Postoperative Pulmonary Complications in the Morbidly Obese: The Role of Tidal Volume and Type of Abdominal Surgery

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BACKGROUND: The patient who is morbidly obese is not adequately represented in the evidence recommending intraoperative low tidal volume (V_T) ventilation. We aimed to explore the association between V_T adjusted for ideal body weight (IBW) and the occurrence of postoperative pulmonary complications in subjects who were morbidly obese and undergoing abdominal surgery, as well as its implications on intraoperative ventilatory variables. **METHODS:** We included 734 subjects with a body mass index of at least 40 kg/m², undergoing open or laparoscopic abdominal surgery that lasted for at least 120 min. Clinical variables were obtained to estimate the preoperative pulmonary risk as well as intraoperative ventilator data to perform associations. Outcomes were defined by medical billing code diagnoses and oxygen use. All data were collected electronically by using Structured Query Language. **RESULTS:** The subjects received a mean V_T /IBW of 9.41 mL/kg IBW, and postoperative pulmonary complications occurred in 7.5% of the subjects. The occurrence of complications was correlated with the presence of several preoperative risk factors for postoperative pulmonary complications. V_T /IBW was not associated with postoperative pulmonary complications. This finding remained present after separating different levels of V_T /IBW. In a multivariate analysis, only laparoscopic surgery was an independent protective factor against postoperative pulmonary complications (odds ratio 0.07, 95% CI 0.01–0.55). **CONCLUSIONS:** V_T /IBW was not associated with the occurrence of postoperative pulmonary complications in subjects who were morbidly obese and undergoing prolonged abdominal surgery. Future prospective studies are indicated to guide the optimum ventilation strategy for patients who are morbidly obese. *Key words:* morbid obesity; tidal volume; pulmonary complications; surgery; laparoscopy; ventilation. [Respir Care 2020;65(12):1908–1915. © 2020 Daedalus Enterprises]

Introduction

In the general population, a protective lung ventilation strategy during surgery results in a decreased incidence of postoperative pulmonary complications.^{1–3} The combination of low tidal volume (V_T) and PEEP, with or without recruitment maneuvers, has been shown to be the most

beneficial.^{4–6} In the surgical setting, studies used and defined protective V_T as 5–8 mL/kg ideal body weight (IBW), and compared it with conventional V_T of >8 mL/kg IBW, which usually ranges between 9 and 12 mL/kg IBW.^{1,2} Despite a strong level of evidence behind these interventions, it has been demonstrated that intraoperative lung-protective strategies are not uniformly used in clinical practice.⁷

Severe grades of obesity are poorly represented in the cumulative evidence,¹ and patients who are morbidly obese

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The authors declare no conflicts of interest.

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are particularly prone to receive higher V_T when adjusted for IBW.⁸ Although other components of lung protective ventilation have been evaluated in several trials, to our knowledge, a low V_T strategy has never been tested in trials for this population.⁹ The aim of this study was to explore V_T in relation to the postoperative pulmonary outcome of subjects who were morbidly obese, as well as its implications on intraoperative ventilatory settings. This was intended to be an exploratory analysis because an evidence-based recommendation for V_T has not been specifically defined for this population.

Methods

Study Design

This was a retrospective single-center study at a tertiary care, university-affiliated hospital. Approval from our institutional review board was obtained before initiation of the study, and it was considered exempt from the need of informed consent.

Inclusion and Exclusion Criteria

We selected open or laparoscopic abdominal-pelvic procedures that lasted at least 120 min (from induction to extubation). We included adult subjects (ages ≥ 18 y) with a body mass index (BMI) of at least 40 kg/m² who were admitted for postoperative care, intubated after induction, and extubated at the end of the procedure. Cardiac, thoracic, vascular, head and neck, neurosurgical, and other nonabdominal procedures were excluded. Our selection criteria assumed that protective strategies might have differential effects in nonabdominal surgery¹⁰ and that pulmonary outcomes should be addressed separately for cardiothoracic procedures. We also excluded cesarean sections and gynecologic procedures that did not require laparoscopy or an abdominal or pelvic skin incision (eg, dilation and curettage). Records that lacked information with regard to height and weight, an electronic anesthesia record, or preoperative S_{pO_2} were also excluded.

Variables

Preoperative Variables. We obtained demographics, which included age, sex, weight, and height. We also obtained the clinical variables that were relevant to estimate the preoperative risk of postoperative pulmonary complications based on the risk factors outlined by the ARISCAT (Assess Respiratory Risk in Surgical Patients in Catalonia) score,¹¹ a well-known and externally validated risk score.¹² This included the American Society of Anesthesiologists physical status, a system with 6 classes that reflect progressive increases in preoperative morbidity.¹³ We also

QUICK LOOK

Current knowledge

In the general population, intraoperative protective ventilation with low tidal volumes is currently recommended. Nonetheless, patients who are morbidly obese are more likely to receive high tidal volumes, which has not been linked in observational studies to more complications in this population.

What this paper contributes to our knowledge

In this retrospective study, low tidal volume was not associated with clinical postoperative pulmonary complications. In turn, laparoscopic surgery (as opposed to open surgery) was independently correlated with decreased pulmonary complications.

collected the history of COPD, asthma, laparoscopic and/or open surgery, liver cirrhosis, and congestive heart failure because these are known risk factors not included in the score.^{14,15}

Intraoperative Variables. Data were derived from the anesthesia information management system, which was implemented in January 2015. In our institution, an electronic anesthesia record is generated with prospectively collected information transmitted from the anesthesia machine and monitor. Other data that required manual input from the provider include the anesthetic events (induction, intubation, emergence, extubation, recruitment maneuvers) as well as medications administered, which can also be recorded in real time with 1-min intervals. We collected expiratory V_T , mode of ventilation, PEEP, breathing frequency, peak inspiratory pressure (PIP), and end-tidal carbon dioxide (P_{ETCO_2}) levels for our analysis.

Data Collection

The Department of Quality and Clinical Analytics performed an electronic search of the data by using Structured Query Language of the electronic medical records. No data were collected manually, but the data set was examined after collection to ensure that the inclusion and exclusion criteria were met.

Outcomes

We collected respiratory outcomes at 30 d after surgery. These included new diagnoses of pneumonia (including aspiration pneumonitis), atelectasis, bronchitis or exacerbation of COPD or asthma, mild respiratory failure (defined

as the need of supplementary oxygen starting 12 h after surgery until 5 d after surgery), severe respiratory failure (a diagnosis of acute respiratory failure by International Classification of Diseases code or a need of intubation), and pleural effusion. As with the preoperative clinical history, most of the postoperative outcomes (except oxygen use and intubation) were collected by using the presence of ICD-10 that matched these events. The presence of these diagnoses determined the occurrence of an event or postoperative pulmonary complication. Because the oldest portion of the sample may have included ICD-9, the entire sample was also queried for the corresponding ICD-9 and these were included in the outcomes. Our primary outcome was the proportion of the subjects who experienced any postoperative pulmonary complications at 30 d.

Statistical Analysis

The subjects were stratified into 2 groups based on whether they experienced postoperative pulmonary complications. IBW was calculated by using the following formula¹⁶: IBW for men (kg) = $50 + 2.3 (\text{height [in]} - 60)$, and IBW for women (kg) = $45.5 + 2.3 (\text{height [in]} - 60)$. The baseline characteristics, preoperative risk factors, and intraoperative ventilator data were summarized with mean, SD, or median and interquartile range for continuous variables, and frequency and proportion for categorical variables. The subjects were divided into 2 groups by whether they experienced postoperative pulmonary complications. The 2 groups were compared with the independent *t* test or the Wilcoxon rank-sum test for continuous variables, and the chi-square test or Fisher exact test if any cell with an expected frequency <5 for categorical variables. For our secondary analysis, we explored the relationship between V_T /IBW ratio and PIP, P_{ETCO_2} , PEEP, and minute ventilation by using Pearson correlations. Scatterplots were used to visualize data. All statistical analyses were performed by using R software (version 3.6, R Foundation for Statistical Computing, Vienna, Austria). All statistical tests were 2-sided, and $P < .05$ was considered statistically significant.

The intraoperative ventilator data were filtered to exclude any data point outside of the time interval between intubation and extubation as well as modes of ventilation considered to be primarily spontaneous or not controlled by the anesthesia machine (eg, spontaneous, manual, pressure support, and CPAP). An examination of the data points of synchronized intermittent mandatory ventilation modes revealed that these values did not affect the average or the distribution of the data, for which they were included as part of the mean. For V_T , blank data points and data points with no specification of a ventilation mode were also excluded from the analysis. To adjust for erroneous data,

the following were the ranges for inclusion of the intraoperative data points: V_T between 4 and 15 mL/kg IBW, PEEP between 0 and 20 cm H₂O, PIP between 10 and 60 cm H₂O, P_{ETCO_2} between 20 and 60 mm Hg, and breathing frequency of 6–22 breaths/min. We then calculated the mean for every one of the variables.

Results

We identified, through the electronic search, 961 records of surgeries performed between January 2015 and March 2018. We examined these records and eliminated those erroneously identified as abdominal (eg, endovascular procedures) as well as those records that lacked preoperative SpO_2 values. A total of 734 surgeries were included in our final sample. The baseline clinical characteristics of our study sample are described in Table 1. In brief, most of the procedures were performed in women (79.6%) and were laparoscopic in nature (77.2%). Certain conditions were prevalent in the subjects who were morbidly obese, including obstructive sleep apnea (52.5%), asthma (24.1%), and recent acute respiratory infection (43.7%). The most common American Society of Anesthesiologists class recorded was 3 (87.3%).

The intraoperative ventilator variables are shown in Table 2. The IBW was mean $\pm$ SD 58.77 ± 10.28 kg, and surgeries lasted a mean $\pm$ SD of 184.99 ± 66.04 min. Importantly, the average PEEP was 5 cm H₂O, with a minimum SD of 0.82. The mean $\pm$ SD V_T was 543 ± 67.74 mL, for a V_T /IBW of 9.41 ± 1.4 mL/kg IBW. Of 734 subjects, 131 (17.8%) received a $V_T < 8$ mL/kg IBW, 357 (48.6%) received a V_T of 8–10 mL/kg IBW, and 246 (33.5%) received a $V_T > 10$ mL/kg IBW.

There were 96 postoperative pulmonary complications in our sample. The most common complication was mild respiratory failure (ie, postoperative supplementary oxygen), which occurred in 46 subjects, followed by severe respiratory failure (21 subjects). Only one subject required reintubation. Other complications recorded were aspiration pneumonia (6 subjects), atelectasis (3 subjects), pneumonia (7 subjects), bronchitis (6 subjects), and pleural effusion (6 subjects). Overall, 55 of 734 subjects (7.5%) had at least one postoperative pulmonary complication. In the subjects who received <8, 8–10, and >10 mL/kg IBW, the rates of complications were 4.58 (6/131), 9.17 (30/357), and 8.37% (19/227), respectively.

The subjects who experienced pulmonary complications were older (55.42 vs 47.63 y; $P < .001$), had more American Society of Anesthesiologists class 4 (20.1 vs 1.6%; $P < .001$), underwent an emergency (30.9 vs 5.2%; $P < .001$), and open abdominal procedures (56.4 vs 20%; $P < .001$) more frequently, and had a longer duration of surgery (227.95 vs 181.51 min; $P = .002$). In addition, these subjects had a higher prevalence of congestive heart

Table 1. Baseline Clinical Characteristics Among Subjects Who Were Morbidly Obese and Undergoing Abdominal Surgery in Relation With Postoperative Pulmonary Complications

Variable	All Subjects (N = 734)	Yes (n = 55)	No (n = 679)	P
Age				
≤50 y	419 (57.1)	21 (38.2)	398 (58.6)	.001
51–80 y	314 (42.8)	33 (60)	281 (41.4)	
>80 y	1 (0.1)	1 (1.8)	0 (0)	
Race				
White	309 (42.1)	22 (40)	287 (42.3)	.66
Black	80 (10.9)	8 (14.5)	72 (10.6)	
Others	345 (47)	25 (45.5)	320 (47.1)	
Sex				
Women	584 (79.6)	44 (80)	540 (79.5)	>.99
Men	150 (20.4)	11 (20)	139 (20.5)	
American Society of Anesthesiologists physical status class				
2	69 (9.4)	0 (0)	69 (1.2)	<.001
3	641 (87.3)	42 (76.4)	599 (88.2)	
4	22 (3)	11 (20)	11 (1.6)	
5	2 (.3)	2 (3.6)	0 (0)	
Emergency surgery				
No	682 (92.9)	38 (69.1)	644 (94.8)	<.001
Yes	52 (7.1)	17 (30.9)	35 (5.2)	
Laparoscopic surgery				
No	167 (22.8)	31 (56.4)	136 (20)	<.001
Yes	567 (77.2)	24 (43.6)	543 (80)	
Acute respiratory infection				
No	413 (56.3)	26 (47.3)	387 (57)	.21
Yes	321 (43.7)	29 (52.7)	292 (43)	
History of obstructive sleep apnea				
No	349 (47.5)	27 (49.1)	322 (47.4)	.92
Yes	385 (52.5)	28 (50.9)	357 (52.6)	
History of congestive heart failure				
No	681 (92.8)	42 (76.4)	639 (94.1)	<.001
Yes	53 (7.2)	13 (23.6)	40 (5.9)	
History of asthma				
No	557 (75.9)	43 (78.2)	514 (75.7)	.80
Yes	177 (24.1)	12 (21.8)	165 (24.3)	
History of cirrhosis				
No	721 (98.2)	53 (96.4)	668 (98.4)	.25
Yes	13 (1.8)	2 (3.6)	11 (1.6)	
History of COPD				
No	680 (92.6)	44 (80)	636 (93.7)	.001
Yes	54 (7.4)	11 (20)	43 (6.3)	

failure (23.6 vs 5.9%; $P < .001$), and COPD (20 vs 6.3%; $P = .001$). As expected, the subjects who experienced complications had a higher prevalence of these risk factors of postoperative pulmonary complications.

There were no significant differences in the intraoperative ventilatory variables between subjects who experienced postoperative pulmonary complications and those who did not. We also explored the association between peak pressure and pulmonary complications reported in the LAS VEGAS study^{17,18} as well as the modified driving pressure because it has been suggested as a risk factor for severe complications (ie, intubation).¹⁹ Again, there was no significant difference between peak pressures, modified driving pressures, and the occurrence of complications.

Overall, in univariate logistic regression analysis (Tables 1 and 2), several variables were associated with the occurrence of postoperative pulmonary complications: older age, higher American Society of Anesthesiologists Classification, emergency surgery, non-laparoscopic surgery, longer duration of surgery, history of congestive heart failure, and history of COPD. Neither V_T nor V_T/IBW were associated with the occurrence of postoperative pulmonary complications.

We then studied V_T along with the other variables in a multivariate logistic regression analysis (Table 3). Importantly, V_T was not associated with the occurrence of pulmonary complications in our study (odds ratio 1.79, 95% CI 0.83–3.86; $P = .14$). We then performed a separate analysis of the rate of postoperative pulmonary complications by using several cutoffs of V_T/IBW . There was no significant difference in the rates of complications when using 8 mL/kg IBW as a cutoff (4.58 vs 8.12%; $P = .23$). The subjects were also subdivided into 3 groups: <8, 8–10, and >10 mL/kg IBW. Neither of these categories were statistically different in their rates of postoperative pulmonary complications (4.58 vs 9.17 vs 8.37%; $P = .36$). Notably, laparoscopic surgery remained as the sole independent protective factor against these pulmonary complications (odds ratio 0.07, 95% CI 0.01–0.55).

Also, we generated scatterplots with V_T or V_T/IBW in relation to PIP, PEEP, modified driving pressure (PIP – PEEP), and P_{ETCO_2} (Fig. 1). Correlation coefficients are depicted in Table 4. Overall, there was poor correlation between the ventilatory variables. Nonetheless, the use of V_T/IBW instead of V_T produced more significant findings, especially with regard to P_{ETCO_2} , in which V_T/IBW had a better correlation ($r -0.363$, 95% CI -0.424 to -0.298 ; $P < .001$).

Discussion

In the subjects who were morbidly obese and undergoing abdominal surgery, V_T/IBW was not associated with the occurrence of postoperative pulmonary complications, even after V_T/IBW was studied in several subgroups to reflect the usage of protective (<8 mL/kg IBW) or nonprotective ventilation (≥ 8 mL/kg IBW) in the intraoperative period. These results were in line with previous

POSTOPERATIVE PULMONARY COMPLICATIONS AND OBESITY

Table 2. Intraoperative Ventilatory Variables Among Subjects Who Were Morbidly Obese and Were Undergoing Abdominal Surgery: Relation With Postoperative Pulmonary Complications

Variable	All Subjects (N = 734)	Yes (n = 55)	No (n = 679)	P
IBW, kg	58.77 ± 10.28	57 ± 1.1	58.91 ± 10.29	.15
BMI, kg/m ²	47.7 ± 6.66	49.73 ± 8.96	47.53 ± 6.42	.08
Duration of surgery, min	184.99 ± 66.04	227.95 ± 107.16	181.51 ± 60.32	.002
V _T , mL	543.02 ± 67.74	535 ± 6.1	543.66 ± 68.32	.24
V _T /IBW, mL/kg	9.41 ± 1.4	9.53 ± 1.11	9.4 ± 1.43	.37
Age, y	48.21 ± 11.8	55.42 ± 11.5	47.63 ± 11.63	<.001
PEEP, cm H ₂ O	5 ± 0.82	5.18 ± 0.95	4.98 ± 0.81	.20
PIP, cm H ₂ O	29.24 ± 4.19	28.74 ± 3.98	29.28 ± 4.21	.34
Modified driving pressure, cm H ₂ O	24.24 ± 4.27	23.56 ± 4.1	24.3 ± 4.28	.21
S _{pO₂} , %	98.86 ± 1.18	98.97 ± 1.17	98.85 ± 1.18	.35
Preoperative S _{pO₂} , %	98.62 ± 3.04	99.23 ± 1.37	98.5 ± 3.26	.66
P _{ETCO₂} , mm Hg	34.75 ± 2.77	34.55 ± 2.61	34.77 ± 2.79	.69
F _{IO₂} , %	0.79 ± 0.16	0.82 ± 0.16	0.79 ± 0.16	.13
Breathing frequency, breaths/min	13.1 ± 1.83	13.35 ± 2.07	13.08 ± 1.8	.40

Data are mean ± SD; IBW = ideal body weight; BMI = body mass index; V_T = tidal volume; PIP = peak inspiratory pressure; P_{ETCO₂} = end-tidal carbon dioxide.

Table 3. Multivariate Logistic Regression Model Between Preoperative and Intraoperative Variables and the Occurrence of Postoperative Pulmonary Complications

Variable	Odds Ratio (95% CI)	P
V _T /IBW	1.79 (0.83–3.86)	.14
Age > 50 y (vs <50 y)	3.37 (0.54–21.21)	.20
Men (vs women)	1.76 (0.2–15.76)	.61
Emergent surgery	1.27 (0.06–25.68)	.88
American Society of Anesthesiologists class		
3	0.35 (0.01–9.27)	.53
4	5.94 (0.12–291.07)	.37
5	1.82 (0.03–97.78)	.77
Acute respiratory infection	2.6 (0.38–17.72)	.33
History of		
OSA	1 (0.17–5.93)	>.99
COPD	2.35 (0.21–26.56)	.49
Asthma	0.61 (0.08–4.92)	.65
Cirrhosis	0.86 (0.01–66.57)	.95
Congestive heart failure	6.99 (0.61–80.49)	.12
Duration of surgery	1.01 (1–1.02)	.11
Laparoscopic surgery (vs open surgery)	0.07 (0.01–0.55)	.01
S _{pO₂}		
Intraoperative	1.11 (0.48–2.59)	.81
Preoperative	0.97 (0.73–1.29)	.81
PIP	0.95 (0.66–1.37)	.79
Modified driving pressure	1.04 (0.73–1.49)	.82

V_T = tidal volume
IBW = ideal body weight
OSA = obstructive sleep apnea
PIP = peak inspiratory pressure

observational data for individuals who were not obese and individuals who were obese (BMI > 30 kg/m²), in which V_T was not an independent predictor of pulmonary complications.^{17,18}

The average V_T/IBW used in our population was 9.41 mL/kg IBW, which showed that protective ventilation strategies are not being routinely followed in this population, even though BMI is an independent predictor of pulmonary complications²⁰ and obstructive sleep apnea is more prevalent in patients who are morbidly obese.²¹ There was no significant difference in V_T/IBW between the subjects who did versus those who did not develop complications (9.5 vs 9.4; *P* = .37), as has been previously reported in the general¹⁸ and in high-risk populations.¹⁴ Although the V_T used in our sample was higher, the results were in line with the idea that higher BMIs are associated with higher V_T either as an effect of BMI^{8,17} per se or because of the discrepancies between actual and IBW.⁷

It is notable that there was minimum variability in the levels of PEEP used in these subjects, most of them who received only 5 cm H₂O. Several studies, which used physiologic and radiologic outcomes, support the use of higher levels of PEEP in this population.^{9,22–24} Nonetheless, the PROBESE trial showed that a higher PEEP strategy did not improve clinical outcomes among patients who are obese.²⁵ The most significant finding among the ventilatory parameters was that V_T/IBW was significantly better correlated to P_{ETCO₂} than to V_T alone.

Although several risk factors were identified in the univariate analysis, including older age, American Society of

Fig. 1. Relationship between V_T and other intraoperative ventilatory variables. A: V_T versus PIP. B: V_T versus modified driving pressure (PIP – PEEP). C: V_T versus P_{ETCO_2} . D: V_T/IBW versus PIP. E: V_T/IBW versus modified driving pressure (PIP – PEEP). F: V_T/IBW versus P_{ETCO_2} . Red triangles indicate the values at which postoperative pulmonary complications occurred. V_T = tidal volume; PIP = peak inspiratory pressure; P_{ETCO_2} = end-tidal carbon dioxide; IBW = ideal body weight.

Table 4. Pearson Correlation Among Intraoperative Ventilation Data

Variable 1	Variable 2	Pearson r (95% CI)	P
PIP	V_T	–0.037 (–0.109 to 0.035)	.31
P_{ETCO_2}	V_T	–0.216 (–0.284 to –0.146)	<.001
Modified driving pressure (PIP – PEEP)	V_T	–0.012 (–0.085 to 0.06)	.74
Modified driving pressure (PIP – PEEP)	V_T/IBW	0.144 (0.073–0.214)	<.001
P_{ETCO_2}	V_T/IBW	–0.363 (–0.424 to –0.298)	<.001
PIP	V_T/IBW	0.112 (0.04–0.183)	.002

PIP = peak inspiratory pressure
 V_T = tidal volume
 P_{ETCO_2} = end-tidal carbon dioxide
IBW = ideal body weight

Anesthesiologists physical status, emergent surgery, history of congestive heart failure and COPD, and duration of surgery, the only variable that remained statistically significant in the multivariate analysis was laparoscopic surgery. Postoperative pulmonary complications occurred in 18.6% of subjects undergoing open abdominal procedures

compared with 4.2% in those having laparoscopic surgery (odds ratio 0.07, 95% CI 0.01–0.55; $P = .01$).

Patients who are morbidly obese can present a significant challenge for intraoperative ventilation. Decreased lung volumes^{26,27} and decreased respiratory compliance²⁸ can lead to hypercapnia, hypoxia, and high inspiratory pressures. In addition, laparoscopic surgery has been conceived to promote atelectasis by displacing the diaphragm cephalad and decreasing pulmonary compliance. In fact, higher levels of PEEP are required to maintain a neutral transpulmonary pressure.²⁹ If laparoscopic surgery remains a protective risk factor in prospective studies for patients who are morbidly obese, it would suggest that the pulmonary benefits of laparoscopic abdominal procedures (compared with open procedures) outweigh the intraoperative challenges that may arise from the increased intra-abdominal pressure.

Our study had several strengths. We used the electronic system to include the largest sample to date in a study that concerned perioperative protective ventilation in the patients who were morbidly obese. Our outcomes were based on diseases and diagnoses for which they were clinically relevant. Moreover, the data collection for intraoperative ventilatory parameters was accurate because it is electronically and prospectively generated and filtered for erroneous data.

We acknowledge several limitations in our study. The retrospective nature of our cohort had an inherent risk for selection bias, and the accuracy of the postoperative events was limited by reporting. Although postoperative events remain close to those of the general population, these are underestimated when considering the higher overall rates in patients who are obese.¹² In addition, only 17.8% of the subjects received low V_T . This limited our ability to determine other independent predictors, such as V_T or peak pressure.

The clinical outcomes are based on International Classification of Diseases code diagnoses and not on events determined by clinical criteria. For certain complications, such as atelectasis, pneumonia, or bronchitis, a diagnosis may only be generated in the medical record when it needs to be addressed as a clinical problem or may be suspected and recorded in the record but not confirmed. In addition, routine imaging may not be performed to confirm the absence of a complication. Overall, we suspect the rate of events was underestimated with this approach. Although clinically modifiable as an independent variable, V_T may be protective because of the resultant effect on inspiratory pressures. In fact, the only intraoperative ventilatory parameter in the LAS VEGAS study that conferred a higher risk of complications was peak pressure.¹⁸ Overall, the evidence is limited in evaluating V_T independently because the studies investigated mainly bundled interventions⁶ or adjusting V_T in function of the resultant inspiratory pressures.¹⁶

Conclusions

V_T was not correlated to an increased frequency or risk of postoperative pulmonary complications in the subjects who were morbidly obese and undergoing prolonged abdominal surgery. The optimum ventilation strategy for this population is still unclear. Prospective trials that compare the effect of adherence with a protective ventilation bundle to the current practice in patients who are morbidly obese are, therefore, required. Alternatively, other ventilation targets, such as peak pressure, individualized PEEP titration, and transpulmonary pressures, might clarify the actual role of V_T in pulmonary complications. We propose that the outcomes of future studies should continue to be clinical and weigh the severity of complications, ultimately influencing clinical practice.

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