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A Physiological Based Approach of Perioperative Management in Obese Patients

The high-risk non-cardiac surgical population represents a major global healthcare challenge. Recent estimates suggest that 234 million major surgical procedures are performed worldwide each year (Weiser et al. 2008). Complications following major surgery are a leading cause of morbidity and mortality (Head et al. 2008; Jencks et al. 2009). Previous sickness before surgery is second only to cardiovascular disease in terms of associated short-term complications and increased mortality (Head et al. 2008). Obesity is a metabolic disease continuously increasing worldwide (Weiser et al. 2008; Head et al. 2008). Many etiologic factors may be implicated in determining obesity: Genetic, environmental, socioeconomic and individual ones, such as age and sex. Since these patients are characterised by several systemic physiopathological alterations, perioperative management may present some problems, mainly related to respiratory alterations (Shenkman et al. 1993). In this brief review we will discuss:

1 The influence of body mass on respiratory function and on ventilatory management in the perioperative period; and
2 The possible role of intensive care to reduce pulmonary complications and, morbidity in the postoperative period.

How to Calculate Obesity

In clinical practice, several criteria have been proposed to exactly define obesity (Shenkman et al. 1993):
1. Height/weight indexes. The advantage of using these is that one does not have to look up ideal body weight in a table.
2. Calculation of the ratio between the actual and "ideal" weight of the patient. The "ideal" weight in kilograms is computed subtracting 100 (in men) and 105 (in women) from the patient's height in centimetres. A person weighing greater than 120 % of their "ideal" weight may be considered obese, and greater than 200 % of "ideal" weight as a pathologic obese.
3. Calculation of the Body Mass Index (BMI, or Quetelet's index). This index is computed as the ratio between weight, expressed in kilograms, and height squared, expressed in metres.

On the base of BMI, it is possible to divide the population in several classes:
a) Underweight with a BMI (kg/m2) lower than 20;
b) Normal weight with a BMI between 20 and 25;
c) Overweight with a BMI between 25 and 30;
d) Obese with a BMI between 30 and 40; or
e) Morbid obese with a BMI greater than 40 (Weiser et al. 2008).

BMI is commonly used when dealing with obesity, because it is simple to compute and well correlated with the risk of death.

Respiratory Function in the Intra-operative Period

Body mass is an important determinant of respiratory function during anaesthesia and paralysis not only in morbidly but also in moderate obese patients. Since obese patients are starting from a respiratory condition that is already physiologically poor, the effects on the morphological and functional variations of the respiratory system after the induction and maintenance of anaesthesia and paralysis are more pronounced than in normal subjects.

Lung Volumes. The reduction in lung volumes is well associated with the increase in body mass (Shenkman et al. 1993). In morbidly obese patients, the Functional Residual Capacity (FRC) decreases after induction of anaesthesia to approximately 50% of pre-anaesthesia values (Smetana 1999; Reinius et al. 2009). It is now accepted that the main causes of the reduction in FRC during anaesthesia and paralysis can be: a) atelectasis formation and b) blood shift from abdomen to thorax. The occurrence of atelectasis can be due to changes in the shape and motion of the diaphragm, the ribcage, or both of them promoted by the loss of diaphragmatic tone induced by anaesthetics and paralysing agents. With an enhancement of body mass, an increase in intra-abdominal pressure can occur (Pelosi et al. 1998). The increased intra-abdominal pressure is mainly directed toward the most dependent lung regions with a more important cephalad displacement. This results in a decreased movement of the dependent part of the diaphragm, where atelectasis is more likely to occur. This preferential alteration of the diaphragm favours a greater development of atelectasis in the dependent lung regions more than in healthy subjects.

Respiratory Mechanics. The alterations of respiratory mechanics that occur during anaesthesia and paralysis are well related to the body mass. The decrease in compliance of the respiratory system with the increase of body mass is mainly determined by the reduction in lung compliance, rather than in chest wall compliance (Pelosi et al. 1996). Also respiratory resistances are influenced by body mass (Pelosi et al. 1996). The more important factor for the decreased lung compliance and increased resistance is the reduction in FRC, since the intrinsic mechanical characteristics of lung parenchyma – "specific compliance" – and –"specific resistance" are nearly unchanged.

Gas Exchange. Oxygenation decreases with the increase in body mass (Pelosi et al. 1998). In fact, the arterial hypoxaemia, that characterises awake obese patients, is worsened during anaesthesia and paralysis. As previously discussed, the lung bases are underventilated because of airway closure and atelectasis, thus producing pulmonary "shunt" and hypoxaemia. Even in obese patients without hypoventilation syndrome, the physiological dead space is increased compared to normal subjects during anaesthesia.

How to Ventilate Obese Patients

Increased intra-abdominal pressure seems to play a relevant role in the reduction of FRC, which appears to be the prevalent phenomenon, resulting in a decrease of respiratory compliance and oxygenation. This suggests the occurrence of relevant collapse and lung dependent atelectasis.

To approach the respiratory system alterations that occur in these patients, different modalities of ventilation have been proposed:
1. Use of lower inspiratory oxygen fractions to maintain physiologic oxygenation (Rothen et al. 1995);
2. Ventilation using tidal volumes lower than 13 ml/Kg ideal body weight (Bardoczky et al. 1995);
3. Inclusion of large, manually or automatically performed lung inflations (sighs) (Rothen et al. 1993); and
4. Application of a positive end-expiratory pressure (PEEP) after a recruitment manoeuvre (Reinius et al. 2009; Pelosi et al. 1999).

The superiority of one or more of these different ventilatory settings in comparative studies has never been investigated. As a consequence of respiratory modifications induced by general anaesthesia and paralysis, the main aim of mechanical ventilation in obese patients is to "keep the lungs open" during the entire respiratory cycle. This counteracts negative effects induced by the increased body mass and the high intraabdominal pressure (airway closure, atelectasis, impaired respiratory mechanics and oxygenation), which occur in the intraoperative period but that can persist few days in the postoperative period, too. The use of low tidal volumes (and, as a consequence, low alveolar ventilation) with low PEEP levels and high inspired oxygen fraction (FiO2) greater than 0.8 should be avoided since it has been clearly showed that this may lead to the formation of progressive reabsorption atelectasis. The use of continuously high tidal volumes (>13 ml/kg ideal body weight) seems to be ineffective to further improve oxygenation, while it can induce hypocapnia, if respiratory rate is not decreased.

Moreover, the continuous use of high tidal volumes even during anaesthesia can be deleterious on the lung structure and on haemodynamics.

To ventilate a lung showing a tendency to collapse the following must be provided:
1. Inspiratory pressure to open the collapsed lung regions (recruitment pressure);
2. A positive end-expiratory pressure (PEEP) high enough to keep the lung open at end-expiration associated with low tidal volumes; and
3. FiO2 lower than 0.8.

Adequate opening pressure can be obtained applying periodic large, manually performed lung inflations (recruitment manoeuvres) (Reinius et al. 2009). To achieve a transpulmonary pressure enough to reopen collapsed alveoli, airway pressures up to 60 cmH2O are necessary. On the other hand, an application for a relatively short period of time (six seconds) is recommended to avoid possible negative effects on haemodynamics. The recruitment manoeuvre should be performed always only when volemic and haemodynamic stabilisation is reached after induction of anaesthesia and should be repeated every half an hour in absence of PEEP. The role of PEEP in anaesthesia is still controversial. This is likely due to the opposite effects induced by PEEP on oxygenation in different patients. PEEP can resolve atelectasis, if present, and prevent small airways collapse, improving ventilation-perfusion matching and oxygenation. However, increasing PEEP may lead to negative effects on ventilation-perfusion ratio and pulmonary shunt, if alveolar overstretching and cardiac output reduction or redistribution becomes the prevalent phenomena. The final effect on oxygenation of PEEP application depends on the balance between the positive and negative effects in any given patient. We found that applying 10 cmH2O of PEEP during anaesthesia and paralysis induces an oxygenation improvement in morbidly obese patients, but not in average subjects (Pelosi et al. 1999). Moreover, we found that the partitioned Pressure-Volume curves measured at PEEP 0 and 10 cmH2O roughly follow the same pattern in normal subjects, while in obese patients the Pressure-Volume curves at 10 cmH2O PEEP are shifted upward and on the left, suggesting the occurrence of alveolar recruitment. The amount of alveolar recruitment was also related to the improvement of oxygenation.

Thus we believe that morbidly obese patients during general anaesthesia should be ventilated with physiologic tidal volumes (6-10 ml/Kg Ideal Body weight) and a respiratory rate to maintain normocapnia. In addition, an application of 10 cmH2O PEEP after a recruitment manoeuvre associated with a FiO2 between 0.4 and 0.8 are recommended (Reinius et al. 2009). This suggested ventilator setting has been proven to be effective also during bariatric laparoscopic surgery (Valenza et al. 2007; Delay et al. 2008). Further studies are needed to define the optimal levels of PEEP and tidal volume during general anaesthesia in obese patients, for opening up and keeping the lung open, as well as improving oxygenation and respiratory mechanics.

Respiratory Function in the Post-operative Period

Respiratory function is deeply altered in the post-operative period (Pelosi et al. 1997). Both upper abdominal and thoracic surgery can result in a post-operative pulmonary restrictive syndrome. This restriction of pulmonary function may persist for several days, leading to a high incidence of post-operative pulmonary complications such as sputum retention, atelectasis, and bronchopulmonary infection, even in the absence of a previously demonstrable intrinsic lung disease. These complications produce further worsening of pulmonary function and cause secondary hypoxaemia. To reduce post-operative pulmonary complications, different techniques and treatments have been proposed, such as chest physiotherapy, incentive spirometry, and intermittent positive pressure breathing (Fagevik et al. 1997). Some authors have proposed the use of continuous positive airway pressure (CPAP) (Fagevik et al. 2002) or bi-level positive airway pressure (Bi-PAP) administered by non-invasive techniques in the first 24 hours during the post-operative period (Joris et al. 1997).

We believe that CPAP is the easiest method of respiratory assistance compared to ventilation, especially if performed in the ward or in the surgical department. CPAP should be always administered in the postoperative period when the PaO2 / FiO2 ratio falls below 300, and maintained for a prolonged period of time during the day. The use of the helmet instead of the mask can improve the efficacy of the treatment and the comfort of the patient (Morer et al. 2009). The aim is to give ventilatory support in order to more rapidly restore lung volumes to the pre-operative values, improving oxygenation and reducing work of breathing. Moreover, for several days after surgery, patients should remain in semi-recumbent position (30°- 45°), to reduce the abdominal pressure on the diaphragm. These data suggest that a more physiological approach to respiratory treatment in the postoperative period could be useful in improving respiratory outcome. The role of a preventive admission of morbidly obese patients undergoing abdominal surgery in intermediate or general intensive care units (ICUs) during the post-operative period is not yet defined. Some advantages of ICUs admission are a gentler weaning from the ventilator, to easily perform chest physiotherapy and non-invasive ventilatory treatment, an optimised fluid treatment, a more careful pain control. On the other hand, there are increased costs and more difficulties related to organising the time schedule of operations.

Conclusion

The important alterations in the respiratory function of morbidly obese patients in the perioperative period may play a significant role in determining pulmonary complications in the intra and post-operative period. In morbidly obese patients, adequate ventilatory settings aimed at keep the lungs open during surgery and in the postoperative period (associated with ICU admission) may help to reduce the incidence of postoperative pulmonary complications.

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