Perioperative and Intensive Care Management of the Obese Surgical Patient

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3.1 Introduction

The number of overweight patients undergoing major surgical procedures and subsequently admitted to the intensive care unit (ICU) is dramatically increasing [1]. Since these patients are affected by several systemic pathophysiological alterations and comorbidities (Table 3.1), their management in both the operating room and ICU may present several challenges for the clinicians.

Major surgery, general anesthesia and mechanical ventilation (MV) can *per se* contribute to the development of lung and systemic organ failure. However, a reliable tool to assess the perioperative and ICU risk for obese patients has not been yet defined [2].

3.2 Perioperative Management of the Obese Patient

3.2.1 Preoperative Evaluation

Preoperative evaluation of obese patients should take into consideration the assessment of the patient's baseline functional state and comorbidities as well as the complexity of surgery. The vast majority of obese patients undergoing surgery are relatively healthy and their risk is similar to that of normal weight patients [3].

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Table 3.1 More frequent systemic pathophysiological alterations in the obese patient

Respiratory system
↑ Oro-pharyngeal adiposity → upper airway obstruction
↓ Compliance ($C_{chest\ wall} > C_{lung}$) → ↓ compliance during MV
↑ Chest wall elastance
↑ Total respiratory resistance (>during sleep)
↑ Work of breathing
↓ FRC and EELV → atelectasis
Small airway collapse → auto-PEEP, ↑ risk of wheezing
V/Q mismatch → atelectasis
↑ O_2 consumption → ↓ O_2 reserve
↑ Production and ↓ excretion rate of CO_2
↑ Risk of airway hyper-reactivity, OSA, OHS, overlap syndrome
Endocrinological system
↑ Insulin-resistance
↓ Glucose tolerance
Metabolic syndrome
Cardiovascular system
↑ Blood pressure, cardiac output, cardiac workload
Left ventricular hypertrophy → ↑ diastolic and systolic dysfunction
↑ Risk of arrhythmias (> atrial fibrillation)
↑ QT interval
↑ Risk of ischemic heart disease and heart failure
↑ Pulmonary artery pressure → pulmonary hypertension
↓ Right ventricular ejection fraction → cor pulmonale
Prothrombotic state → ↑ risk of myocardial infarction, stroke, VTE
Other
Functional and anatomical hiatus hernia
Altered lipid metabolism
↓ Micronutrients
↓ Gut motility
↑ Risk of visceral fat (>♂)
Drug-specific changes in volume of distribution

$C_{chest\ wall}$ chest wall compliance, C_{lung} lung compliance, *FRC* functional residual capacity, *EELV* end-expiratory lung volume, *PEEP* positive end expiratory pressure, *V/Q* ventilation/perfusion, *OSA* obstructive sleep apnea, *OHS* obesity hypoventilation syndrome

However, several risk factors in obese patients have been correlated to an increased incidence of perioperative complications and mortality, including: central obesity, metabolic syndrome [1], hypertension, BMI >50 kg/m^2, male sex, age >45 years, risk factors for pulmonary embolism, overlap syndrome, obesity hypoventilation syndrome (OHS) and poor compliance to continuous positive airway pressure (CPAP) [4].

Difficult intubation and mask ventilation occur more frequently in obese compared to non-obese patients, and a thorough assessment of these risks should be performed. Risk factors for difficult ventilation include increasing BMI, age above 50 years and history of snoring. The main predictors for difficult intubation are almost the same as for the non-obese patients; other specific factors include neck circumference, the severity of obstructive sleep apnea (OSA) and OHS, pre-tracheal soft tissue thickness and high BMI [5, 6].

Table 3.2 Preoperative evaluation in the obese patient

Basic exams	Advanced exams
Respiratory assessment	
Exclusion of OSA and OHS (snoring, apneic episodes, frequent night arousals) Cephalometric measurements SpO_2 Arterial blood gas analysis (lactate, PaO_2, HCO_3^-)	Chest radiography STOP-Bang questionnaire Apnea hypopnea index High-resolution nocturnal oximeter Polysomnography Spirometry PAP therapy titration
Cardiovascular assessment	
Signs of heart failure (ankle edema, high jugular venous pressure) Blood pressure Blood sample (full blood count, hemostasis tests, etc.) Electrocardiogram	Troponins and BNP Echocardiogram Exercise tolerance
Endocrinological assessment	
Strict glycemic control BMI Waist/hip ratio	HbA1c
Renal assessment	
Creatinine, electrolytes, urea	BUN/creatinine ratio, GFR Urine tests

OSA obstructive sleep apnea, *OHS* obesity hypoventilation syndrome, SpO_2 saturation of peripheral oxygen, PaO_2 arterial oxygen partial pressure, HCO_3^- hydrogencarbonate ion, *PAP* positive airway pressure, *BNP* B-type natriuretic peptide, *HbA1c* glycated hemoglobin, *BMI* body mass index, *BUN* blood urea nitrogen, *GFR* glomerular filtration rate

OSA is frequently undiagnosed (and untreated) until an acute-on-chronic respiratory failure occurs, which during the perioperative period can be exacerbated by the administration of sedatives, opioids and prolonged supine position [7, 8]. Preoperative identification of high-risk patients for respiratory complications is crucial as these patients can benefit from preoperative positive airway pressure (PAP) therapy and eventually ICU admission [6, 8].

The main key points of preoperative evaluations in obese patients are summarized in Table 3.2 [3, 6]. In the case of emergency surgery, the previous described assessments are not always feasible; therefore, the preoperative risk should be evaluated mainly through a quick clinical examination, and arterial blood gas samples to assess blood gas exchanges and serum lactate [3].

3.2.2 Intraoperative Management

3.2.2.1 Regional Anesthesia

Regional anesthesia presents several advantages, especially in obese patients, including minimal airway manipulation, avoidance of cardiopulmonary depression due to anesthetic drugs, reduced opioid requirements and postoperative nausea and vomiting. Unfortunately, loco-regional procedures in obese patients are often

Table 3.3 Intraoperative management of the obese patient: key points

Induction of anesthesia
Consider the use of loco-regional anesthesia
For general anesthesia, better easily reversible and short acting anesthetic drugs
Anesthetic and neuromuscular blocking agents dose-titrated on effect
Prolonged pre-oxygenation (FiO_2 up to 100%, if necessary)
Ramped position or 30° reverse Trendelenburg position
nPAP support, in selected patients
Ready availability of difficult airway management devices
Awake intubation, in selected patients
Supraglottic device as rescue in difficult ventilation or intubation or first line in selected patients
Maintenance of anesthesia
No evidence regarding the best anesthetic strategy to use (propofol versus volatile agents)
Continuous monitoring of sedative and neuromuscular blockade effects
Faster onset and offset of desflurane or sevoflurane compared to isoflurane
Protective ventilation with ↓ Vt (6–8 mL/kg Predicted or Ideal Body Weight), ↓ P_{plat} (<24 cmH_2O), ↓ P_{driv} (<16 cmH_2O)
Use of PEEP and RMs to improve intraoperative oxygenation and compliance
Lowest FiO_2 ensuring satisfactory oxygenation (SpO_2 92–95%)
No data suggesting intraoperative superiority among the different ventilation modes
Emergence from anesthesia
Nerve stimulator to guide neuromuscular blockade reversal
Patient fully awake, with restored airway reflexes
Reverse Trendelenburg position or ramped position, if possible
Immediate post-anesthesia care
Head-up or sitting position
Intensive physiotherapy and incentive spirometry
Early mobilization
Careful fluid management
Opioid-sparing analgesia, if possible
Oxygen therapy to maintain preoperative levels of SpO_2
Early nPAP support, in selected patients (airway pressures <20 cmH_2O)
Extended postoperative prophylaxis for VTE, in selected patients
Frequent glycemic monitoring and delayed reintroduction of diabetic drugs, if necessary
Intensive care support based on comorbidities and surgery

FiO_2 fraction of inspired oxygen, n*PAP* non-invasive positive airway pressure, *Vt* tidal volume, P_{plat} plateau pressure, P_{driv} driving pressure, *PEEP* positive end expiratory pressure, *RMs* recruitment maneuvers, SpO_2 saturation of peripheral oxygen, *VTE* venous thromboembolism

technically challenging and may be ineffective and therefore a plan for airway management and intubation is always recommended [6].

3.2.2.2 General Anesthesia

Each anesthesiological step can be potentially more difficult to perform in obese patients compared to the general population (Table 3.3).

Induction of Anesthesia

Ideal or adjusted body weight is used to calculate initial anesthetic drug doses rather than total body weight. Current kinetic models use to titrate anesthetic agents to site effect that can generate paradoxical concentrations in morbidly obese patients. Therefore, the monitoring of the depth of anesthesia and of the neuromuscular block should be always considered. Caution is required with the use of long-acting drugs, especially opioids [3].

Quick and profound episodes of desaturation are common in obese patients; therefore, prolonged pre-oxygenation in ramped position is suggested to maximize the intrapulmonary oxygen reserve and to increase the safety period of apnea between induction and intubation [2].

In morbidly obese patients or patients with severe OSA, airway obstruction, hypoxemia or acute respiratory failure (ARF), pre-induction with high-flow oxygen with nasal cannula (HFNC) or PAP therapy should be considered [8].

Intubation should always be considered potentially at risk in obese patients and devices for difficult intubation should always be easily available; in particular, videolaryngoscopes have shown to be useful also in obese patients [2].

Supraglottic devices are increasingly used as rescue ventilatory, mainly in difficult ventilation or intubation. The use of supraglottic airway devices as a first line device should be reserved only for highly selected patients undergoing short procedures, when the upper airway is accessible and tracheal intubation quickly feasible [3].

Maintenance of Anesthesia

In obese patients, no evidence is available regarding the best anesthetic strategy to use. Achieving appropriate oxygenation and carbon dioxide levels as well as the choice of the respiratory settings to apply to obese patients during surgery can be challenging because of the previously described respiratory pitfalls [2, 9].

Several ventilatory strategies have been suggested to improve the perioperative outcome of obese patients; lung protective ventilation strategy with low tidal volume (Vt) and the use of positive end expiratory pressure (PEEP) should be considered in the operating room. The use of protective Vt is warranted to avoid high plateau pressure (P_{plat}) and high driving pressure (P_{driv}), even if this can necessitate an increase of the respiratory rate to optimize carbon dioxide levels [10].

The appropriate intraoperative level of PEEP and its effect on postoperative outcome is controversial. Many authors are focusing their research on identifying strategies to set individualized PEEP ($PEEP_{ind}$); however, nowadays the hypothesis that $PEEP_{ind}$ could produce better outcomes has still to be proven. Furthermore, some authors demonstrated that $PEEP_{ind}$ could be significantly higher compared to the routinely used PEEP during anesthesia [11], thus posing the patient at risk for PEEP-related hemodynamic effects [12]. Intraoperative recruitment maneuvers (RMs) can have an important role in atelectasis reduction [13]. It is not clear which is the most efficient RM mode in preventing pulmonary complications [14]; however, it is well known that bag squeezing presents several pitfalls that have to discourage its use in favor of RMs consisting of stepwise transient changes of ventilator settings [15].

In obese patients, there are no data suggesting the superiority in terms of outcome between the different controlled ventilation modes [14]. Pressure support ventilation might be the most beneficial ventilatory mode, as it preserves muscular tone and prevents posterior-basilar atelectasis [2], but it is not often feasible in the intraoperative settings.

Emergence from Anesthesia

During the extubation phase in obese patients, a large number of complications are described. Therefore, an extubation plan should be always put in place (Table 3.3) [16].

3.2.3 Postoperative Management

Obesity predisposes to several postoperative complications, mainly involving the respiratory system [17]. To decrease the risk of complications, there are several postoperative strategies that could be adopted (Table 3.3) [7, 17, 18]. Several studies encourage the use of postoperative PAP therapy in obese patients to improve postoperative outcome [4], mainly in subjects with OHS and/or OSA [2, 8]. To date, there is no evidence supporting the use of a specific patient interface device and ventilation modality in obese patients. Intolerance is reported as a PAP treatment-related complication, while anastomotic leakage does not seem to be connected to the insufflation of PAP [19]. More studies about HFNC are needed before recommending this strategy in the post-extubation phase [2].

Obese patients without major medical comorbidities are managed in the standard post-anesthesia care unit [20]. Indications to ICU admission could be: BMI ≥ 50 kg/m^2, long-acting opioid treatment, OSA or OHS and/or PAP therapy requirements, need for respiratory and cardiac monitoring, difficult glycemic control, intraoperative surgical or anesthetic complications and emergency surgery [3].

3.3 ICU Management of the Obese Surgical Patient

Critically ill obese patients may be at higher risk for acute cardiovascular, pulmonary and renal complications in comparison to healthy-weight patients [18]. Furthermore, obesity is associated with an increased risk of morbidity and death in the general population, but a decrease in mortality has been reported by some authors in patients with septic shock and acute respiratory distress syndrome (ARDS) (obesity paradox). The actual existence and basis for this apparent paradox are still debated [21]. In Table 3.4, the complications and corresponding management of obese patients admitted to ICU post-surgery are summarized [18, 20].

Table 3.4 Main ICU complications of the obese surgical patient and suggestions for reducing the risk of complications

Complications	Suggestions
Respiratory system	
Post-extubation stridor	Sitting/ramping position, post-extubation PAP therapy
Extubation failure	Fully awake patients, opioid-sparing analgesia, sitting/ramped position, PAP therapy, tracheotomy
Ventilator-associated pneumonia, ARDS	Individual-tailored ventilator strategies, lung protective ventilation, post-extubation PAP therapy, light sedation, physiotherapy, prone position, nitric oxide, high-frequency percussive ventilation, jet ventilation, and veno-venous extracorporeal membrane ventilation.
Catheter-related pneumothorax	Ultrasound-guided insertion
Cardiovascular system	
Acute congestive heart failure	Careful fluid management and adequate control of hemodynamic parameters
Myocardial infarction	Close monitoring
Atrial fibrillation	Continuous electrocardiogram-monitoring
Acute cor pulmonale	Adequate respiratory treatment
Thromboembolic diseases	Extended postoperative mechanical and pharmacologic prophylaxis for VTE
Endocrinological system and nutritional state	
Protein malnutrition	Isocaloric high protein diet
↓ Gut motility	Early enteral feeding
Hyperglycemia	Glycemic control, adequate insulin therapy, isocaloric high protein diet
Hypoglycemia	Delay in diabetic drugs reintroduction
Others	
CKD and AKI	Monitoring of renal function
Non-alcoholic steatohepatitis	Monitoring of hepatic function
Fluid retention	Isocaloric high protein diet
Acquired infections	Adequate antibiotic therapy
Catheter-related infections	Early change of catheters
Urinary tract infections	Frequent inspection of urinary catheters, routine urinary exams
Wound healing/skin necrosis	Wound management; hypoperfusion, hypoxia and hyperglycemia therapy
Decubitus ulcers	Specific mattresses, adequate protein intake and early mobilization
Neural injuries	Special beds and lifting devices, padding of pressure points
Multiple organ failure	Tailored monitoring and treatment

ICU intensive care unit, *ARDS* acute respiratory distress syndrome, *PAP* positive airway pressure, *VTE* venous thromboembolism, *CKD* chronic kidney disease, *AKI* acute kidney injury

3.4 Conclusions

Obese patients present several challenges in the perioperative period and in the ICU. Obese patients present a bundle of pathophysiologic changes, with consequent pulmonary and cardiovascular issues, which make them susceptible to several complications. Future studies are warranted to better define the optimal settings of invasive mechanical ventilation, weaning protocols, hemodynamic monitoring and other specific strategies in this cohort of patients.

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