Anesthetic Challenges of Obesity:

Planning for the Worst While Providing the Best

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INTRODUCTION

Obesity, according to the National Institutes of Health, is a major health problem with clearly established consequences, including increased risks of coronary artery disease, hypertension, dyslipidemia, diabetes mellitus, gall bladder disease, degenerative joint disease, obstructive sleep apnea (OSA), thromboembolic events, reduced wound healing, and socioeconomic and psychosocial impairment.[1] The varying classifications of obesity are all based on a patient's body mass index (BMI).[2,3] (Table 1)

The BMI itself is not the only determinant of the increased morbidity and mortality in the obese. Central obesity, as described by men with waist circumferences greater than 40 inches or women with waist circumferences greater than 35 inches, poses a higher risk of diabetes, dyslipidemia, hypertension, and cardiovascular disease than pear-shaped, peripherally concentrated adiposity. Obesity, its complications, and its treatments impact the anesthesiologist tremendously. Whenever a morbidly obese patient undergoes bariatric (weight loss surgery) or non-bariatric surgery, the physiological and mechanical changes of obesity must be considered.

PHYSIOLOGICAL CHANGES OF OBESITY

AIRWAY CHANGES

The multiple airway changes due to obesity are the first and foremost concern of the anesthesiologist. Obese patients routinely have an increased neck circumference, and dimensions greater than 17 inches in men or 16 inches in women are good prognosticators of undiagnosed obstructive sleep apnea.[4] The increase in soft tissue surrounding the upper airway and the lack of any anterior or lateral bony support of the nasopharynx, oropharynx, and hypopharynx exacerbate this obstruction. This is particularly evident in anesthetized patients during the critical times of induction and emergence of anesthesia. Extra facial adiposity can also make mask ventilation difficult, if not impossible. A beard complicates this issue and we sometimes ask patients to shave if there is no recent documented airway management by an anesthesia

Table 1

BMI Classifications and Associated Disease Risks

			Disease Risk* Relative to Normal Weight and Waist Circumference	
Commonly Used Terms	**Classifiication by NIH2/WHO3**	**BMI (kg/m2)**	**Men ≤102 cm (40 in) Women ≤88 cm (35 in)**	**Men > 102 cm (40 in) Women > 88 cm (35 in)**
Underweight	Underweight	< 18.5	–	–
Normal weight	Normal	18.5 - 24.9	–	–
Overweight	Overweight/Pre-obese	25.0 - 29.9	Increased	High
Obesity	Obesity Class I	30.0 - 34.9	High	Very High
Morbid Obesity	Obesity Class II	35.0 - 39.9	Very High	Very High
Extreme Obesity	Obesity Class III	40.0 +	Extremely High	Extremely High
Super Obesity	Obesity Class III	>55	Extremely High	Extremely High

*Disease risk for type 2 diabetes, hypertension and CVD. Modified by KRD from: [2]NIH National Heart Lung and Blood Institute (NHLBI) (2000) and [3]Diet, Nutrition and the Prevention of Chronic Diseases WHO (2002).

team. An obese patient can also exhibit a large tongue and a decrease in mandibular and cervical mobility. These factors alone, or in combination, can make intubating the obese patient extremely challenging. Because the obese patient is always considered to have a difficult airway, precautions are taken to place the patient in a "sniffing" position, also known as HELP (Head Elevated, Laryngoscopy Position).[5] (Figure 1)

Figure 1. A morbidly obese patient will be in position for direct laryngoscopy when an imaginary horizontal line can be drawn from the sternal notch to the external auditory meatus. To achieve this, the upper body and head should be significantly elevated with pillows, blankets, or towels. Reproduced from Airway Cam Video Series, Volume 3: Advanced Airway Imaging and Laryngoscopy Techniques, published by Airway Cam Technologies, Inc., Wayne, Pa.

This position not only aids in ventilation but also places the sternal notch and external auditory meatus in an imaginary horizontal line facilitating intubation. In addition to using this position, the anesthesiologist uses multiple other strategies for airway management based on the American Society of Anesthesiologists' Difficult Airway Algorithm.[6] Careful planning and execution of airway management are essential duties of the anesthesia team as the potential to lose a patient's airway always exists in any surgical case.

Airway changes in this population are also of concern outside the operative arena.[7] Since bariatric surgical patients have a 39-71% incidence of obstructive sleep apnea, we established a questionnaire for the Pre-Anesthesia Clinic (PAC) to predict a surgical patient's risk for obstructive sleep apnea and need for further evaluation by a cardiologist and pulmonologist. Patients opting for bariatric corrective surgery and those with Class 3 morbid obesity (BMI>40) and super obesity (BMI>55) for any surgery are automatically referred to a pulmonologist for pre-operative evaluation.

We also use guidelines for post-operative monitoring and initial disposition of obese patients based on a scoring system designed to estimate the peri-operative risk of complications. Ideally this determination is made prior to the day of surgery, but if this fails to occur, then the anesthesiologist and surgeon together may elect presumptive management based on clinical criteria, or may delay surgery to allow time for further evaluation of the problem.

Three major factors we examine include the severity of sleep apnea, the type of surgery, and the anticipated need for post-operative opioids. We determine the total OSA score by adding the score from the first criterion to the higher of the last two criteria. This score is adjusted slightly based upon any intra or post-operative problems and home support capabilities such as familiarity with CPAP and its use. To be a potential outpatient surgical candidate, a patient needs a score no greater than 4 out of 6. Though such patients may be at increased perioperative risk from obstructive sleep apnea, they can usually be discharged to home or to the routine ward depending on the clinical risk evaluation. Patients with a score of 5 out of 6 could be at significant risk for complications and should be considered for direct observation in monitored beds rather than the routine ward. This is based, once again, on clinical circumstances.

Patients with scores of 6 out of 6 are routinely monitored in a direct observation area with telemetry monitoring. There is consensus among many experts that simple oxygen saturation monitoring in an isolated room on a ward is not sufficient in these patients. Observational units, but not necessarily ICU's, with RN: patient ratios of 1:3-4 are needed along with frequent visual observation and EKG, noninvasive blood pressure and telemetry oxygen saturation monitors. Although we currently only use this protocol for obstructive sleep apnea patients undergoing total joint replacements, we may extend this program to other patients if it proves beneficial.

RESPIRATORY CHANGES

Obesity also has significant detrimental effects on the respiratory system. Obesity causes a proportional increase in O2 consumption and CO2 production secondary to fat metabolism. There is also a reduction in chest wall compliance even in the occasional patient with intrinsically normal lung compliance, with evidence of restrictive lung disease as proven by a vital capacity <75% of predicted. The reduced vital capacity,

functional residual capacity, and forced expiratory volume at 1 second, together with increased closing capacity, leads to increased shunting. All of the changes then lead to chronic hypoxia, hyperventilation, and a low to normal CO2 level.

The introduction of anesthesia exacerbates these conditions because obese patients desaturate quickly and are prone to increased atelectasis. Atelectasis starts with preoxygenation and continues long after extubation. Postoperative atelectasis can result in hypoxemia, increased work of breathing, increased reintubation rate, increased infections, and all the complications that stem from these problems. To prevent and manage atelectasis and hypoxia, pre-oxygenation of patients with 100% FIO2 with CPAP, intraoperative PEEP, and reverse Trendelenberg positioning are effective modalities. Increasing respiratory rate and or tidal volumes, however, do not lead to improvements in oxygenation.[8]

CARDIOVASCULAR CHANGES

Cardiovascular changes in obese patients are numerous and play a significant role in their management.[9] Cardiac output increases 0.1L/minute for every kg of adipose tissue which leads to increased preload and afterload in the obese patient. Approximately 50% of morbidly obese patients have moderate hypertension. The incidence of coronary artery disease in morbidly obese patients is doubled as compared to the non-obese population. Metabolic conditions, including decreased levels of nitric oxide and adiponectin (an anti-atherogen), along with increased sympathetic tone, lead to increased levels of angiotensin II and C- reactive protein. This culminates in an increased risk of atherosclerosis. Structural heart problems such as left ventricular hypertrophy (LVH) are also increased due to the increased levels of leptin which directly stimulate synthesis of catecholamines and hypertrophy of cardiomyocytes.[10]

Medications taken for weight loss contribute to cardiovascular changes as well. Sibutramine, which inhibits reuptake of norepinephrine, serotonin and dopamine without depleting neural synapses of catecholamines, causes a transient dose related increase in systolic and diastolic blood pressure by a mean of 2-4 mmHg and a small increase in heart rate by a mean of 3-5 beats per minute.[11] Orlistat, by comparison, has a greater potential for physiologic changes. Its multiple effects include blocking the digestion and absorption of dietary fat by binding lipases in the digestive tract, and decreasing the absorption of fat soluble vitamins (A, D, E and K) in 5- 15% of patients, thereby increasing warfarin's effect.[12,13] Although a cause and effect relationship has not definitely been proven, Orlistat has been blamed for aggravated hypertension in patients with previously treated hypertension and in normotensive patients. Obesity is also an independent risk factor for venothromboembolic events which are accentuated in the perioperative period. All of these changes increase the complexity of managing the obese patient's hemodynamic state.

PHARMACOLOGICAL CHANGES

Obesity vastly affects drug pharmacokinetics. Highly lipophilic drugs have a larger volume of distribution (V_D) and a longer elimination half-life. Routine anesthetic drugs such as benzodiazepines, barbiturates and narcotics, such as fentanyl, require initial bolus dosing based on total body weight (TBW), but maintenance dosing based upon ideal body weight (IBW). Certain lipophilic drugs, such as digoxin, procainamide and remifentanil, are exceptions to this rule and have a normal V_D. Other drugs, such as the paralytics rocuronium and vecuronium, are dosed according to IBW. (Table 2)

Table 2: Weight-based Dosing of Common IV Anesthetic Drugs *Dosing parameter is bolus loading dose unless indicated otherwise. IBW= Ideal Body Weight, TBW= Total Body Weight, VD= Volume of Distribution. Modified from: Ogunnaike, B.O. et al. Anesth Analg. 2002:95(6):1793-1805.

GASTROINTESTINAL, RENAL, HEPATIC AND IMMUNOLOGICAL CHANGES

Obese patients present with other derangements of important physiologic functions. The additional abdominal pressure from adipose tissue can result in an increased risk of diaphragmatic hernia as well as an increased risk of aspiration pneumonitis. Insulin resistance, as well as elevated cholesterol, triglycerides, and liver enzymes are also common. Potential fluid and electrolyte imbalances resulting from extreme dieting, and laxative and diuretic use and abuse often occur. Obesity produces a low-grade, chronic inflammatory state in which white adipose tissue and adipose tissue derived macrophages secrete "adipokines" and cytokines, such as tumor necrosis factor –[alpha], interleukin (IL) -1 and IL-6 which are important in healing and stress responses.[15] Interestingly, the Obesity Paradox

Table 2

Weight-based Dosing of Common IV Anesthetic Drugs[4]

Drug	Dosing	Comments
Propofol	IBW Maintenance: TBW	Systemic clearance and VD at steady-state correlates well with TBW. High affinity for excess fat and well perfused organs. High hepatic extraction and conjugation relates to TBW.
Thiopental	TBW	Increased VD, blood volume, cardiac output and muscle mass. Increased absolute dose. Prolonged duration of action.
Midazolam	TBW Maintenence: IBW	Central VD increases in line with body weight. Increased absolute dose. Prolonged sedation because larger initial doses are needed to achieve adequate serum concentrations.
Succinylcholine	TBW	Plasma cholinesterase activity increases in proportion to body weight, necessitating an increased absolute dose.
Vecuronium	IBW	Recovery may be delayed if given according to TBW because of increased VD and impaired hepatic clearance.
Rocuronium	IBW	Faster onset and longer duration of action. Pharmacokinetics and pharmacodynamics are not altered in obese patients.
Atacurium/Cisatracurium	TBW	Absolute clearance, VD, and elimination half-life do not change. Unchanged dose per unit body weight without prolongation of recovery because of organ independent elimination.
Fentanyl	TBW	Increased VD and elimination half-time, which correlates positively with the severity of obesity.
Sufentanil	TBW Maintenance: IBW	Distributes as extensively in excess body mass as in lean tissues. Dose should account for total body mass. Infusion at IBW due to increased elimination half-time in obese.
Remifentanil	IBW	Systemic clearance and VD corrected per kilogram of TBW- significantly smaller in the obese. Pharmacokinetics are similar in obese and nonobese patients. Age and lean body mass should be considered for dosing.

*Dosing parameter is bolus loading dose unless indicated otherwise. IBW= Ideal Body Weight, TBW= Total Body Weight, VD= Volume of Distribution. Modified from: Ogunnaike, B.O. et al. Anesth Analg. 2002:95(6):1793-1805.

is a theory which suggests that patients with normal weight up to class II obesity may have a lower risk of complications compared to their underweight or more overweight counterparts because they have sufficient nutritional reserve and a more efficient metabolic state so that they are "primed" to mount the appropriate inflammatory and immune response to the stress of surgery.[16] The study, however, is limited in its findings as the patients in a particular BMI class were not necessarily comparable in terms of major independent risk factors for postoperative complications and death. Also, there was inadequate follow-up of the patients beyond 30 days.

MECHANICAL CHALLENGES OF OBESITY

PATIENT TRANSFER

Simply moving patients from one bed to another can be a challenging task. Patient transfer systems such as the Airpal® and the Airpal RAMP™ (Rapid Airway Management Positioner) allow two providers to move almost any sized patient easily on an inflatable air mattress. We utilize these devices in both the operating theatre and on the floors. This lowers both the number of attendees required to help and the healthcare costs related to injuries for the staff. Motorized lifts, found in several of the ICU rooms and on the bariatric floor, are very beneficial for elevating class III obese patients. Placing the obese patient prone or in a lateral position for back or thoracic cases is still problematic; therefore, "lift teams," or those providers with training in safely moving these patients, assist in this process. These teams are also responsible for moving patients requiring decubitus care or pulmonary toileting.

POSITIONING

Nerve injuries, particularly ulnar neuropathies, are a major concern for anesthesiologists. Adiposity in an immobilized patient lying supine on an operating room table can place enough pressure on nerves to cause potentially permanent sensory or motor loss. Adequate padding of ulnar nerves, securing legs to prevent femoral and sciatic injuries and utilizing "bean bags" for patients in an inclined position are often a must. Each operative case, as well as each patient, requires unique methods of positioning that constantly challenge the anesthesiologist.

EQUIPMENT

Caring for obese patients often requires specialized or altered equipment. From Skytron™ operating room tables designed to hold up to 1200 pounds when flat and 800 pounds when articulated, to 68" operating room doorways, much effort, expense and thought goes into taking care of the bariatric patient. Blood pressure cuffs often are placed in the lower arm because the upper arm adiposity may not be conducive to automated blood pressure monitoring. Articulating fiberoptic bronchoscopes and video laryngoscopes, such as the Glidescope,™ frequently are used to secure the bariatric patient's airway. Anesthesiologists must also be prepared to utilize cricothyroidotomy kits in extreme emergencies. But, the equipment changes are not only needed for anesthesia personnel, but for surgeons as well. Certain surgical interventions require longer instruments, thicker sutures, and wired sternal cables. Lancaster General Health developed a bariatric protocol designed to help care for any obese inpatient, outpatient, or visitor who may need medical services. Reinforced restroom facilities, furniture, and oversized patient gowns are just a few of the pieces of equipment required to care for patients outside of the operating room.

CONCLUSION

Obesity has become an epidemic in our society. These patients place incredible demands on the health system's time and resources, and we care for more and more each day. This reality requires the anesthesia team, as well as the entire hospital community, to be ever more diligent in the care we provide. It is our duty and our privilege to offer the best possible medical care.

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