



Preoxygenation and intraoperative ventilation strategies in obese patients: a comprehensive review

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Purpose of review

Obesity along with its pathophysiological changes increases risk of intraoperative and perioperative respiratory complications. The aim of this review is to highlight recent updates in preoxygenation techniques and intraoperative ventilation strategies in obese patients to optimize gas exchange and pulmonary mechanics and reduce pulmonary complications.

Recent findings

There is no gold standard in preoxygenation or intraoperative ventilatory management protocol for obese patients. Preoxygenation in head up or sitting position has been shown to be superior to supine position. Apneic oxygenation and use of continuous positive airway pressure increases safe apnea duration. Recent evidence encourages the intraoperative use of low tidal volume to improve oxygenation and lung compliance without adverse effects. Contrary to nonobese patients, some studies have reported the beneficial effect of recruitment maneuvers and positive end-expiratory pressure in obese patients. No difference has been observed between volume controlled and pressure controlled ventilation.

Summary

The ideal ventilatory plan for obese patients is indeterminate. A multimodal preoxygenation and intraoperative ventilation plan is helpful in obese patients to reduce perioperative respiratory complications. More studies are needed to identify the role of low tidal volume, positive end-expiratory pressure, and recruitment maneuvers in obese patients undergoing general anesthesia.

Keywords

intraoperative ventilation, obesity, preoxygenation

INTRODUCTION

Morbid obesity is a global epidemic. Worldwide obesity has more than doubled since the 1980s with around 600 million people being obese [1]. In the USA, 35% individuals over the age of 20 years were obese in 2011–2012 [2]. There has been a steady increase in the number of obese patients undergoing both bariatric and nonbariatric surgeries.

Morbidly obese patients scheduled for surgery pose a challenge to anesthesiologists. Obesity is associated with other medical comorbidities such as diabetes, hypertension, airway hyper-reactivity, obstructive sleep apnea, obesity hypoventilation syndrome, and pulmonary hypertension [3]. They are at higher risk for difficult mask ventilation [4] and intubation [5]. Obese patients have altered respiratory mechanics. They have reduced functional residual capacity (FRC), inspiratory capacity, vital capacity, and decreasing oxygen reserve [6,7].

These respiratory parameters are further reduced when the patient moves from the sitting to the supine position [6]. In addition, obese patients have increased oxygen consumption because of a high metabolic rate [8]. Thus obesity along with its comorbidities increases the risk of perioperative respiratory complications [9]. Preoxygenation is vital as these patients are at a higher risk of oxygen desaturation during apnea following anesthetic induction [10]. Also strategies of intraoperative

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KEY POINTS

- Positioning obese patients head up and use of continuous positive airway pressure enhances preoxygenation.
- Apneic oxygenation in obese patients increases safe apnea duration.
- Use of low tidal volume is a lung protective mechanical ventilation strategy in nonobese patients.
- Recruitment maneuver with positive end-expiratory pressure improves intraoperative oxygenation and respiratory compliance in obese patients but not in healthy nonobese patients.
- Evidence suggests there is no difference between volume and pressure controlled ventilation.

ventilation are important to reduce respiratory complications during surgery and in the postoperative period. It is unclear which oxygenation and ventilation techniques will be helpful to reduce respiratory complications in obese patients undergoing surgery. This review highlights the various preoxygenation and ventilation techniques in obese patients to improve oxygenation during induction and maintenance of anesthesia and reduce postoperative pulmonary complications.

PREOXYGENATION

The rationale for preoxygenation is to increase the safety period of apnea after induction until intubation by maximizing intrapulmonary oxygen reserves. The induction of general anesthesia in healthy nonobese individuals may impair oxygenation via an increase in intrapulmonary shunt [11]. Atelectasis is known to occur within minutes after induction of anesthesia in obese patients [12], thereby decreasing oxygen reserve [7]. In an animal study, atelectasis was shown to stimulate alveolar macrophages to produce inflammatory markers like IL-1 and tumor necrosis factor leading to direct or indirect lung injury [13]. Increasing BMI is associated with a rapid decrease in oxygen saturation following induction [10].

In healthy nonobese patients, both 3 min of tidal breathing and eight deep breaths taken within 60 s are effective preoxygenation techniques [14]. Even after 5 min of preoxygenation, studies have shown that supine obese individuals desaturate to $\text{SaO}_2 < 90\%$ within 2–3 min [10]. Use of a high fraction of inspired oxygen (FiO_2) during induction increases atelectasis [15]. Therefore, additional measures like use of head up or propped up position,

continuous positive airway pressure, apneic oxygenation, and use of supraglottic airway devices have been described in the literature to enhance oxygenation in the high-risk group of morbidly obese patients (Table 1).

POSITIONING AND PREOXYGENATION

Position during preoxygenation has been shown to influence the time before significant desaturation occurs [16]. FRC, which serves as oxygen stores of the body, is highly sensitive to body changes, being larger in the upright than in the supine position. Oxygenation in obese individuals is further compromised in the supine position [25]. Head up positioning ($20\text{--}25^\circ$) during induction and intubation displaces the abdominal contents away from the diaphragm increasing the safe apnea period from 155 s (s) in supine position to 201s in head up position [16,17].

Compared with the supine position, preoxygenation in the sitting position (90°) has also been shown to extend the tolerance to apnea in obese patients by approximately 1 min [6]. Ramping or head elevated laryngoscopy position, a technique, which aligns all three axes: oral, pharyngeal, and laryngeal, helps in ventilation and intubation in obese patients. It is achieved by placing pillows or blankets under the head, neck, and upper body until the external auditory meatus and the sternal notch are horizontally aligned [26,27]. The commercially available preformed head elevation pillow or inflatable pillow has also been shown to improve ventilation and intubating conditions in obese patients [28,29].

POSITIVE PRESSURE VENTILATION AND PREOXYGENATION

Use of either continuous positive airway pressure (CPAP) of 5 cm H_2O or pressure support ventilation (PSV) of 5 cm H_2O has been shown to enhance preoxygenation in obese patients and prevent desaturation episodes in a rapid sequence induction. This was achieved by using tight fitting CPAP mask with or without pressure support mode (PSV-Pro) (5 cm H_2O) during preoxygenation [19]. CPAP works by increasing end-expiratory lung volume and diminishing small airway closure during induction. Futier *et al.* [20] showed that noninvasive positive pressure ventilation improves oxygenation. Addition of a recruitment maneuver further improves respiratory function. Recruitment maneuver consists of applying transient positive inspiratory pressure (40 cm H_2O for 40s) and helps by opening collapsed alveoli. However Cressey *et al.*

Table 1. Preoxygenation strategies in obese patients

Preoxygenation and positioning						
Author study type	No.	Comparison	Surgery	Mean age (year)	BMI	Results
Altermatt (2005) [6]	40	Sitting 90° vs. supine	Elective surgery	41 (20–58)	43 (5)	Supine patients desaturate earlier vs. sitting ($P < 0.05$)
RCT				37 (20–55)	43 (6)	
Dixon (2005) [16]	42	Head up 25° vs. supine	Gastric bypass	41 (6)	45 (6)	Supine patients desaturate earlier vs. head up ($P = 0.02$)
RCT				45 (10)	47 (7)	
Lane (2005) [17]	40	Head up 20° vs. supine	Cholecystectomy	59 (19)	26 (5)	Supine patients desaturate earlier vs. head up ($P = 0.002$)
RCT				56 (13)	28 (5)	
Preoxygenation with CPAP.						
Cressey (2005) [18]	20	CPAP 7.5 cm vs. Mapelson A	GA (RSI)	34 (8)	45 (7)	CPAP vs. Mapelson A.
RCT				47 (11)	44 (6)	No difference in oxygenation ($P > 0.05$)
Harbut (2014) [19*]	44	CPAP 5 cm + PSV 5 cm vs. none	Lap gastric bypass	47 (13)	43 (6)	CPAP + PSV
RCT				42 (12)	44 (6)	Better oxygenation, less desaturation. ($P < 0.05$)
Futier (2011) [20]	66	Conv. O ₂ vs. NPPV vs. NPPV + RM	Lap gastric surgery	41 (9)	46 (4)	NPPV + RM > NPPV > conv. O ₂ at improving
RCT				42 (10)	46 (2)	Oxygenation ($P < 0.05$)
				43 (11)	45 (5)	
Gander (2005) [21]	30	Preoxy CPAP10 + PEEP10 for 5 min after induction vs. control		35 (8)	46 (7)	CPAP + PEEP better oxygenation.
RCT				38 (12)	47 (6)	Increased safe apnea time ($P = 0.038$)
Apneic oxygenation						
Baraka (2007) [22]	34	Preoxy vs. Preoxy + nasopharyngeal insufflation	Gastric bypass	36 (11)	43 (5)	Nasopharyngeal O ₂ insufflation
RCT				37 (11)	42 (7)	Increases safe apnea duration
Ramachandran (2010) [23]	30	Apneic oxygenation vs. none	Elective surgery	53 (9)	31 (1)	Apneic oxygenation increases safe apnea duration ($P < 0.05$)
RCT				53 (7)	31 (1)	
Preoxygenation with supraglottic device						
Sinha (2013) [24]	40	Proseal LMA vs. facemask	Bariatric surgery	41 (14)	47 (8)	Better oxygenation in Proseal LMA group
RCT				39 (13)	46 (6)	

conv.; conventional; CPAP, continuous positive airway pressure; LMA, laryngeal mask airway; NPPV, noninvasive positive pressure ventilation; PEEP, positive end expiratory pressure; Preoxy, preoxygenation; PSV, pressure support ventilation; RCT, randomized control trial; RM, recruitment maneuver; RSI, rapid sequence induction.

[18] failed to demonstrate the benefit of CPAP alone (without PSV) in obese patients during a rapid sequence induction. Use of a recruitment maneuver in addition to noninvasive positive pressure ventilation improves end-expiratory lung volume and respiratory mechanics. Combining preoxygenation with CPAP and positive end-expiratory pressure (PEEP) during induction in morbidly obese patients increases nonhypoxic apnea duration by 1 min [21].

APNEIC OXYGENATION

During apnea, oxygen continues to flow from alveoli to blood at the rate of 250 ml/min to meet the oxygen consumption and carbon dioxide flows from blood to alveoli at 8–20 ml/min. The difference in gas flow is because of differential gas solubility, affinity of hemoglobin [30], and because of buffering of CO₂ by HCO₃ at both the blood and tissue level [31]. This creates a subatmospheric pressure in the alveoli creating mass movement of gas from pharynx to alveoli, a phenomenon known as apneic oxygenation [32]. The prerequisites for effective apneic oxygenation are a continuous source of oxygen, patent airway, and efficient preoxygenation [33]. This technique can increase safe apnea duration in obese patients with challenging airways and pre-existing respiratory comorbidities. Apneic oxygenation with nasal prongs (5 l/min of oxygen) during simulated prolonged laryngoscopy in obese individuals resulted in prolongation of SpO₂ > 95% for at least 6 min after apnea and higher minimum SpO₂ in 53% of patients when compared with the control group [23]. Similar results were seen in the study conducted by Baraka *et al.* [22] where nasopharyngeal oxygen insufflation during preoxygenation and apneic periods delayed the onset of oxygen desaturation from 145 s in control group to at least 4 min in the study group.

OTHER TECHNIQUES OF PREOXYGENATION

Use of low FiO₂ prevents atelectasis during induction of general anesthesia but at a cost of reduction in the duration of safe apnea. A randomized control trial studied the effect of preoxygenation with 100%, 80%, and 60% oxygen on safe apnea duration and formation of lung atelectasis in healthy non-smoking individuals. The results of the study showed that area of atelectasis in basal lung scan was 5.6% in 100% oxygen group versus 0.6% and 0.2% in 80% and 60% oxygen groups. The time before the saturation dropped to 90% was 7, 5, and 3.5 min in 100, 80, and 60% oxygen groups respectively [34]. Owing to the drop in oxygenation

in a shorter time with lower FiO₂, a change in practice from preoxygenation using 100% oxygen is not warranted.

Supraglottic devices are increasingly used as ventilatory devices for general anesthesia in obese patients as an alternative to tracheal tube [35]. Use of supraglottic airway devices as a conduit for preoxygenation prior to intubation provides an airtight seal, allows application of PEEP, gastric decompression via drain tube and improves oxygen reserves in morbidly obese patients [24,36]. Supraglottic devices serve not only as rescue measures in difficult ventilation or intubation but also may be used as a preliminary device for ventilation and a channel for intubation.

INTRAOPERATIVE VENTILATION TECHNIQUES

Various intraoperative ventilation strategies include the use of different modes of ventilation, use of PEEP, recruitment maneuver, and low versus high tidal volume to reduce postoperative pulmonary complications like atelectasis, pneumonia, and respiratory failure [37]. Lung protective ventilation strategies have proven impact on the clinical outcome of intensive care patients [38]. A recent meta-analysis showed that use of lung protective ventilation strategies consisting of low tidal volume and PEEP intraoperatively decreased postoperative pulmonary complications in the nonobese patients [39]. The Intraoperative Protective Lung Ventilation trial showed that the use of lung protective strategies in high-risk patients (normal weight) undergoing abdominal surgery reduced the need for postoperative ventilatory support and hospital stay [40]. A recent review on perioperative lung protective ventilation strategies in obese patients has recommended use of low tidal volume (approximately 8 ml/kg based on ideal body weight), lung recruitment with PEEP and recruitment maneuvers and judicious use of oxygen (less than 0.8 if possible) to prevent absorption atelectasis [41]. Various studies have been conducted to compare ventilation plans in the obese surgical patient under general anesthesia to decrease postoperative respiratory complications (Table 2).

TIDAL VOLUME FOR VENTILATION

A recent meta-analysis of randomized control trials showed that protective lung ventilation with low tidal volume (5–8 ml/kg) in anesthetized patients with normal weight undergoing surgery resulted in lower risk of lung injury and postoperative pulmonary infection [39,54,55]. A multisite randomized

Table 2. Ventilation strategies during general anesthesia

Intraoperative ventilation strategies in obese patients					
Author study type	Surgery	No.	Comparison	BMI	Results
Aldenkortff (2012) [42]	Abdominal surgery	505	Six studies: PEEP vs. PEEP + RM	>30	RM + PEEP vs. PEEP alone improved oxygenation (PaO ₂ /F _i O ₂) (P = 0.0001)
Meta-analysis	Nonabdominal surgery		Two studies: RM vs. RM + PEEP Two studies: different levels of RM + PEEP Four studies: PCV vs. VCV		PCV vs. VCV no difference in oxygenation
Baltieri (2014) [43]	Bariatric surgery	40	Four groups: preoperative BiPAP, intraoperative PEEP, postoperative BiPAP Control group	40–55	Positive pressure reduced atelectasis Postoperative BiPAP: maximum benefit
RCT					
Desfresne (2014) [44]	Lap gastric bypass	50	PEEP10 vs. PEEP10 + 2 RM	>35	Two intraoperative RMs did not improve postoperative lung function (FRC) and oxygenation
RCT					
Dion (2014) [45]	Bariatric surgery	20	PCV vs. VCV vs. PC-VG for 20 min	>40	PCV and PC-VG: lower peak inspiratory pressure than VCV (P < 0.01)
RCT					No difference in oxygenation
Enekvist (2011) [46]	Lower abdomen surgery	20	Normal TV vs. large TV	>25	Large TV increased arterial O ₂ tension (P < 0.05)
RCT					
Gupta (2012) [47]	Lap. chole	102	VCV vs. PCV	30–40	PCV increased arterial oxygenation (P < 0.05)
RCT					
Hager (2006) [48]	Open gastric bypass	30	Normocapnia (ETCO ₂ 35 mm Hg) vs. hypercapnia (ETCO ₂ 50 mm Hg)	61	Mild hypercapnia increased tissue oxygenation (P = 0.029)
RCT					
Remisicco (2011) [49]	Bariatric surgery	30	RM vs. no RM		RM decreased postoperative pulmonary complications (P = 0.02)
RCT					
Intraoperative position and oxygenation					
Pelosi (1996) [50]	Elective surgery	10	Prone position vs. supine position	>30	Prone position better than supine
Observat					Prone position improved FRC, lung compliance and oxygenation (P < 0.01)
Perilli (2003) [51]	Bariatric surgery	20	PEEP vs. 30° reverse trendelenberg	>40	PEEP vs. reverse trendelenberg
Observat					No difference in oxygenation
Ventilation strategies comparing obese vs. normal patients					
Sprung (2003) [52]	Lap. surgery		TV (600–700 ml) with RR10 vs. double TV (1200–1400 ml) RR10 vs. TV600, RR20		Increasing TV or RR did not affect oxygenation
Prospective					
Futier (2010) [53]	Abdominal surgery	40	Stepwise increase in PEEP		Increase in PEEP did not improve oxygenation
Prospective					

BiPAP, Bi-level positive airway pressure; Chole, cholecystectomy; FRC, functional residual capacity; Lap., laparoscopy; PCV, pressure controlled ventilation; PC-VG, pressure controlled volume guaranteed ventilation; PEEP, positive end-expiratory pressure; RM, recruitment maneuver; RR, respiratory rate; TV, tidal volume; VCV, volume controlled ventilation.

controlled trial also recommended low tidal volume (8 ml/kg) as a protective ventilation strategy in non-obese patients undergoing general anesthesia for open abdominal surgery [40,56[■]]. In obese individuals, predicted body weight should be used to calculate tidal volume as excess weight is because of adipose tissue and not the actual lung volume. Evidence shows that obese patients tend to be ventilated with higher tidal volume when the calculation is based on total body weight rather than predicted body weight [57,58]. Sprung *et al.* [52] compared the effects of tidal volume and respiratory rate on oxygenation in obese patients. Neither doubling the tidal volume nor increasing the respiratory rate affected oxygenation. Similar results were seen by Bardoczky *et al.* [59] where increasing the tidal volume from 13 ml/kg to 22 ml/kg in 3 ml/kg (ideal body weight) increments did not affect arterial oxygenation in obese patients. Most of the recent evidence of beneficial effect of low tidal volume is in the normal weight patients. It is not known if the lung protective strategy with low tidal volume is applicable to high-risk obese patients undergoing general anesthesia and more research is needed.

MODE OF VENTILATION IN OBESE SURGICAL PATIENT

Currently, there is no gold standard method for intraoperative ventilation in obese patients. Volume controlled ventilation (VCV) delivers a set tidal volume but may result in high airway pressures and barotrauma. Pressure controlled ventilation (PCV) allows limitation of high airway pressure but may result in variable tidal volumes depending upon lung resistance and compliance. Pressure control volume guaranteed ventilation (PCV-VG) mode combines benefit of VCV and PCV. It ensures delivery of preset tidal volume consistently with lowest inspiratory pressure [60]. Studies have compared various ventilatory methods in obese patients. A systematic review of four trials compared VCV versus PCV in obese patients [42]. There was no difference between these two ventilatory modes in intraoperative tidal volume, mean airway pressure, or oxygenation [42]. Dion *et al.* compared PCV, VCV, and PCV-VG in obese adolescents undergoing laparoscopic bariatric surgery. PCV-VG combines the benefit of both PCV and VCV and allows delivering a target tidal volume, which is autoregulated and pressure controlled. No difference in oxygenation, ventilation or hemodynamic variables was noted in the study between these three modes of ventilation, but PCV-VG and PCV provided ventilation with lowest peak inspiratory pressure [45].

With dynamic changes in lung resistance and compliance during laparoscopic surgeries, ventilation with PCV-VG was an easier method with fewer adjustments needed as compared with PCV [45].

METHODS TO PREVENT ATELECTASIS

Atelectasis is known to occur in all patients after general anesthesia and muscle paralysis [61]. Overweight patients tend to develop more extensive atelectasis when compared with normal patients [62]. This may be an explanation for greater post-operative pulmonary complications in obese patients as atelectasis has been shown to persist after extubation up to 24 h [12]. Various intraoperative strategies like the use of PEEP and recruitment maneuver are used to reduce atelectasis. Recruitment maneuvers are proposed to open the collapsed alveoli and PEEP keeps them open [63,64].

EVIDENCE TOWARD USE OF POSITIVE END-EXPIRATORY PRESSURE AND RECRUITMENT MANEUVER IN OBESE PATIENTS

A recent meta-analysis of ventilation strategies in obese patients by Aldenkrott *et al.* concluded that recruitment maneuver with PEEP maintained better intraoperative oxygenation and lung compliance compared with PEEP alone with minimal effect on hemodynamics [42]. Various recruitment maneuver methods have been described in obese patients in the literature. Chalhoub *et al.* [65] and Futier *et al.* [66] performed recruitment maneuver using 40 cm of H₂O inspiratory pressure for 40 s along with PEEP of 5–10 cm of H₂O. Renius *et al.* [67] and Whalen *et al.* [68] recruited the alveoli with 50–55 cm H₂O for 10 s and suggested that the positive effects of recruitment maneuver was maintained for 30–40 min. Intraoperative recruitment maneuver has been shown to reverse pneumoperitoneum induced respiratory effects in healthy and obese patients undergoing laparoscopic surgery [66]. Almarakbi *et al.* [69] compared four different intraoperative ventilation strategies (PEEP alone, single recruitment maneuver, single recruitment maneuver + PEEP, and recruitment maneuver + PEEP with recruitment maneuver performed every 10 min) in obese patients undergoing laparoscopic surgery. The results of this study revealed that recruitment maneuver + PEEP with recruitment maneuver performed every 10 min was associated with best intraoperative oxygenation and respiratory compliance [69]. Repeated recruitment maneuver prevented the decruitment of alveoli leading to sustained improvement in respiratory compliance and oxygenation.

Similar results were also seen when incremental increase in PEEP maneuver was applied hourly. Pelosi *et al.* [70] found that 10 cm H₂O PEEP improved oxygenation in obese but not in normal subjects. The application of PEEP resulted in greater alveolar recruitment in obese patients. The unchanged oxygenation in normal patients is attributed to decreased cardiac output associated with PEEP [71]. There are no recommendations on the optimal duration or time of application of recruitment maneuver. Randomized studies have been conducted where a single recruitment maneuver was applied either after induction of anesthesia [20,67], after abdominal opening [65], after pneumoperitoneum [68], or after suture of abdominal aponeurosis [72]. Rothen *et al.* [73] concluded that reopening of the alveoli occurs within first 7–8 s of vital capacity maneuver in healthy anesthetized subjects with no previous lung disease. More studies are needed to determine the optimal timing of application of recruitment maneuver and its duration.

Evidence against the use of positive end-expiratory pressure and recruitment maneuver in nonobese patients

Contrary from the results of the previous studies in obese patients, a recent multisite randomized trial found no benefit of PEEP or recruitment maneuver in patients with normal BMI [56^{**}]. High versus low PEEP during general anesthesia for abdominal surgery (PROVHILO) allocated 900 nonobese patients to high PEEP group (12 cm of H₂O) with recruitment maneuver or low PEEP group (≤ 2 cm of H₂O) without recruitment maneuver. The tidal volume both in the control and intervention group in the PROVHILO study was 7–8 ml/kg. The findings of the study were that high PEEP and recruitment maneuver does not protect against postoperative pulmonary complications and suggested the use of low tidal volume and low PEEP without recruitment maneuver [56^{**}].

A recent comprehensive review on intraoperative protective mechanical ventilation for prevention of postoperative pulmonary complications in healthy nonobese individuals has suggested a protocol to be used in patients undergoing open abdominal surgery [74^{*}]. Their suggestions include use of low tidal volume (6–8 ml/kg) combined with low PEEP (≤ 2 cm H₂O) initially. Strategies to treat hypoxemia should include stepwise increase in FiO₂ first, then followed by PEEP and recruitment maneuvers [74^{*}].

Thus evidence suggests the beneficial role of PEEP and recruitment maneuver in obese patients but not in patients with BMI in the normal range. However,

further studies are warranted to guide intraoperative ventilation strategies in obese patients.

ADVERSE EFFECTS OF POSITIVE END-EXPIRATORY PRESSURE AND RECRUITMENT MANEUVER

Barotrauma is a major concern in patients treated with recruitment maneuver. Two randomized trials including 92 patients reported no barotrauma in obese patients where a recruitment maneuver was used [65,75]. Similar results were seen when recruitment maneuver was used to improve oxygenation in critically ill patients in intensive care [76,77]. Recruitment maneuver using high inspiratory pressures may result in hypotension and increasing requirements of vasopressors [68]. Recruitment maneuver has been shown to decrease cardiac output in intensive care patients [78,79]. A recent meta-analysis concluded that recruitment maneuver plus PEEP when compared with PEEP alone did not impair mean arterial pressure in obese ventilated patients [42]. More research is warranted to determine the effect of recruitment maneuver on cardiac output in obese patients undergoing noncardiac surgeries.

Nonventilatory measures

Use of nonventilatory measures like composition of inspiratory gas, intraoperative positioning, and type of anesthetic influences oxygenation and postoperative respiratory complications.

EFFECT OF OXYGEN ON ATELECTASIS

The composition of inspiratory gas plays a vital role in recurrence of collapse of alveoli because of resorption of gas in lung units. Lung collapse reappears rapidly if recruitment is done with 100% oxygen when compared with a mixture of oxygen (40%) and poorly resorbed gas like nitrogen (60%) [80].

POSITIONING AND INTRAOPERATIVE VENTILATION

Prone position has proved beneficial in patients with acute lung injury and adult respiratory distress syndrome by decreasing ventilation perfusion mismatch [81,82]. Prone position when correctly performed (free abdomen movement) is known to increase FRC, lung compliance and oxygenation in obese patients during general anesthesia when compared with supine position [50,83]. Reverse trendelenberg position intraoperatively in obese patients undergoing upper abdomen surgery improves oxygenation with minimal effect on hemodynamics

[84]. Reverse trendelenberg position counteracts effects of weight of abdominal contents and surgical retractors improving the FRC [84].

Type of anesthesia: inhalational versus intravenous

Volatile anesthetics like sevoflurane and isoflurane are known bronchodilators and cause hypoxic pulmonary vasoconstriction. However, no clinical difference in oxygenation is noted when compared with intravenous anesthetics [85]. There is some preliminary data of anti-inflammatory effects of inhalational anesthetics and a trend toward lower postoperative respiratory complications when compared with propofol [86,87]. None of these studies are done in obese individuals and needs further research.

CONCLUSION

Currently, there is no gold standard preoxygenation or intraoperative ventilation strategies for obese patients. There is evidence to suggest that propped up, head-up, and ramping is superior to the supine position for preoxygenation. Use of noninvasive ventilation like CPAP and apneic oxygenation with nasal prongs improves oxygenation and safe apnea duration from induction to intubation. Evidence suggests intraoperative protective mechanical ventilation in healthy nonobese patients undergoing open abdominal surgery includes use of low tidal volume (6–8 ml/kg) and low PEEP (≤ 2 cm H₂O) because use of higher PEEP combined with recruitment maneuvers does not protect against postoperative pulmonary complications (PROVHILO study). A recent meta-analysis in obese patients has suggested the use of low tidal volume, PEEP with recruitment maneuver beneficial. Well designed multicentric prospective trials in obese individuals are needed to identify ideal lung protective ventilation plans in these high-risk individuals to improve oxygenation and reduce lung injury and postoperative respiratory complications.

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Conflicts of interest

There are no conflicts of interest.

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- of special interest
- of outstanding interest

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