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**Ruslan Kuts, Michael Dubilet, Dmitry Natanel,
Dmitry Frank, Alexander Zlotnik**

OBESE PATIENTS: ANESTHETIC CHALLENGES

*Department of Anesthesiology and Critical Care,
Soroka University Medical Center,*

Ben-Gurion University of the Negev, Faculty of Health Sciences, Beer Sheva, Israel

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Руслан Куц, Михаил Дубилет, Дмитрий Натанель, Дмитрий Франк, Александр Злотник

ТУЧНЫЕ ПАЦИЕНТЫ: АНЕСТЕЗИОЛОГИЧЕСКИЕ ПРОБЛЕМЫ

В эпоху всемирной эпидемии ожирения люди с избыточной массой тела обычно становятся пациентами анестезиолога. Анатомическое распределение лишнего жира в организме приводит к многочисленным патофизиологическим последствиям, особенно от этого страдает сердечно-легочная система. Данные изменения могут непосредственно влиять на периоперационный курс, поэтому должны быть оценены. Ожирение связано с многочисленными сопутствующими заболеваниями, в связи с этим особое внимание нужно уделить тщательному изучению истории болезни пациента и физическому осмотру его до операции.

В этой статье рассматривается вопрос об обеспечении безопасной анестезии страдающему ожирением пациенту. Также обсуждаются физиологические эффекты ожирения и важные предоперационные, интраоперационные и послеоперационные проблемы.

Ключевые слова: ожирение, анестезия, патофизиология.

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In the age of the worldwide obesity epidemic, the obese patient is commonly encountered by the anesthesiologist. The anatomical distribution of increased body fat has numerous pathophysiologic consequences, especially as it pertains to the cardiopulmonary system. These changes may directly impact the perioperative course and must be appreciated. Obesity is associated with numerous co-morbidities, and special attention must be made to obtaining a thorough history and physical examina-

tion prior to surgery. In this chapter, we review important consideration for providing safe anesthesia to the obese patient. The physiologic effects of obesity are discussed, as well as important preoperative, intraoperative, and postoperative concerns.

Key words: obesity, anesthetic, pathophysiology.

I. Impact of Obesity on Physiology

Respiratory System

Obesity is associated with several alterations in respiratory mechanics and gas exchange, which is thought to result from the increased elastic load created by excess weight on the thorax and abdomen [1]. Obese patients exhibit an increased ventilation demand and work of breathing, and total oxygen consumption and carbon dioxide production are increased, even at rest [3]. Respiratory muscle insufficiency results in increased respiratory rate with decreased tidal volumes, which leads to the formation of peripheral atelectasis. Changes in lung volumes include decreased functional residual capacity (FRC) expiratory reserve volume (ERV), forced vital capacity (FVC), total lung capacity (TLC), increased respiratory muscle insufficiency, and peripheral atelectasis [2; 4]. This excess weight and reduced lung volumes results in a reduced respiratory system compliance and an increase in airway resistance [5]. These changes in respiration all contribute to a ventilation-perfusion mismatch, which worsens when patients are in the supine position, particularly when under general anesthesia. After substantial weight loss, there is an improvement of gas exchange and increased arterial oxygenation [3].

Cardiovascular System

Obesity is associated with an increase in blood volume, primarily to perfuse the extra adipose tissue [6]. Systemic blood flow is also increased by up to 2 to 3 mL/100 g of adipose tissue. The increased blood flow is largely distributed to fat depots, and with the exception of renal and splanchnic vascular beds, blood flow to individual organs is largely unchanged. Pulmonary blood volume increases parallel to the extent of body fat. Increases in stroke volume and ventricular dilatation result in an increased cardiac output by 20 to 30 mL/kg of excess body fat. This results in an increased work of the heart and elevations in systolic and diastolic blood pressures. Obese patients are prone to cardiovascular disease because adipose tissue releases various bioactive mediators that result in inflammation, abnormal lipids, and insulin resistance. The obese patient may be particularly prone to left ventricular failure during rapid fluid administration during surgery, primarily due to the negative inotropic effects of anesthetic agents or pulmonary hypertension induced by hypoxia or hypercapnia [7]. Obese patients may also be prone to cardiac dysrhythmias due to fatty infiltration of the cardiac conduction system.

Endocrine System

Obesity is directly associated with numerous hormonal abnormalities, and many are reversible with weight reduction [8]. Although obese and non-obese individuals often have a similar hypothalamic-pituitary-thyroid (HPT) profile [8; 9], subclinical hypothyroidism is observed in up to 25% of obese patients [10]. Even small changes in resting energy expenditure may result in significant weight gain, and thus these patients may benefit from thyroid hormone replacement [9]. Weight reduction leads to a long-term decrease

in peripheral thyroid hormones but not in TSH [11]. Obese patients generally exhibit increased sympathetic nervous system activity, reflected by increased norepinephrine levels. However, catecholamine production is suppressed by glucocorticoids, and the relative hypercortisolemia in obesity may be related to the observed decreased levels of epinephrine. Furthermore, the epinephrine response to various stimuli, such as surgery, is decreased [8]. Resting growth hormone levels and growth hormone response are decreased in obesity, which returns to normal with weight loss [9]. Obesity is also known to be associated with a resistance of peripheral fatty tissues to insulin, resulting in a type II diabetes mellitus and increased cardiovascular disease [12].

Gastrointestinal System

Obesity results in several physiological impairments in gastrointestinal and hepatic function. Obesity is known to be associated with increased gastric volume and acidity and delayed gastric emptying time [7]. There is a significant association between increasing BMI and gastroesophageal reflux symptoms, which resolves with weight reduction [13]. There is a relatively high prevalence of nonalcoholic fatty liver disease, hepatic inflammation, and cirrhosis in patients with obesity, and liver disease should be investigated in patients scheduled for surgery [14]. Even in patients without liver disease, elevations in liver enzymes are common, which decrease to normal levels with weight reduction [15].

Renal System

Obesity is associated with increased systemic arterial pressure, renal plasma flow and glomerular filtration rate, which is thought to contribute to the development of glomerular disease, leading to nephrotic syndrome and renal failure [16]. The obese patient's kidney shares many of the functional abnormalities observed in diabetic patients, such as renal vasodilation, which makes it susceptible to damage [17]. These effects have been shown to be reversed with weight loss, which may prevent the development of obesity-related glomerulonephropathy. Furthermore, obesity results in activation of the rennin-angiotensin and sympathetic systems, resulting in increased sodium reabsorption. This in turn leads to a loss of nephron function, further increased arterial pressure, and renal injury [18].

II. Preoperative Evaluation

Co-morbid Conditions and Considerations

Several studies have demonstrated that the increased risk of perioperative complications for obese patients are likely related to other concomitant comorbidities, and not the obesity per se [19; 20]. Similarly, the presence and severity of comorbidities are more predictive of perioperative complications than the degree of obesity [21]. As such, careful preoperative evaluation, including an extensive and detailed history and physical examination, is imperative to identify comorbid conditions and to medically optimize the patient prior to elective surgery. Up to 72% of obese patients presenting for elective surgery report at least one concomitant disease, most commonly arterial hypertension, chronic gastritis, diabetes mellitus [21; 22]. Many obese patients presenting for surgery have the constellation of clinical findings consistent with metabolic syndrome, including central obesity, hypertension, insulin resistance, or insulin resistance or impaired glucose tolerance. Taken together, it is thought that the physiologic and metabolic derangements associated with metabolic syndrome are associated with an increased risk of morbidity and mortality compared with the sum of each individual components [23].

The presence of respiratory and cardiac disease, for which the risk is directly proportional to the degree of obesity [4], deserves special consideration because they may result in severe perioperative morbidity and mortality. Obstructive sleep apnea (OSA) and obesity-hypoventilation syndrome (OHS) are extremely common in the obese population. Most morbidly obese surgical patients have not had a polysomnographic study [24], and thus the perceived prevalence may be greatly underappreciated by the clinician. OSA and OHS are associated with chronic complications including cardiac arrhythmias, pulmonary hypertension, cor-pulmonale, systemic hypertension, coronary artery disease (CAD), congestive heart failure (CHF), polycythemia, and stroke [25–27]. Patients should be asked about daytime somnolence, nocturnal gasping for air, and witnessed snoring habits or episodes of apnea. OSA is especially prevalent in obese patients with a short, thick neck, but should be suspected in all surgical patients preoperatively [28]. Those who exhibit signs of OSA and OHS may warrant further evaluation with polysomnography or nocturnal oximetry prior to surgery, though some advocate for routine polysomnography of all morbidly obese patients prior to surgery [30]. Studies have demonstrated that obese patients may be at increased risk for the development of several other acute and chronic respiratory diseases, including asthma, primary pulmonary hypertension (PPH), chronic bronchitis, community-acquired pneumonia, and venous thromboembolism (VTE) [30].

Obesity-related changes in cardiac hemodynamics may alter left ventricular structure and function, which may result in heart failure. Obesity is associated with an increase in blood volume and cardiac output, which results in ventricular dilatation, hypertrophy, and increased wall stress. Although the true prevalence of coronary artery disease (CAD) in obese patients is unknown, obesity is recognized as an independent risk factor for CAD. Furthermore, diagnosed or occult CAD is known to greatly increase perioperative risk [4]. Symptoms of cardiac disease may be nonspecific in the obese patient, and many bariatric patients have limited mobility due to several factors including osteoarthritis, lower extremity edema and wounds, prolonged immobility, or real cardiopulmonary disease. Nonetheless, severely obese patients with poor functional capacity should be evaluated carefully. Exertional chest pain or dyspnea, lower extremity edema, or recent changes in exercise tolerance, may be indicative of present or worsening coronary disease, and should always be inquired during the preoperative visit.

Extensive preoperative laboratory tests generally have a low incidence of yielding abnormal results (< 10%) and very rarely influence patient management. It is therefore recommended that within 6 months of elective surgery, routine laboratory tests should include measurements of hematocrit, glucose, creatinine, and blood urea nitrogen. More extensive testing, including chest X-rays, pulmonary function tests, coagulation studies, and cardiac stress tests are generally not recommended for low risk patients unless otherwise indicated by comorbidities, according to the American Society of Anesthesiologists (ASA) practice advisory on pre-anesthesia evaluation. The challenge for the clinician is to identify which patients are at increased perioperative risk, and who may benefit from more extensive testing prior to surgery. An electrocardiogram (ECG) is reasonable for patients with at least 1 risk factor for coronary disease or poor exercise tolerance. Functional capacity, symptoms of cardiovascular disease, and an analysis of the patient's cardiac risk factors will help determine whether a stress test should be used to evaluate for occult ischemic heart disease. A chest X-ray may be indicated to evaluate for undiagnosed heart failure in severely obese patients, and in patients with known or suspected OHS, a baseline arterial blood gas analysis may be useful.

Obese patients present with a short, thick neck, large tongue and redundant fatty tissue externally on the chest and neck, and internally on the oropharynx, which has historically been thought to obstruct access to the upper airway during tracheal intubation. Although there is much literature on the subject, the conclusions are often conflicting. Some authors seem to advocate that increased BMI is a risk factor for difficult tracheal intubation, while others argue that there is often no correlation between absolute obesity or BMI and the degree of intubation difficulty, provided that the patient is carefully positioned prior to induction of general anesthesia. Obesity per se has generally not been reliably demonstrated to be an independent risk factor of difficult direct laryngoscopy when other predictors of difficult intubation, such as Mallampati classification, thyromental distance, and neck range of motion, are normal. Although some studies have demonstrated that tracheal intubation becomes more difficult with increasing BM, other studies have demonstrated that even the super obese (BMI > 50 kg/m²) are no more difficult to intubate than the obese or morbidly obese. A careful preoperative airway examination is an important part of the presurgical evaluation of obese patients, and several physical exam findings may alert the clinician to a potential difficult intubation. The Mallampati classification, which uses visible structures in the oropharynx to predict a difficult intubation, has been an integral component of the routine airway exam since it was first described in 1985. Although it has been shown to have significant inter-observer bias, and lack sensitivity and sepecificity, a Mallampati score of 3 or 4 has been shown to significantly be associated with difficult tracheal intubation in obese patients. A thyromental distance less than 6 cm has been shown to predict 75% of difficult laryngoscopies in the general surgical population. Although some studies suggest that a short thyromental distance may predict a difficult tracheal intubation in obese patients [49], this has not been reliably described. Neither reduced inter-incisor gap nor mandibular recession was found to be predictable risk factors for difficult tracheal intubation in obese patients. Neck circumference greater than 43 cm at the level of the thyroid cartilage has been shown to be associated with an increased risk of difficult intubation, and may be useful to evaluate during the preoperative assessment. As neck circumference increases, the probability of a difficult intubation exponentially increases. At 40 cm, the probability of a difficult intubation is approximately 5%, but increases to approximately 35% at 60 cm. Although some studies have suggested that OSA may be associated with difficult tracheal intubation, other prospective observational studies failed to demonstrate this association. A history of difficult intubation or ventilation during a previous surgery is useful in etermining preoperative risk of difficult intubation, and should be inquired about.

III. Intraoperative Management

Intraoperative Monitoring

There are no data that demonstrate that routine invasive hemodynamic monitoring improves safety and outcomes in the morbidly obese patient. Rather, the decision for invasive monitoring, including intra-arterial and central venous pressure monitoring, should be based on patient comorbidities. It should be noted that the shape of the patients upper arm may preclude proper placement of a noninvasive blood pressure cuff, and alternative sites, including the forearm may be safely used. As it may be difficult to obtain adequate peripheral venous access in the morbidly obese patient, the establish-

ment of central venous access may be necessary. However, it should be noted that placing a central venous line may be technically challenging in the morbidly obese patient. Ultrasound guidance is recommended for placement of central venous lines, and may also be helpful in the placement of arterial and peripheral venous lines. If muscle relaxants are used, it is recommended that a neuromuscular monitor be used to guide dosing and reversal. Excess fat overlying the nerves may make surface electrodes inaccurate, so needle electrodes are recommended.

Pre-induction and Induction

Obesity is known to result in a decrease FRC, decreased ERV, increased oxygen consumption, peripheral atelectasis, and an increased incidence of obstructive sleep apnea. These characteristics contribute to potential difficulties in mask ventilation, and more rapid oxygen desaturations compared with leaner patients. The clinician should know how to safely manage both the anticipated and unanticipated difficult airway, and should be familiar with the ASA's Difficult Airway Algorithm. Prior to induction of general anesthesia, the clinician should formulate a clear plan to safely intubate the morbidly obese patient. Special attention should be made to the patient's physical examination and predicted level of difficulty with tracheal intubation, the suspected risk of aspiration and need for rapid sequence induction (RSI), the presence of a cervical spine collar, as well as hemodynamic stability and other clinical factors. Special care should be made to properly position the patient, and emergency backup equipment should always be readily available. If difficulties in establishing an airway are anticipated, additional help may be requested prior to induction. Premedication with sedatives are generally advised against in the obese patient, as respiratory depression and upper airway obstruction is common. If the patient is very anxious, a small amount of midazolam (1–2 mg intravenously) may be administered. If a sedative agent was administered, close monitoring of the patient is warranted. For patients considered at risk for aspiration, administration of an H₂-blocker (i. e. cimetidine 300 mg or ranitidine 100 mg intravenously) should be considered, as well as 30 ml of an oral antacid before induction of anesthesia. Prior to induction for tracheal intubation, attention should be paid to properly positioning the patient to provide the longest tolerated period of apnea and improve the laryngoscopic view. The use of a ramp to elevate the head, neck, and shoulders until the external auditory meatus and the sternal notch are horizontally aligned, has been reliably demonstrated to improve the laryngoscopic view during the tracheal intubation of obese patients. Folded towels and blankets, pillows, or pre-manufactured elevation pillows have all been successfully described to create such a ramp. A linear relationship appears to exist between the degree of obesity and the benefits of the "ramped" position. Likewise, positioning the bed in a 30° reverse Trendelenburg configuration has been shown to improve the alveolar-to-arterial oxygen gradient, increase ventilatory compliance, and reduce peak and plateau airway pressures compared with the supine position.

Morbidly obese patients tend to desaturate rapidly because of a decreased FRC secondary to cephalad diaphragmatic displacement and increased oxygen consumption, and adequate preoxygenation of these patients is of obvious vital importance. Pre-oxygenation is more efficient in a 25° head up or sitting position, which increases FRC and oxygen tension. During pre-oxygenation, the application of positive end-expiratory pressure (PEEP) prolongs the safe apnea period by 50% and results in improvements in arterial oxygen tension, due to prevention of atelectasis formation and recruitment of collapsed

alveoli. A PEEP of 10 cm H₂O was shown to be superior to 5cm H₂O or no PEEP. Similarly, intraoperative esaturations due to atelectasis may be treated with alveolar recruitment maneuver (35–55 cm H₂O for 6 seconds), followed by the application of 5–10 cm H₂O PEEP. Prior to induction, maintaining the patient in 30° reverse-Trendelenburg position greatly prolongs the safe apnea period compared with both the supine and 30° sitting positions. These methods allow for a greater safe apnea time to allow the anesthesiologist to adequately secure the airway. There is controversy regarding whether muscle relaxants should be administered in the morbidly obese patient prior to intubation. Some clinicians prefer to maintain spontaneous ventilation in the obese patient, although this may provide suboptimal conditions for intubation. Alternatively, while providing neuromuscular blockade may improve laryngoscopic conditions, the patient may desaturate significantly before adequate spontaneous ventilation resumes in patients who prove to be difficult mask ventilation and intubation. Even when succinylcholine is the muscle relaxant used for RSI, patients will likely become hypoxic long before resumption of spontaneous ventilation. Tracheal intubation may be further made difficult after several failed intubation attempts due to laryngeal trauma and subsequent bleeding or edema. For obese patients with known OSA, slow induction while maintaining spontaneous ventilation is advised because failure to maintain a patent airway during a strong negative inspiratory force can induce pulmonary edema.

Incommon practice, obese patients have often been considered to be at increased risk for gastric aspiration on induction of general anesthesia. Although conflicting data exists regarding the gastric volume and pH, and barrier pressure in the morbidly obese patient, several studies have demonstrated that the presence of obesity alone does not necessarily increase the risk of gastric aspiration. Furthermore, RSI requires that a muscle relaxation be administered prior verification that the patient can be effectively mask ventilated, and results in additional risks should ventilation and intubation prove difficult. Thus, in the absence of other factors that may increase the risk of aspiration, including gastroesophageal reflux, diabetes mellitus, pregnancy, gastrointestinal disorders, and emergency surgery, RSI with cricoid pressure may not be necessary for every obese patient. The risks and benefits of RSI should be carefully considered in each individual patient. Regardless, some authors recommend that all morbidly obese patients receive aspiration prophylaxis, even in the absence of other risk factors. It is also generally recommended to insert a large bore nasal or oral gastric tube to decompress the stomach prior to surgical manipulation. It is now becoming more common to encounter patients returning for repeated bariatric surgery. Due to the physiologic and anatomical changes following bariatric surgery, the risk of aspiration appears to be increased, therefore, RSI is advised in these patients, even when the bariatric surgery has resulted in significant weight loss. Obesity is a known predictor of difficult mask ventilation, and this should be kept in mind when preparing a plan of induction and intubation. It seems obvious that a supraglottic airway device and fiberoptic bronchoscope should be immediately available during induction of general anesthesia. Both the standard laryngeal mask airway (LMA) and LMA supreme has been demonstrated to be useful in obese patients that are predicted of difficult mask ventilation. The LMA may not be ideal in patients at risk for aspiration of gastric contents, though, and the patient may require a secondary technique for tracheal intubation. The intubating LMA was shown to be more easily used in obese patients than in lean patients.

Over the past decade, videolaryngoscopy has been increasingly utilized in airway management, and has largely been considered a useful alternative to direct laryngoscopy when

a difficult intubation is anticipated. Various types of videolaryngoscopes are commercially available and widely used, and many have been successfully demonstrated for the intubation of obese patients. The use of videolaryngoscopic-guided intubation with the Glidescope, Storz V-Mac, and McGrath scopes have been highly successful in the obese patient with a predicted difficult airway. Compared with direct laryngoscopy, videolaryngoscopy has been shown to significantly improve the laryngoscopic view in almost one third of morbidly obese patients in whom direct laryngoscopy was difficult. Therefore, it seems reasonable that these devices be readily available when intubating the morbidly obese patient. Routine awake fiberoptic intubation (AFOI) of morbidly obese patients is the preferred airway management technique employed by many clinicians, although it is associated with greater costs, time, and patient discomfort. Furthermore, routine AFOI has not been validated in all morbidly obese patients, and is likely not necessary for most patients. However, AFOI may be particularly useful when the patient has a history of being a difficult mask ventilation or intubation. In obese patients with OSA, some authors have advised that AFOI may be appropriate in patients in whom mandible advancement, neck extension, and mouth opening may be difficult. The widespread use of videolaryngoscopy and availability of supraglottic “rescue” devices has greatly reduced the prevalence of AFOI in the morbidly obese patients. For patients in whom an unanticipated difficult airway has resulted in a “cannot intubate, cannot ventilate” scenario, the morbidly obese patient deserves special concern because of the propensity to rapidly desaturate. In the obese patient, the Combitube has been used to successfully provide emergent oxygenation, and in the pre-hospital and hospital setting, the intubating LMA have been used as a rescue to facilitate tracheal intubation. Establishing a surgical airway emergently may be technically more difficult in the morbidly obese patient, and is often due to discrepancies between the size and angulation of standard tracheostomy tubes and distance between the skin and trachea of obese patients. The minor complication rate of tracheostomy placement is estimated at 25% in the morbidly obese patient, with potentially life-threatening complication rates approaching 10%. Complication rates may be much higher when the tracheostomy is performed emergently in a patient that cannot be ventilated or intubated. Ultrasound guidance may helpful to guide tracheostomy placement in this context.

Pharmacologic Considerations

The use of short-acting medications is advised to ensure rapid recovery in the postoperative period, and reduce postoperative respiratory complications. The dose of induction agents and muscle relaxants must be carefully considered, as the protein binding, distribution of drugs, and elimination are different in obese patients compared with lean patients. The volume of distribution (VD) of highly lipophilic drugs, including many synthetic opioids, are increased in the obese patient due to increased body fat. Less lipophilic drugs have little or no change in VD with obesity. Although albumin levels appear unchanged in obese patients, an increase in other plasma proteins results in an increased free fraction of basic drugs. Thus, the effects of drugs are often unpredictable, with significant inter-patient variation. The appropriate dosage is generally recognized as being somewhere between the ideal body weight (IBW) and total body weight (TBW), and the dose of the medication should be titrated to effect. For medications in which limited pharmacokinetic and pharmacodynamic data exists, it is recommended that the starting dose be closer to the patient’s lean body mass (about 120% of IBW), and titrated to effect.

Doses of cephalosporins for surgical prophylaxis should be increased in the obese population. The pharmacokinetics of muscle relaxants are minimally affected by obesity, and their dosage should be based on IBW. Pancuronium has been associated with an increase in post-operative respiratory complications in obese patients, and many clinicians prefer the intermediate-acting muscle relaxants rocuronium or vecuronium. Some authors have demonstrated a more predictable behavior of cisatracurium compared with rocuronium and vecuronium, and therefore advocate for its use. Pseudocholinesterase activity increases linearly with weight, and the dose of succinylcholine should therefore be based on TBW. At a dose of 0.04 mg/kg neostigmine for neuromuscular blockade, adequate reversal is four times slower in the obese patient than in the lean patient. Halogenated vapor anesthetics are metabolized to a greater extent in obese patients compared with lean patients, and combining low-dose halogenated anesthetics with a regional technique may reduce the build-up of toxic metabolites. Some authors advocate that desflurane be used for anesthesia maintenance in the morbidly obese patient, because of its rapid and consistent recovery profile. However, sevoflurane has also been safely used in obese patients as well, and studies have demonstrated that with careful titration, the differences in wakeup times between sevoflurane and desflurane in the obese patients were negligible. The analgesic properties and rapid recovery with nitrous oxide make its use tempting in obese patients, however increases in oxygen demand limit its use.

Dexmedetomidine, a highly selective α_2 -adrenergic agonist with hypnotic, sedative, sympatholytic, and analgesic properties, has been increasingly popular for use in morbidly obese patients. Its lack of any significant respiratory depression makes dexmedetomidine especially desirable for the obese patient, and its use has been shown to decrease narcotic use, antiemetic therapy, and length of stay in the postanesthesia care unit (PACU).

Positioning

Obese patients present unique concerns with regards to safe positioning for surgery. Standard operating tables may not be large enough to accommodate patients over 205 kg, but operating tables capable of holding up to 455 kg are available. Morbidly obese patients, especially super-obese and diabetic patients, are at increased risk of compression nerve damage and bed sores during surgery compared with lean patients⁸⁶. Special care should be taken to protect pressure areas during surgery to minimize these risks. Brachial plexus and sciatic nerve palsies, femoral nerve palsies, and ulnar neuropathy have all been described in the obese patient. Despite careful positioning and appropriate padding, nerve injury still may result in the morbidly obese patient during surgery. These injuries often resolve with time.

IV. Postoperative concerns and management

Emergence and Extubation

The presence and severity of comorbidities in the obese patient should be considered during emergence from general anesthesia, and particularly when cardiac disease is present, a “smooth” emergence is important to maintain hemodynamic stability. External stimuli during stage II anesthesia, including vigorous suctioning, external noise, nasal or oral airway insertion, or manipulation of the head and neck, should be minimized to avoid bucking and acute increases in blood pressure. The use of anti-hypertensive medications, especially short-acting beta blockers, are particularly useful in this setting.

Extubation of the morbidly obese patient, like intubation, should be performed with extreme caution. This is especially true in cases where the intubation was difficult and reintubation may prove even more difficult. Furthermore, obese patients with OSA are at an increased risk for airway obstruction after extubation. When approaching the time for extubation, patients should be placed in the reverse Trendelenburg position to improve FRC and optimize ventilation, reduce the risk of reflux, and access the airway in the event that reintubation is needed.

Patients should remain intubated until their muscle relaxation is fully reversed (confirmed with a neuromuscular monitor), they demonstrated that they are awake and follow commands, with adequate spontaneous ventilation. Morbidly obese patients have been shown to be at increased risk for postextubation stridor, and a cuff leak test should be utilized to identify laryngeal edema. Laryngeal ultrasound has also been advocated to evaluate peri-cuff airflow and accurately predict postextubation stridor, although this has yet to be specifically studied in the obese population. Extubation over an airway exchange catheter may be useful for patients who are a difficult intubation, in the event that they need to be emergently reintubated.

As on induction, patients are prone to obstruction and rapid desaturation after extubation due to a decrease in FRC and increased metabolic oxygen consumption. As such, continuous pulse oximetry monitoring is essential in the early postoperative period. Immediately after extubation, a patent airway must be confirmed and maintained, and the patient should be continuously stimulated and encouraged to breathe deeply. Patients should be maintained in the reverse-Trendelenburg or sitting position to increase FRC and facilitate breathing. Continuous oxygen by nasal cannula or facemask should be utilized judiciously as indicated. Patients in whom difficulties in mask ventilation or intubation was encountered intraoperatively should be counseled after the patient fully regains consciousness. The patient should be informed as to the nature of the difficulty, and it should be discussed how this knowledge is relevant to future airway management. Furthermore, a detailed record of the problem and subsequent solution should be maintained in the patient's chart.

The Postoperative Period

Obese patients are at increased risk for postoperative complications in both the early and late postoperative period. In the first 24 hours after extubation, morbidly obese patients are at risk for mechanical obstruction and significant atelectasis, and often experience frequent desaturations despite the use of supplemental oxygen. Short-term physiotherapy and incentive spirometry in the PACU can contribute to the early recovery of lung function. The sitting or lateral position is advantageous over the supine position, and should be maintained during the postoperative period. The PACU should be equipped with emergency airway equipment and medications, and staff trained in airway management should be readily available. Noninvasive ventilation with BiPAP or CPAP has been advocated in the morbidly obese patient after surgery, and has been shown to reduce mechanical obstruction and atelectasis, and may reduce the rates of postoperative pneumonia. Patients have been shown to benefit most from the positive effects of CPAP when it is administered immediately after extubation. There should be discussion between the anesthesiologist, surgeon, and respiratory therapist prior to its initiation, and if used, should be administered by specially trained nurses and respiratory therapists. Patients with OSA are encouraged to bring their own CPAP machines to the hospital because these masks usually provide the best fit, and it is recommended that patients should be placed on CPAP right after extubation if possible.

Morbid obesity is a major independent risk factor for sudden death due to postoperative pulmonary embolism. Due to the increased risk of VTE in morbidly obese patients, several prophylactic measures are employed. Pneumatic compression devices are applied prior to anesthesia induction. Postoperative, and often preoperative, deep vein thrombosis (DVT) prophylaxis is initiated. Enoxaparin 40 mg twice daily was shown to be more effective in preventing DVT than 30 mg twice daily, with no increased risk of bleeding. Perhaps the most important prevention of DVT is early ambulation, which should be greatly encouraged. Early physical therapy can be useful to provide extra motivation for early ambulation. Especially in obese patients with cardiac disease, in whom tachycardia and hypertension are best avoided, optimal pain control is very important. Morbidly obese patients are at increased risk of opioid-induced respiratory depression due to mechanical airway obstruction and poor ventilatory response to the hypoxemia and hypercapnia. Therefore, the use of non-opioid analgesia is recommended whenever appropriate. Epidural analgesia may be appropriate for obese patients undergoing open procedures, who are at the greatest risk for atelectasis and may require high-dose opioids. However, neuraxial anesthesia may be technically challenging in the morbidly obese patient due to difficulties in identifying key landmarks and in patient positioning. Even epidural opioids should be used with caution, as a delayed respiratory depression and even respiratory arrest in the obese patient has been described. Alternatively, a local-anesthetic epidural solution may be used, and is recommended by the ASA when concomitant OSA is suspected or confirmed. Opioid-based patient controlled analgesia (PCA) has been used safely in morbidly obese patients after surgery, and its initial dose should be based on lean body mass. A continuous opioid infusion mode via PCA should be avoided because of the risks of respiratory depression. Continuous visual and electronic monitoring of these patients is advisable in the early postoperative period, and patients should be encouraged to do frequent deep breathing and incentive spirometry. The clinician should consider many variables, including BMI, presence and degree of comorbidities, and anticipated postoperative opioid requirements when deciding whether patients will require intensive care unit-level observation after surgery. Furthermore, the decision should be based on the presence of any intraoperative events, as well as events that occur in the first 2 hours in the postoperative period, where they patient has the highest likelihood of having a complication. After abdominal surgery in obese patients at risk for aspiration of gastric contents, post-operative nasogastric drainage may be useful.

V. Special Considerations

Laparoscopy

Although laparoscopy can be safely performed on the obese patient, the anesthesiologist should be cognizant of the systemic changes that accompany the pneumoperitoneum. These changes are pronounced in obese patients, particularly when in the Trendelenburg position. With increased intraabdominal pressure (IAP), systemic vascular resistance proportionally increases. At an IAP < 10 mmHg, a reduction in splanchnic blood flow results in an increase in venous return, with subsequent increases in cardiac output and arterial blood pressure. At an IAP > 20 mmHg, however, there is compression of the inferior vena cava and decreased venous return, resulting in a decreased cardiac output and arterial blood pressure. During peritoneal insufflation, obese patients have a higher IAP in the supine and Trendelenburg position compared with lean patients. Increased IAP from pneumoperitoneum exerts force on the diaphragm, restrictions in diaphragm

mobility and a reduction in vital capacity. This can lead to an uneven distribution of ventilation in the lung, and mismatches in ventilation and perfusion, hypoxia, and hypercarbia can result. Decreases in arterial oxygenation during laparoscopy was demonstrated to be proportional to weight, and could not be improved by increasing the tidal volume or respiratory rate. Absorption of carbon dioxide can worsen the hypercarbia and acidosis, which can be offset by hyperventilation. Catastrophic complications, including gas embolism, pneumothorax, and mediastinal emphysema should always be kept in mind during laparoscopic procedures.

Obesity and Regional Anesthesia

Regional anesthesia should always be considered, as potential difficult intubations are avoided. Regional anesthesia techniques may be technically challenging, as anatomical landmarks may be difficult to indentify. Often, longer needles may be required to perform a regional block. It is highly recommended that ultrasound guidance be used when performing regional blocks. Furthermore, the spread of local anesthetic is related to BMI, and the epidural and subarachnoid spaces are decreased. Therefore, it is recommended that for both epidural and intrathecal blocks, the local anesthetic dose be reduced by 20–25%.

Ключові слова: ожиріння, анестезія, патофізіологія.

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