restrain to prevent from falling off table with certain positions. Supine and head down positions are poorly tolerated. Pressure care is essential, and pressure points should be regularly reviewed.

G: Glucose.

- If diabetic, expedite surgery to minimise fasting. Follow institutional protocols for perioperative glucose and insulin management, discuss with endocrinologist, monitor blood glucose.

Postoperative concerns: early and late

- Obesity is not an exclusion criteria for day case surgery. All patients must be treated on an individual basis. Consider whether comorbidities are optimised, and good (opiate free) analgesia can be provided safely. Patients on home CPAP must use their devices postoperatively. The postoperative destination should be carefully considered. Not all children need to be in a monitored environment postoperatively. Patients with severe OSA should be in a high care setting with continuous O_2 saturation monitoring.
- These patients have an increased length of stay in recovery[4] and increased unplanned admission.
- Nurse non-supine, preferably in the recovery position.
- Consider the use of nasopharyngeal airway, CPAP or BI-PAP with close overnight monitoring.
- Patients are at risk for poor pain control due to opiate-sparing techniques. Opiate analgesia via patient-controlled analgesic (PCA) techniques can be used safely. Regional anaesthesia

with catheters, and the use of additives to prolong action (e.g. alpha agonists) are encouraged and anecdotally opiates via PCA are required more frequently in children than in adults in order to achieve good pain control.

- Post-bariatric surgery: Long-term vitamin and micronutrient deficiencies shown – vit D, A, ferritin, B_{12}. Ongoing psychological support may be required if certain conditions pre-exist. Increased risk-taking behaviours, suicidal ideation, sexual activity, alcohol. Reproductive health planning – adolescent girls undergoing bariatric surgery have higher risk for pregnancy than peers.

In summary, obesity in children is increasing and of concern to the anaesthetist. Obesity is a multisystemic disease that carries increased perioperative morbidity, and careful preoperative evaluation is essential to planning. Evidence-based interventions should be implemented to mitigate risk and facilitate good outcomes. Bariatric surgery is potentially a useful intervention to prevent and treat obesity and its complications, although timing, indications and exclusion criteria remain controversial. Further study is warranted. Public health interventions should be aimed at raising awareness of the problem, and an interdisciplinary approach to curbing this epidemic.

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