2 Emergency Anesthesia and Resuscitation in the Obese Patient

Rita Cataldo, Ida Di Giacinto, Massimiliano Sorbello, and Flavia Petrini

2.1 Pathophysiological Peculiarities of Anesthesiological Interest in Obese Patients: Preoperative Assessment in Emergency

Obesity is considered an important risk factor for cardiovascular disease, type 2 diabetes mellitus, dyslipidemia, hypertension and respiratory diseases affecting especially pulmonary function. Body mass index (BMI) by itself, though included in the new ASA classification [1], does not provide information about adipose tissue distribution and function, key factors in the onset of comorbidities.

2.1.1 Respiratory Function

One of the causes of respiratory impairment in obese patients is elevation of the diaphragm by the abdominal fat. This results in increased respiratory work related

R. Cataldo
Unit of Anesthesia, Intensive Care and Pain Management, Department of Medicine, Campus Bio-Medico University, Rome, Italy
e-mail: r.cataldo@unicampus.it

I. Di Giacinto
Anesthesiology, Polyvalent Intensive Care and Transplantation Unit, Department of Organ Failure and Transplantation, S. Orsola-Malpighi University Hospital, Bologna, Italy
e-mail: digiacintoida@gmail.com

M. Sorbello
Anesthesia and Intensive Care Unit, Policlinico-Vittorio Emanuele University Hospital, Catania, Italy
e-mail: maxsorbello@gmail.com

F. Petrini (✉)
Department of Perioperative Medicine, Pain Therapy, Rapid Response Systems and Intensive Care, University of Chieti-Pescara and ASL2 Abruzzo, Chieti, Italy
e-mail: flavia.petrini@unich.it

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to the decreased compliance and higher resistance of the airways: an obese patient uses about 15% of his oxygen reserve to breathe as compared to 3% in a lean patient. Obese patients have reduced functional residual capacity (FRC) and therefore a tendency to rapidly develop atelectasis with alteration of the ventilation/perfusion (V/Q) ratio, hypercapnia, increased expiratory resistance, wheezing, tachypnea and, most importantly, rapid desaturation.

These problems are often exacerbated in emergency and cause the respiratory system of the obese to work at its maximum even under standard conditions, with no reserve in the event of a critical situation. The reduced reserve compromises the patient's ability to tolerate respiratory insults such as pneumonia. Furthermore, an obese person has increased airway pressure due to increased airway resistance (heavier chest wall and abdomen, lung base atelectasis). All of these will lead to a reduced oxygen supply, increased respiratory work, and a very short desaturation time at the induction of anesthesia with a short safe apnea time.

2.1.2 Cardiovascular Function

Obesity and the related metabolic syndrome also interfere negatively with the patient's cardiovascular function. The metabolic syndrome makes the patient more susceptible to risk factors for ischemic heart disease. Furthermore, obesity is an inflammatory syndrome that also involves the endothelium, placing the arteries at greater risk of atheromas. Finally, the additional work needed to perfuse the increased body surface can result in progressive ventricular dysfunction. The risk of heart failure is elevated in obese patients, and its genesis is complex and often multifactorial. Ventricular hypertrophy and hypertension lead to a higher systolic workload, which is associated with an increase in circulating blood to perfuse the adipose tissue. As soon as the system gets "out of breath", left ventricular dysfunction sets in, associated with cardiovascular decompensation and heart failure. The obese patient is often affected by coronary disorders and arrhythmias such as atrial fibrillation, which worsen cardiac function especially in emergency conditions (altered volemia, pain, respiratory failure and hypoxia) where preoperative optimization is desirable but impossible.

The pulmonary and cardiovascular systems are so closely connected that alterations in their functioning reinforce each other. In the obese patient, the clinical presentation of "obesity cardiomyopathy" can be exacerbated by the pulmonary hypertension commonly associated with obstructive sleep apnea (OSA) and obesity hypoventilation syndrome (OHS) (sometimes combined in an overlap syndrome) and right ventricular dysfunction.

In patients with specific problems (BMI >50, overlap syndrome, obesity cardiomyopathy), rapid echocardiographic assessment is recommended if time permits, even directly on the operating table or in the emergency department.

2.1.3 Risk of Thromboembolism

Because it induces an inflammatory state, obesity is a risk factor for deep venous thrombosis (DVT) and pulmonary embolism (PE). The risk is increased by trauma, emergency abdominal and pelvic surgery, and hospitalization in the intensive care unit (ICU). Prophylaxis against DVT/PE is mandatory and the use of pharmacological strategies must not exclude active mechanical pressure, which can be started in the operating room (OR). Every therapeutic effort must be made towards early postoperative mobilization. A vena cava filter is not routinely recommended for primary prophylaxis.

2.1.4 Risk of Difficult Airway

Obese patients are also at risk of a difficult airway. Although this does not necessarily mean difficult intubation, problems can arise in the perioperative maintenance of adequate oxygenation. Obese patients may not have an increased risk of difficult intubation *per se* but are likely to present difficulties in face mask and supraglottic airway device (SAD) ventilation in linear relation to their BMI. In the case of a "can't intubate, can't oxygenate" (CICO) scenario, the obese patient's anatomy involves an increased risk of difficult cricothyroidotomy because of problems with landmark identification and pretracheal tissue thickness. Therefore, in emergency surgery even more than elective surgery, it is essential to be prepared for a difficult airway and explore and identify predicting indexes.

Standard difficult airway indexes can be easily and quickly assessed even in an emergency setting if the patient is conscious and cooperative (Mallampati score, neck extension, thyromental distance, interincisor distance, presence or absence of teeth or fixed dentures). In addition, there are specific scores such as neck circumference and waist-to-hip ratio (WHR). Neck circumference should be measured (raising an alert above 41 and 43 cm in female and male patients, respectively) or indirectly assessed (shirt collar size), whereas patients with android (apple-shaped) or gynoid (pear-shaped) obesity can be easily identified. Whenever possible, a STOP-Bang questionnaire is recommended: a score ≥ 5 is highly suggestive of severe OSA, resulting in a higher risk of difficult ventilation and intubation. Especially in such cases (obese patient with metabolic syndrome, high OSA risk, android obesity, increased neck circumference), preparing an adequate airway management strategy (including spontaneous breathing techniques) is of paramount importance. Adequate preoxygenation aiming for an $EtO_2 > 90\%$ with the patient in the ramped position is always imperative; depending on the clinical setting and the time available, positive-pressure ventilation by face mask or a high-flow nasal cannula can be used, taking into account that positive pressure oxygenation is the gold standard in obese patients. Apneic oxygenation during airway instrumentation (the so-called NO-DESAT technique) [2, 3], preferably with a high-flow nasal cannula, should be considered.

2.2 Intraoperative Care

The intraoperative management of the obese patient in an emergency setting presents organizational as well as professional challenges. The skills of the health providers (nurses, anesthesiologists, surgeons) must be complemented by adequate and readily available instrumentation. This means that hospitals must develop appropriate protocols and checklists specifically for the management of obese patients and strongly promote teamwork strategies.

Adequate devices such as surgical tables, stretchers, positioning devices, non-invasive blood pressure (NIBP) cuffs and locoregional anesthesia (LRA) needles are indispensable. Also, compression devices for intraoperative DVT prophylaxis should be adjusted to the size and volume of the obese patient. Computed tomography (CT) and magnetic resonance imaging (MRI) scanners have to be suitable for extra-large patients and an ultrasound (US) scanner must always be available at the bedside.

Venipuncture can be challenging in an emergency; in highly critical situations it may be wise to cannulate a femoral vein with the patient in the "frog-leg position". Access to central veins requires the use of US, as does locating the deep veins of the arm for placement of a peripherally inserted central catheter or midline catheter if easier peripheral approaches are unfeasible.

2.3 Airway Management

2.3.1 Rapid Sequence Induction/Intubation

Rapid sequence induction/intubation (RSII) is not expressly indicated in obese patients but follows the same indications as in the non-obese (full stomach, symptomatic esophageal reflux, pregnancy, diabetes with gastroparesis). Any previous bariatric surgery should be added to the list of indications, as restrictive and malabsorptive techniques favor the reflux or stagnation of fluids in the stomach. The so-called modified RSI (mRSI) includes hemodynamic optimization and abolishes succinylcholine in favor of rocuronium at a dose of 1–1.3 mg/kg calculated on lean body weight (LBW) with neuromuscular block monitoring; Sellick maneuver should be abandoned (if not in presence of clear regurgitation) and ventilating the patient by means of a face mask with low insufflation pressure after adequate preoxygenation up to ETO_2 >90% in the ramped and reverse Trendelenburg position is accepted. Use of an LBW-based propofol bolus in emergency conditions, even if titrated, may result in cardiovascular impairment, which must be prevented by fluid filling (if possible) and/or administration of vasoactive agents. Ketamine, especially in emergencies with cardiovascular impairment, can be a useful clinical alternative.

2.3.2 Strategies

Because the obese patient is at high risk of rapid desaturation, a robust strategy for airway management is essential [4]:

1. use a peri-oxygenation approach, including preoxygenation and apneic oxygenation with a nasal cannula during airway instrumentation (NO-DESAT);
2. decide whether or not to abolish spontaneous breathing and perform awake fiberoptic or videolaryngoscopic intubation;
3. if deciding to abolish spontaneous breathing, consider mRSI;
4. apply "first-pass-success" tracheal intubation, which means that, to maximize the chances of success, the first attempt must be made in the best possible conditions (ramped position; highly experienced anesthetist; use of a videolaryngoscope if present and if the operator is skilled, or a standard laryngoscope with the introducer or stylet premounted on the tracheal tube);
5. in case of intubation failure, switch quickly to SAD or return to mask ventilation;
6. consider cricothyroidotomy regardless of SpO_2 values if it is clear that other strategies are unfeasible. Identify the cricothyroid membrane possibly with the patient awake; a quick US examination before induction might be helpful.

A strategy for safe airway management is incomplete without a plan for safe extubation, whether this is done in the OR or after the patient has been transferred to the post-anesthesia care unit (PACU) or ICU for postoperative care. Extubation, especially in obese patients and even more in the presence of OSA or perioperative respiratory distress, is a high-risk situation because of either the lessened level of attention or unpreparedness. Reversing the neuromuscular block to a TOF ratio ≥0.9, preferably 1, is mandatory. The patient has to be extubated in semi-sitting position fully awake, cooperative and preoxygenated with 100% O_2; use of an airway exchange catheter is advisable if difficult extubation is expected. Adequate and tailored post-extubation respiratory monitoring should be considered in selected patients.

2.4 Drugs in the Emergency Setting

Because of the peculiar pharmacodynamics and pharmacokinetics in obese patients, proper drug dosage is challenging and should be adapted as appropriate to total, ideal, adjusted or lean body weight based on the lipophilic and hydrophilic characteristics of the single molecules. Obese patients may experience awareness during intubation due to the rapid redistribution of the hypnotic, and it is necessary to quickly switch to anesthesia maintenance even in conditions of hemodynamic instability; use of vasoactive agents may be required (Table 2.1).

Choosing short-acting drugs and opioid-sparing strategies, and whenever possible a combination of general anesthesia with regional techniques, should be preferred. Even in an emergency, minimally invasive techniques such as laparoscopy or thoracoscopy, although challenging for operators, result in shorter recovery times after surgery and should be preferred over more invasive procedures.

After induction, it is important to monitor blood glucose levels, which can be altered in critical patients with metabolic syndrome or insulin-dependent diabetes mellitus. Care should also be taken to control body temperature, which can easily drop to critical levels in a patient with a large body surface area. This will

Table 2.1 Drug dosage in obese patients

Drugs	Loading dose	Maintenance dose
Neuromuscular blockers and antagonists		
Succinylcholine	TBW	
Vecuronium	IBW	IBW
Atracurium	LBW	LBW
Rocuronium	LBW	LBW
Sugammadex	TBW	
Neostigmine	ABW	
Sedative-hypnotics		
Benzodiazepine	IBW	IBW
Propofol	LBW	ABW
Thiopental	LBW	IBW
Phenobarbital	TBW	IBW
Ketamine	TBW	IBW
Etomidate	TBW	
Dexmedetomidine		LBW
Analgesics		
Morphine	LBW	
Remifentanil	LBW	
Fentanyl	LBW	
Sufentanil	LBW	
Alfentanil	ABW	
Paracetamol	LBW	
Corticosteroids		
Methylprednisolone	IBW	IBW
Anti-epileptics		
Phenytoin	IBW + [1.33 × (TBW − IBW)]	IBW
Valproic Acid		IBW
Carbamazepine		IBW
β-blockers		
Propranolol	IBW	IBW
Labetalol	IBW	IBW
Metoprolol	IBW	IBW
Esmolol	IBW	IBW
Calcium channel blockers		
Verapamil	TBW	IBW
Diltiazem	TBW	titration
Antiarrhythmics		
Lidocaine	ABW	ABW
Procainamide	IBW	IBW
Amiodarone	IBW	IBW
Digoxin	IBW	IBW
Adenosine	IBW	IBW
Catecholamines		
Dobutamine Dopamine Epinephrine Norepinephrine Phenylephrine Vasopressin Milrinone		There are no clinical studies in the obese patient. According to literature, ABW or IBW could be used to avoid overdoses, titrating the dose as a function of the clinical target ABW in patients ≤120 kg

IBW = *male* h(cm) − 100; *female* h(cm) − 110
LBW = *male* 90 kg; *female* 70 kg
ABW = IBW + 40% TBW
TBW total body weight, *IBW* ideal body weight, *LBW* lean body weight, *ABW* adjusted body weight

compromise outcome, as it increases the risk of postoperative residual curarization, coagulation impairment, dehiscence of anastomosis or surgical wounds, infections and decubitus ulcers.

The obese patient, especially in an emergency setting, is at high risk of postoperative pulmonary complications (PPCs). Their prevention starts with a wise and proper intraoperative management of ventilation. Appropriate levels of PEEP and recruitment maneuvers, if needed, can prevent atelectasis and may help to keep the lungs fully aerated [5].

2.5 Level of Care

The predictive factors for the use of care resources and services in obese patients are poorly defined [6]. More than BMI *per se*, the occurrence and treatment of comorbidities together with the degree of surgical invasiveness determine which level of care is needed. In an emergency, the availability of expert staff and dedicated equipment make it possible to regulate the level of care. Not all obese patients require admission to the ICU. A track-and-trigger system defined through proactive strategies including checklists, handovers and the application of dedicated scores such as National Early Warning Scores (NEWS) allows early recognition of the decline of vital functions in the various care settings [7, 8].

2.6 Non-operating Room Anesthesia (NORA)

Obese patients often undergo emergency interventions; because of the high risks associated with obesity, minimally invasive procedures should be used whenever possible. The patient may be given general anesthesia or procedural sedation in unconventional settings that are often suboptimally equipped, both logistically and in terms of operator skills; this is referred to as non-operating room anesthesia (NORA). To ensure adequate safety conditions, interventional departments where regional anesthesia, moderate or deep sedation and even general anesthesia can be provided must have OR safety standards including cardiovascular and respiratory monitoring, equipment to manage a difficult airway, adequate patient handling systems, and beds that can bear the weight of an obese person [6].

In an emergency setting, identifying a procedure as "minimally invasive" should not be taken to mean "minimally dangerous", especially with regard to anesthesiological procedures, which are sometimes riskier and more difficult to manage than general anesthesia with tracheal intubation in the OR. In fact, the patient may be in critical condition with respiratory failure, OSA or OHS, and may not tolerate the fully supine or prone position necessary for certain procedures, especially if sedative drugs are infused; special care is needed during spontaneous breathing sedation, and $EtCO_2$ monitoring is mandatory. Cardiovascular status may be compromised and require vasoactive support in environments where finding a central vein can be complicated and invasive monitoring sometimes impossible. In such scenarios it is safer to proceed with tracheal intubation and invasive monitoring before starting the procedure than running the risk of performing these difficult maneuvers in an emergency setting.

The message is to not underestimate NORA but rather to consider the high risks it may involve and prevent them by ensuring that the environments where NORA is performed are adequately equipped and managed. Anesthesiological management should tend towards regional anesthesia when possible and towards conscious sedation with drugs of minor impact on the respiratory drive and hemodynamics. The positive role of dexmedetomidine, now also approved in Europe (and Italy) for use in settings other than the ICU, deserves adequate consideration in this context [9].

2.7 Cardiopulmonary Resuscitation

An inevitable consequence of the increased incidence of obesity worldwide is that more obese patients need resuscitation maneuvers for acute illness or trauma.

Resuscitation in the obese poses numerous challenges, including (1) difficulties in airway management, chest compression and venous access; (2) complicated drug management due to obesity-related pharmacokinetic and pharmacodynamic alterations; and (3) obstacles to instrumental diagnosis [10].

In spite of these difficulties a phenomenon known as "obesity paradox" has been described in the literature, characterized by better neurological outcomes after cardiac arrest and better survival in cases of STEMI, NSTEMI, unstable angina and heart failure in obese compared with normal- or low-weight patients [11–14].

Algorithms for cardiopulmonary resuscitation (CPR) in obese adults are the same as in normal-weight adults, with a sequence of 30 compressions at a frequency of 100–120 beats/min and a depth of 5 cm (equal to one-third of the chest depth) alternating with two ventilations. The effectiveness of CPR is determined by early defibrillation and quality chest compressions, which may not be easy to achieve in an obese patient [15].

An obese body type poses problems that are not accounted for in standard situations. For instance, the anterior and posterior thoracic adipose tissue may redistribute the force applied to the chest during cardiac massage, making the compressions more superficial and thus less effective [16]. When lying supine, the patient's abdominal fat may displace the diaphragm cranially, as also happens in pregnant women. In those cases, cardiac massage to the upper half of the sternum is recommended.

In addition, cardiac massage in an obese patient is much more tiring for the operator, with a risk of ineffective chest compressions. Switching operators at less than the standard 2 min recommended by the guidelines can provide a solution. Mechanical chest compression systems (such as LUCAS) cannot be used because they are not designed for obese body types [17].

Although thoracic fat causes high transthoracic impedance, there are no indications regarding the energy to be delivered by the defibrillator in the obese patient, and no correlation between BMI and the success rate of defibrillation at first shock has been reported in the literature. The usual practice is to start directly with higher energy levels (200 J), to be increased if found ineffective. The higher transthoracic impedance can be counteracted using modern biphasic defibrillators; rectilinear biphasic waveforms seem to be more useful for this purpose [14].

In the case of choking, a variation of the Heimlich maneuver with chest thrusts to the center of the sternum should be applied [17].

Finding a venous access might be challenging, time consuming, and requiring numerous attempts. It is therefore essential to use US guidance, the gold standard in the identification of peripheral and central venous access according to the current guidelines. Despite the difficulties inherent in the use of US in the case of abundant subcutaneous fat, it increases the chances of success and reduces time and complications even in crisis situations [18].

2.8 Other Considerations

2.8.1 Diagnostic Imaging

When standard X-rays are used, the patient's mass may prevent the entire body region (e.g. chest and abdomen) from being captured in a single scan. In addition, certain images such as a lateral view of the cervical spine may be difficult to interpret.

CT and MRI examination may be complicated by problems related to the opening diameter of the machine, the weight limit of the table and the limited field of view. This can result in the need for multiple scans, with increased radiation exposure and a risk of motion artifacts.

US has become the standard of care in emergency diagnostics. However, performing an ultrasound examination in an obese patient is technically complex due to the hypoechogenicity of the adipose tissue and the distance between the skin and the target organ. This makes it necessary to use probes with a frequency of 2 MHz, which allow a greater depth to be reached albeit with lower spatial resolution [19].

2.8.2 Patient Transport

Transporting an obese patient can be extremely difficult. Depending on the patient's build and the environmental circumstances, many people may be needed to lift and transfer the patient to and from the ambulance. There are special stretchers and sheets for the transport of heavy weights on the market. Personnel must be adequately trained, and the hospital must have the means and equipment to accommodate and transport severely obese patients.

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