Different Treatment Strategies in Reducing the Incidence of Major Post-Operative Pulmonary Complications in Morbidly Obese Patients Undergoing Bariatric Surgery

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ABSTRACT

Laparoscopic bariatric surgery is a well-established operation that is frequently carried out in the reverse Trendelenburg position. It is widely known that postoperative pulmonary complications (PPCs), particularly postoperative respiratory failure, significantly increase postoperative length of hospital stay as well as perioperative morbidity and death. Various methods were employed to reduce post-operative problems. Therefore, the purpose of this review was to outline various methods for reducing post-operative problems following bariatric surgery.

Keywords: Obesity, bariatric surgery, postoperative pulmonary complications.

Background

Obesity considerably impairs respiratory performance by reducing lung volume, especially the functional residual capacity (FRC) and expiratory reserve volume (ERV). Strength and resistance may decrease as a result of the respiratory muscles' inefficiency. All of these elements contribute to inspiratory overload, which raises the amount of oxygen consumed, the respiratory energy used, and the amount of effort required to breathe [1].

The interaction of genes with the environment, lifestyle, and emotional variables leads to the complex and multifaceted etiology of obesity. A significant risk factor for obesity is the modern lifestyle [2].

Obstructive sleep apnea (OSA) and obesity have been linked in some studies. However, little is known about the precise pathogenesis of OSA in obese patients [3].

Regardless of the type of surgical procedure employed, bariatric surgery is presently regarded as the most effective treatment option for morbid obesity because it improves weight loss outcomes and comorbidities associated with obesity more than nonsurgical interventions [4].

Clinical effects of bariatric surgery on respiratory system:

Patients who are obese have increased calorie intake and energy expenditure. According to the body surface area, the basal metabolic rate should be taken into account. However, when body weight increases, the surface area of the body increases. when a result, the absolute basal metabolic rate increases in comparison to lean persons, increasing oxygen consumption and carbon dioxide production in obese people [5].

Due to impaired diaphragm function, obese patients' propensity for hypoxia is particularly pronounced in supine position and under anesthesia after bariatric surgery. Since there is a tendency for rapid desaturation progression, the apnea duration at anesthesia induction should be kept to a minimum. Due to ventilation with 100% O2 during intubation and extubation under general anesthesia, absorption atelectasis may be observed [6].

The increased pulmonary blood volume and excessive weight of the adipose tissue bordering the chest wall further reduce lung compliance. Up to 35% less total lung compliance can be experienced. Small airways are closed, and an increased intrathoracic blood volume and cephalad displacement of abdominal contents significantly lower the functional residual capacity [6].

The functional residual capacity (FRC) in the sitting position is reduced by 0.7–0.8 L in non-obese adults. FRC, however, may go below 1 L in obese patients with BMIs greater than 40 kg/m2. The forced vital capacity, forced expiratory volume in one second 1 (FEV1), and mid-expiratory flow are all lowered in morbidly obese patients[7]

Similar to this, an increase in BMI causes an increase in the alveolar-arterial (A-a) oxygen gradient. As a result, during typical tidal breathing, the FRC approximates the closing volume, leading to airway closure, ventilation-perfusion mismatch, and atelectasis. Additionally rising is the prevalence of intrapulmonary shunt. Pneumoperitoneum during laparoscopic surgery becomes noticeable and indicates a decrease in compliance [6].

To the best of our knowledge, there are no studies showing that the inverted Trendelenburg posture reduces postoperative atelectasis, although some reports indicate that it offers a partial recovery in the FRC loss. When the patient is moved from a sitting posture to a decubitus one, the airway resistance increases. These causes lead to an increase in respiratory workload in morbid obesity [6].

Rapid desaturation during hypoventilation or apnoea will be caused by decreased chest wall compliance and diaphragm tone, as well as an increased risk for atelectasis and secretions. This desaturation may persist over the postoperative period. Athelectasis may not improve or may possibly become insufficient with more oxygen alone [8].

General anesthesia and Recruitment maneuver

Increased atelectasis is a side effect of general anesthesia, especially in obese patients, those getting high inspired oxygen concentrations, and those recovering from intra-abdominal surgery [9].

For a safe time for tracheal intubation, pre-oxygenation with a high fraction of inspired oxygen (FIO2) is crucial. However, the FIO2 can be decreased to minimize oxygen atelectasis once the patient's trachea has been securely intubated (often to 0.3 and modified according to oxygen saturation values). The rate of absorption collapse is significantly increased above a FIO2 of 0.8 or 0.9, particularly when there is partial airway closure [10,11].

To ensure effectiveness and stop iatrogenic harm, modern ideas and procedures have developed. Modern modes and functionalities that can be tailored to the needs of various patients are made possible by advancements in computer microprocessor and other technology. For intraoperative anesthetic management, lung protection, and reducing postoperative pulmonary sequela, optimal mechanical ventilatory support is essential. Obtaining the best pulmonary mechanics, including compliance, resistance, and gas exchange, is necessary for effective mechanical ventilation [12].

Because defined volumes are more certain, barotrauma may be easier to avoid with pressure-controlled ventilation and volutrauma with volume-controlled ventilation. Today's systems, particularly in intensive care, incorporate pressure and volume control, making modifications simpler to maintain. Atelectrauma develops when lung units are opened and closed repeatedly, and it is facilitated by a lack of surfactant. Obesity and other external forces, such as increased intra-abdominal pressure or pleural effusions, increase the likelihood of atelectasis. When small airways are repeatedly opened and closed, low PEEP may cause atelectrauma. However, the effects of PEEP will vary depending on the compressing forces happening locally, so some sections of the lungs may be overexpanded and others may not expand at all. To lessen wound infection and postoperative nausea and vomiting, the World Health Organization and the US Centers for Disease Control have advised using a FIO2 of 0.8 [13].

A. Recruitment maneuver:

A recruitment maneuver (RM) is a dynamic, brief rise in transpulmonary pressure that is inversely correlated with lung unit closing. The amplitude of transpulmonary pressure can be used to forecast its success and/or negative outcomes. Sustained inflation, in which airway pressure is quickly increased for a specified amount of time (40 cmH2O for 40 seconds), is the most commonly discussed RM. More recently, stepwise RMs (RMs with a stepwise increase in PEEP) have been proposed to deliver transpulmonary pressure with a gradual increase rather than a quick increase used for sustained inflation with less hemodynamic compromise and hyperinflation [14].

The sigh breath helps to keep pulmonary compliance in check. Sigh breaths also keep venous admixture within a normal range and reduce the alveolar-arterial oxygen difference (P(A-a)O2). Sigh breaths assist in the equal distribution of fresh surfactant across the distal airways and the alveolar surface. The alveolar type II cell's fusion pore serves as a mechanical barrier to restrain additional surfactant release. Breaths of relief break down this barrier and refill the surfactant supply [15].

Through three key mechanisms—dyskinesis, increased FIO2, and ablation of the sigh breath—general endotracheal anesthesia results in compression and absorption atelectasis. Lung compliance declines as a result of dysskinesis, which limits a patient's reliant diaphragm's range of motion. Additionally, it lessens the dependent lung's ability to move, which lowers functional residual capacity [16].

The terms vital capacity breaths, double VT breaths, and sigh breaths are used to characterize alveolar recruitment techniques. As alveolar recruitment techniques are to anesthetized, mechanically ventilated patients, sigh breaths are to awake, spontaneously breathing individuals. They recruit collapsed alveoli and enhance arterial oxygenation by using sustained increases in airway pressure (breath-holds) [17].

Alveolar recruitment maneuver techniques often fall into one of two categories. According to some writers, alveolar recruitment techniques consist of continuously inflating the lungs for 5–30 seconds to a specified peak inspiratory pressure (PIP). Others refer to the gradual, progressive PEEP increase as an alveolar recruitment technique. To preserve the benefits of an alveolar recruitment maneuver, both techniques require PEEP [18].

The incremental PEEP titration is used in the step-wise recruitment maneuver, which balances recruitment and overdistention. PEEP is raised in 2–5 cmH2O increments with a constant VT of 6–8 mL/kg of ideal body weight. At each stage, blood pressure, compliance, SpO2, and driving pressure are all monitored. If there is evidence of recruitment, such as decreased driving pressure, more compliance, or higher SpO2, PEEP is increased. If there are signs of overdistention, such as increased driving pressure, Pplat greater than 30 cmH2O, hypotension, decreased compliance, or low SpO2, PEEP is reduced to the preceding step. If an unfavorable consequence (hypertension or desaturation) occurs, RM is terminated [19].

Application of a recruitment maneuver followed by a decremental PEEP titration (open lung approach) has been suggested as a strategy. This method involves applying a recruitment maneuver, lowering PEEP in 2 cmH2O increments, and measuring compliance at each stage to determine the best compliance. Others have found that the optimal PEEP during the decremental PEEP titration can be determined by arterial oxygenation rather than compliance. The recruitment maneuver is repeated after determining the pressure at which recruitment cannot be maintained using either compliance or oxygenation, and PEEP is then set to be 2 cm H2O higher than the level determined to have the lowest best compliance [18].

Alveolar recruitment maneuver complications

Alveolar recruitment maneuver complications have been variously defined as hypotension (mean arterial blood pressure less than 60 mm Hg), hypertension (systolic blood pressure greater than 150 mm Hg), SpO2 of 90% or less, pneumothorax requiring a chest tube, heart rate less than 60 beats per minute, and the requirement to administer a fluid bolus or vasoactive medication [20].

When anaesthesia-induced atelectasis was proven to exist, some specialists started to wonder if recruitment manoeuvres (RM) could result in barotrauma and pneumothorax. The safety of RMs in healthy lungs ventilated in pressure control mode with a constant driving pressure and gradual increments in PEEP has been demonstrated by studies over the previous four years, including in neonatal models. In reality, no study that has been published to date that indicates RM patients have a higher incidence of pneumothorax. The duration of the peak pressure phase is known to always cause a brief drop in cardiac output at the beginning of the maneuver, which is followed by a return to normalcy within a few minutes. This is due to the fact that during the pressurization phase, right ventricular afterload increases and preload decreases, which has an impact on the left ventricle's filling pressure. However, cardiac output typically returns to pre-RM levels within 15–20 minutes if the entire collapsed area is reopened. This is because correcting the atelectasis-related hypoxic pulmonary vasoconstriction lowers pulmonary vascular resistance [21]

Contraindications:

Some individuals with a history of pulmonary disease, such as emphysema, asthma, pleural bullae, and spontaneous pneumothorax, are contraindicated for RMs. Despite the fact that RMs are not contraindicated for COPD patients, the risks and advantages of the therapy must be considered in each case. The haemodynamic effects of RMs must be weighed against the fact that patients with a history of heart failure and low ejection fraction benefit most from the decrease in pulmonary vascular resistance brought on by the reversal of hypoxic pulmonary vasoconstriction after alveolar opening. It is advisable to minimize the length of RMs in patients with poor ejection fraction and to utilize lower PEEP levels (less than 15 cmH2O) [22].

It is crucial to confirm that the patient satisfies the fundamental requirements for RMs before beginning the procedure. First, the anaesthetic needs to be strong enough to prevent the patient from coughing throughout the procedure. The patient must be hemodynamically stable before beginning the RM, which is the second prerequisite [23].

Table 1. Different recruitment manoeuvres used in individual studies of intraoperative ventilation strategies; described by Guldner and colleagues as three different techniques: ‘bag-squeezing’, ‘stepwise increase in tidal volume’, and ‘stepwise increase in PEEP’. CPAP, continuous positive airway pressure.

Study	Technique
Severgnini and colleagues [24]	Initial setting: 7 ml kg1 IBW, RR 6min1, PEEP 10 cm H2O, I:E ratio 3:1 VT increased in steps of 4 ml kg1 IBW until plateau pressure 30 cm H2O for three breaths Settings returned to original, with PEEP maintained at 10 cm H2O
Futier and colleagues [25]	CPAP 30 cm H2O for 30 s

Treschan and colleagues [26]	Three manual bag ventilations with a maximal pressure of 40 cm H2O before extubation
Weingarten and colleagues [27]	Three-step increase in PEEP: 4–10 cm H2O for three breaths 10–15 cm H2O for three breaths 15–20 cm H2O for 10 breaths PEEP reduced and maintained at 12 cm H2O Repeated 30 and 60 min after the first RM and hourly thereafter

Computer-guided recruitment maneuvers:

Modern anesthesia ventilators have safe, user-friendly features for performing RMs and monitoring pulmonary collapse. Many of these modern computer-controlled systems follow Cdyn trends and monitor Cdyn at every breath. Some can even notify the operator that an RM is required by comparing the evolution of Cdyn versus pre-set PEEP values. Learning to use these automated RM tools makes the process safer because doing so minimizes the possibility of human error occurring during the maneuver. Automated RMs can also predict the length of the entire RM in real time and how this will change depending on the settings selected. In order to do stepwise incremental RMs in pressure control mode with a fixed driving pressure, only programs with a particular tool are advised. The operator must still compute post-RM PEEP for each patient, which is the only downside of automated RMs. Although the post-RM PEEP level must be entered into every automated system, none of them can yet determine automatically what level will maximize Cdyn or driving pressure [28].

Method for Evaluating Alveolar Recruitment Maneuvers' Efficacy:

In addition to measuring the P(A-a)O2 and obtaining an arterial blood gas, pulmonary compliance is a more practical and non-invasive method. The formula for calculating dynamic pulmonary compliance is dynamic compliance VT/(PIP PEEP), where VT is divided by the difference between PIP and PEEP. The formula for calculating static pulmonary compliance is VT/(Pplat PEEP), where VT is the difference between plateau pressure (Pplat) and PEEP. A decrease in atelectasis would likely be reflected in an increase in pulmonary compliance soon after performing an alveolar recruitment technique, which would increase PaO2 as a result of better ventilation and perfusion matching. The provider would observe that the same VT is supplied at a lower PIP after applying alveolar recruitment procedures during volume control continuous obligatory ventilation. The provider would observe that an enhanced VT is supplied at the same inspiratory pressure level while using pressure control continuous obligatory ventilation. It is now much simpler to assess the efficacy of alveolar recruitment techniques because to the inclusion of options for displaying the pressure-volume loop and estimated dynamic compliance values in modern anesthetic ventilators [28].

Alveolar recruitment's impact on PPCs:

Recent research has indicated that lung protective breathing during surgery may lessen pulmonary problems afterward. Different lung protection methods have been tried, including simple tidal volume reduction and low VT combined with alveolar recruitment methods (moderate positive end-expiratory pressure [PEEP] helped by recruiting maneuvers [29].

There is currently strong evidence that using protective breathing techniques in patients with healthy lungs (i.e. during surgery) dramatically lowers the risk of PPC. Tidal volume (VT), PEEP level, and RM usage are all taken into account during protective ventilation [30].

Low VT is clearly protective against PPCs, although there is debate over the appropriate level of PEEP, and high PEEP levels are thought to damage hemodynamics [31].

Post-operative pulmonary complications

Between 1 to 23% of major surgeries involve PPCs. Postoperative respiratory failure is the most frequent PPC, and several investigations have demonstrated that pulmonary complications are more frequent than cardiac problems. In comparison to 0.2–3% of individuals without a PPC, 1 in 5 patients (14–30%) who have a PPC will pass away within 30 days of major surgery. There has been evidence that hospital stays can be extended by 13 to 17 days [32].

Table 2. European Perioperative Clinical Outcome definitions for postoperative pulmonary complications and other defined outcome measures, in particular, respiratory failure and pneumonia. International statistical classification of diseases and related health problems, ninth revision (ICD-9) codes have also been used to define PPCs.

Outcome measure	EPCO definitions	Other published definitions
Respiratory infection	Antibiotics for suspected infection with one or more of the following: new or changed sputum, new or changed lung opacities, fever, white blood cell count $>12\times10^9$ /L	Two or more of the following for >48 h: new cough/sputum production, physical findings compatible with pneumonia, fever >38 C, and new infiltrate on CXR
Respiratory failure	Postoperative PaO_2 <8 kPa (60 mm Hg) on room air, a PaO_2 :FIO_2 ratio <40 kPa (300mm Hg), or arterial oxyhaemoglobin saturation measured with pulse oximetry <90% and requiring oxygen therapy	Ventilator dependence for >1 post-operative day or re-intubation. Need for post-operative mechanical ventilation >48 h. Unplanned re-intubation due to respiratory distress, hypoxia, hypercarbia, or respiratory acidosis within 30 days of surgery. Re-intubation within 3 days

		requiring mechanical ventilation. Postoperative acute lung injury. ARDS. Requiring mechanical ventilation within 7 days of surgery. Requiring NIV.
Pleural effusion	CXR with blunting of costophrenic angle, loss of sharp silhouette of the ipsilateral hemidiaphragm in upright position, displacement of adjacent anatomical structures, or (in supine position) hazy opacity in one hemithorax with preserved vascular shadows	Pleural effusion requiring thoracocentesis
Atelectasis	Lung opacification with mediastinal shift, hilum or hemidiaphragm shift towards the affected area, with compensatory hyperinflation in adjacent non-atelectatic lung	Requiring bronchoscopic intervention. Major atelectasis (one or more pulmonary segments)
Pneumothorax	Air in the pleural space with no vascular bed surrounding the visceral pleura	Pneumothorax requiring thoracocentesis
Bronchospasm	Newly detected expiratory wheeze treated with bronchodilators	Clinical diagnosis resulting in change in therapy. Refractory wheeze requiring parenteral drugs in addition to preoperative regimen.
Aspiration pneumonitis	Acute lung injury after inhalation of regurgitated gastric contents	
Pneumonia	CXR with at least one of the following: infiltrate, consolidation, cavitation;plus at least one of the following: fever >38 C with no other cause, white cell count <4 or > 12 109 litre1, >70 yr of age with altered mental status with no other cause;- plus at least two of the following: new purulent/ changed sputum, increased	Radiographic change and antibiotics. Antibiotics with new/changed sputum or radiographic change or fever or increased white cell count>12000. Two or more of the following for 2 consecutive days: new cough/sputum production, examination compatible with

	secretions/suctioning, new/worse cough/dyspnoea/tachypnoea, rales/ bronchial breath sounds, worsening gas exchange.	pneumonia, temperature>38 C, and radiographic change. New or progressive infiltrate on CXR or crackles or dullness on percussion and any of the following: new purulent/changed sputum, positive blood cultures, isolation of pathogen from sputum. Positive sputum culture or infiltrate on CXR, and diagnosis of pneumonia or pneumonitis. New infiltrate on CXR plus fever, leucocytosis, and positive sputum Gram stain/culture.
ARDS		Ventilated, bilateral infiltrates on CXR, PaO2 :FIO2300, minimal evidence of left atrial fluid overload within 7 days of surgery
Tracheobronchitis		Purulent sputum with normal chest radiograph, no iv antibiotics
Pulmonary oedema		Pulmonary congestion/ hypostasis, acute oedema of lung, congestive heart failure, fluid overload
Exacerbation of pre-existing lung disease		Not further defined
Pulmonary embolism		Not further defined
Death		

Strategies to reduce PPC:

1-Preoperative strategies:

PPCs can be decreased by improving the patient's respiratory condition. Patients who are already using inhaled beta-2 agonists and anticholinergics for COPD should keep doing so. Using systemic or inhaled corticosteroids for a brief period of time can enhance lung function prior to surgery. Only when infection is evident (new or altered sputum, positive microbiology, new or altered lung opacities, fever, and leukocytosis should antibiotics be provided. Prior to surgery, asthmatics should maintain their current treatments to attain the greatest peak flow possible. Preoperative continuous positive airway pressure (CPAP), a mandibular advancement device, and weight loss may all be helpful in treating severe OSA. Preoperative smoking reduction may lower the frequency of PPCs, however the evidence is inconclusive. The evidence supporting the short-term benefits of quitting smoking is still debatable; patients who stop smoking within two months following surgery may experience greater PPC rates [33].

2-Intraoperative strategies:

Particularly in patients who are obese, minimally invasive surgical methods may lower PPCs. In a bariatric population, open gastric bypass surgery resulted in more pulmonary problems than laparoscopic gastric bypass. Theoretical causes include decreased blood loss, decreased discomfort and inflammation, quicker respiratory recovery, and shorter hospital stays. Prior to surgery, it's critical that the clinician collaborate with the surgeon, anesthesiologist, and pulmonologist if needed. Choosing the optimal surgical approach, anesthetic type (general and regional), surgical drugs, and breathing control would be the primary components of intraoperative strategies [34].

Intra-operative strategies for obese patients:

Application of Extrinsic PEEP combined with recruitment maneuvers:

A number of recent studies suggest that the use of PEEP in combination with RM improves oxygenation and lung compliance by lowering lung atelectasis, but the clinician should avoid the related adverse hemodynamic effects [35].

The effectiveness of recruitment techniques and PEEP on postoperative outcomes including oxygenation and pulmonary function in obese individuals is still debatable. Therefore, additional research is required to determine the postoperative impact and influence of these intraoperative lung recruitment attempts on clinical outcomes. In spite of all pathophysiological changes, the primary goal of mechanical ventilation in obese patients is to "keep the lung open" throughout the entire breathing cycle [36].

3-Postoperative physiotherapy and mobilization:

In general and vascular patients, the I COUGH postoperative respiratory care program lowers risks of pneumonia and unintentional re-intubation. Before surgery, the program begins with educational materials in the form of leaflets and videos. After preoperative method practice, incentive spirometry is advised 10 times per hour (three to five tries per set) during waking hours until discharge, with the device always within reach. The volumes of incentive spirometry are documented every four hours. Every two hours, patients deep breathe and cough. Patients should ideally be mobilized three times per day while seated in a chair or with the head of the bed elevated by at least 30 degrees [37].

When compared to systemic opioids alone, the addition of epidural analgesia to GA considerably lowers the incidence of postoperative pneumonia in the general surgical population. In addition to enhancing respiratory function, epidural analgesia lowers the incidences of pneumonia, postoperative ventilation, and unintentional re-intubation. Patients who are obese are more likely to have OSA, and those who have OSA are more sensitive to sedatives and opioids, increasing their risk of respiratory depression following surgery. Because opioid dose is associated with postoperative increases in OSA and consequently the possibility of PPCs, reduced opioid doses should be given to select patients with known or suspected OSA [18].

Conclusion

When combined with protective lung ventilation, the cycling recruitment method greatly reduces the risk of postoperative pulmonary problems in morbidly obese patients undergoing bariatric surgery under general anesthesia.

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