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A SYSTEMATIC REVIEW OF ONE LUNG VENTILATION DURING THORACIC SURGERY COMPARING THE SAFETY AND EFFICACY OF LOW AND HIGH TIDAL VOLUME

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ABSTRACT

Background: Postoperative pulmonary complications are common and highly morbid, particularly in thoracic surgery patients. Previous reports have demonstrated that protective ventilation can improve postoperative pulmonary function and reduce the incidence of complications, but the precise definition of protective ventilation remains elusive.

The aim: The aim of this study to show about one lung ventilation during thoracic surgery comparing the safety and efficacy of low and high tidal volume.

Methods: By the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, this study was able to show that it met all of the requirements. This search approach, publications that came out between 2014 and 2024 were taken into account. Several different online reference sources, like Pubmed, SagePub, and Sciencedirect were used to do this. It was decided not to take into account review pieces, works that had already been published, or works that were only half done.

Result: Eight publications were found to be directly related to our ongoing systematic examination after a rigorous three-level screening approach. Subsequently, a comprehensive analysis of the complete text was conducted, and additional scrutiny was given to these articles.

Conclusion: Low tidal volumes (defined as less than 10 mL/kg) decreases pneumonia and the need for postoperative ventilatory support (invasive and non-invasive).

Keyword: One lung ventilation, thoracic surgery, high tidal volume, low tidal volume.

INTRODUCTION

Acute respiratory failure due to acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) is a common reason for admission to intensive care units (ICUs) worldwide. A third to half of people with ALI/ARDS die in the ICU, in hospital or during follow-up. People with ALI/ARDS are put on ventilator machines to give the lungs time to recover. However, lung damage can worsen if the volume of air delivered by these machines is too large, or if the pressure reached in the lungs during ventilation is too high.[1]

Positive pressure ventilation (PPV) is one of the key methods in critical care medicine for maintaining gas exchange and providing an opportunity for recovery from direct or indirect pulmonary injury. Additionally, controlled PPV is required in many surgical interventions conducted under general anesthesia. In both perioperative settings and severe acute respiratory distress syndrome (ARDS), ventilation is associated with neuromuscular blockade and allows precise control of respiratory parameters and gas exchange. However, similar to many other invasive techniques, ventilation can be accompanied by both pulmonary and extrapulmonary complications and is associated with life-threatening respiratory events and remote organ dysfunction.[2]

With the continuous development of thoracic surgery, especially video-assisted thoracoscopic surgery (VATS), one-lung ventilation (OLV) is becoming an essential component of thoracic anesthesia. The two principal devices used for achieving OLV are a double-lumen tube (DLT) and a bronchial blocker (BB).[3,4]

OLV requires effective nonventilated lung collapse to facilitate surgical exposure. The insertion of a DLT is a well-established technique for achieving OLV; however, since a DLT has a relatively large external diameter and needs to be rotated during the insertion process, the potential risk for traumatic injuries to the airway is high. An alternate technique for achieving OLV is the use of a BB. The use of a BB causes few hemodynamic fluctuations, and the incidence of postoperative sore throat is low, but some studies have suggested that the use of a BB takes longer to collapse the operative lung than the use of a DLT, especially in patients with chronic obstructive pulmonary disease (COPD).[4–6]

This review focuses on these therapies and their role in the management of severe respiratory failure in ARDS when lung protective ventilation with low tidal volumes and a plateau airway pressure limit according to ARDS Network protocol is not sufficient to manage hypoxemia, respiratory acidosis, or markedly elevated plateau airway pressure.[7]

Indeed, there are several important examples in which improved oxygenation may be associated with increased mortality. In the pivotal ARDS Network trial of low tidal volume ventilation, although the higher tidal volume arm initially showed improved oxygenation, this group ultimately had a higher mortality. Similarly, although use of high frequency oscillatory ventilation has been associated with improved oxygenation, recent randomized controlled trials have shown either no benefit or possible harm. It is important to remember to exercise caution with regard to oxygenation as a meaningful outcome variable in ARDS.[7,8]

METHODS

PROTOCOL

By following the rules provided by Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, the author of this study made certain that it was up to par with the requirements. This is done to ensure that the conclusions drawn from the inquiry are accurate.

CRITERIA FOR ELIGIBILITY

For the purpose of this literature review, we compare and contrast one lung ventilation during thoracic surgery comparing the safety and efficacy of low and high tidal volume. It is possible to accomplish this by researching of the one lung ventilation during thoracic surgery comparing the safety and efficacy of low and high tidal volume. As the primary purpose of this piece of writing, demonstrating the relevance of the difficulties that have been identified will take place throughout its entirety.

In order for researchers to take part in the study, it was necessary for them to fulfil the following requirements: 1) The paper needs to be written in English, and it needs to determine about the one lung ventilation during thoracic surgery comparing the safety and efficacy of low and high tidal volume. In order for the manuscript to be considered for publication, it needs to meet both of these requirements. 2) The studied papers include several that were published after 2014, but before the time period that this systematic review deems to be relevant. Examples of studies that are not permitted include editorials, submissions that do not have a DOI, review articles that have already been published, and entries that are essentially identical to journal papers that have already been published.

SEARCH STRATEGY

We used " one lung ventilation during thoracic surgery comparing the safety and efficacy of low and high tidal volume." as keywords. The search for studies to be included in the systematic review was carried out using the PubMed, SagePub, and Sciencedirect databases.

Table 1. Search Strategy

Database	Search Strategy	*Hits*
Pubmed	*((*"Thoracic surgery"*[MeSH Subheading] OR* "lung ventilation"*[All Fields] OR* "low tidal volume*" [All Fields]) AND (*"High tidal volume"*[All Fields] OR* "outcome"*[All Fields]) AND (*"Efficacy"*[All Fields]) OR (*"Safety*" [All Fields]))*	21943
Science Direct	*((*"Thoracic surgery"*[MeSH Subheading] OR* "lung ventilation"*[All Fields] OR* "low tidal volume*" [All Fields]) AND (*"High tidal volume"*[All Fields] OR* "outcome"*[All Fields]) AND (*"Efficacy"*[All Fields]) OR (*"Safety*" [All Fields]))*	52
Sagepub	*((*"Thoracic surgery"*[MeSH Subheading] OR* "lung ventilation"*[All Fields] OR* "low tidal volume*" [All Fields]) AND (*"High tidal volume"*[All Fields] OR* "outcome"*[All Fields]) AND (*"Efficacy"*[All Fields]) OR (*"Safety*" [All Fields]))*	4

DATA RETRIEVAL

After reading the abstract and the title of each study, the writers performed an examination to determine whether or not the study satisfied the inclusion criteria. The writers then decided which previous research they wanted to utilise as sources for their article and selected those studies. After looking at a number of different research, which all seemed to point to the same trend, this conclusion was drawn. All submissions need to be written in English and cannot have been seen anywhere else.

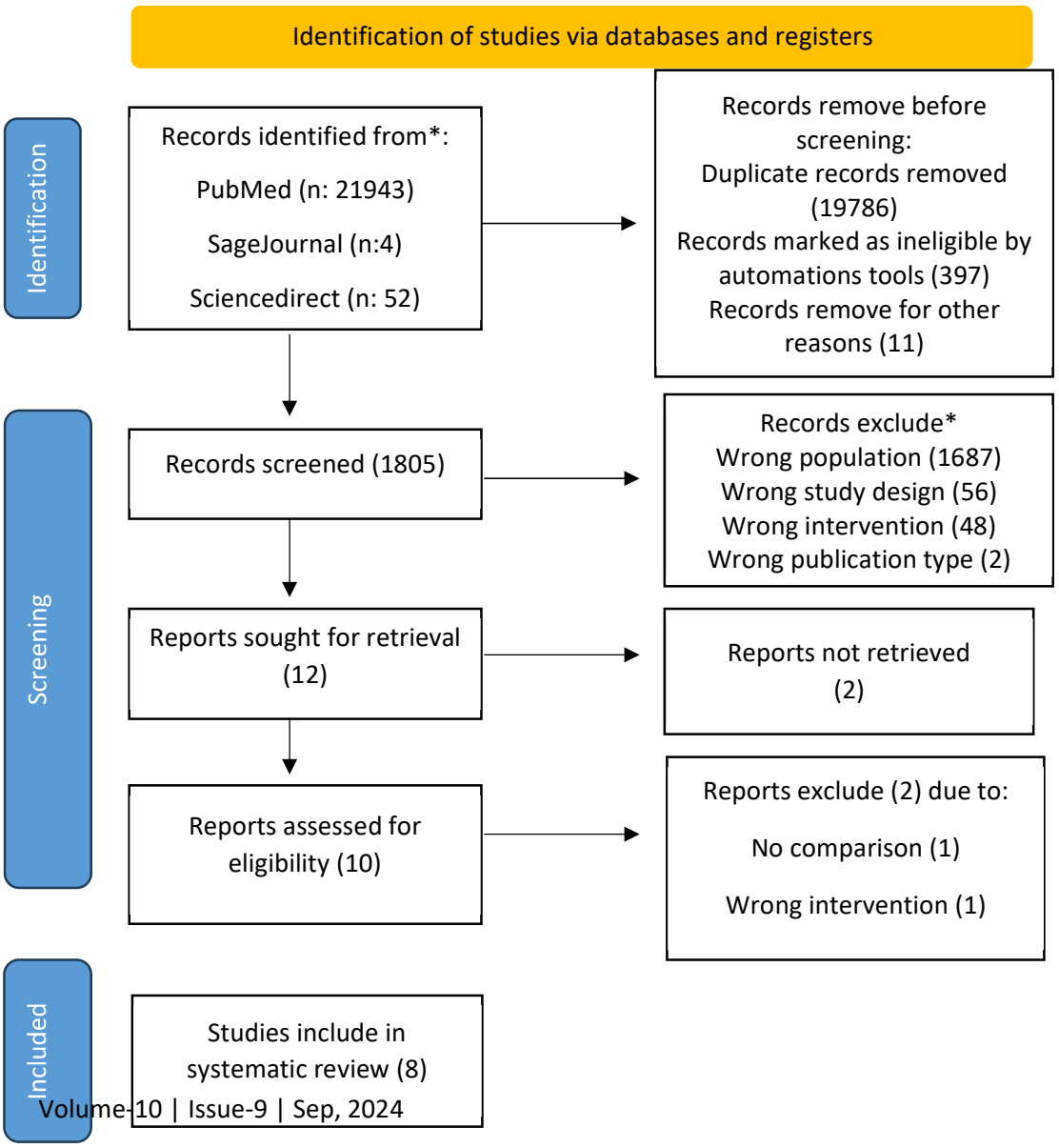

Figure 1. Article search flowchart

Only those papers that were able to satisfy all of the inclusion criteria were taken into consideration for the systematic review. This reduces the number of results to only those that are pertinent to the search. We do not take into consideration the conclusions of any study that does not satisfy our requirements. After this, the findings of the research will be analysed in great detail. The following pieces of information were uncovered as a result of the inquiry that was carried out for the purpose of this study: names, authors, publication dates, location, study activities, and parameters.

QUALITY ASSESSMENT AND DATA SYNTHESIS

Each author did their own study on the research that was included in the publication's title and abstract before making a decision about which publications to explore further. The next step will be to evaluate all of the articles that are suitable for inclusion in the review because they match the criteria set forth for that purpose in the review. After that, we'll determine which articles to include in the review depending on the findings that we've uncovered. This criteria is utilised in the process of selecting papers for further assessment. in order to simplify the process as much as feasible when selecting papers to evaluate. Which earlier investigations were carried out, and what elements of those studies made it appropriate to include them in the review, are being discussed here.

Table 2. Critical appraisal of Study

Parameters	(Colquhoun, DA et al., 2022)	(Liu X & Wang, L., 2022)	(Kiss, T et al., 2019)	(Kremer, R et al., 2019)	(Li, X et al., 2024)	(Wang, YP et al., 2021)	(Guay, J et al., 2018)	(Templeton, TW et al., 2022)
1. Bias related to temporal precedence								
Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Bias related to selection and allocation								
Was there a control group?	No	No	No	No	No	No	No	No
3. Bias related to confounding factors								
Were participants included in any comparisons similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Bias related to administration of intervention/exposure								
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No	No	No	No	No	No	No	No
5. Bias related to assessment, detection, and measurement of the outcome								
Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	No	No	No	No	No	No	No	No
Were the outcomes of participants included in any comparisons measured in the same	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

way? Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Bias related to participant retention Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Statistical conclusion validity Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

RESULT

Using reputable resources like Science Direct, PubMed, and SagePub, our research team first gathered 21999 publications. A thorough three-level screening strategy was used to identify only eight papers as directly relevant to our ongoing systematic evaluation. Next, a thorough study of the entire text and further examination of these articles were selected. Table 1 compiles the literature that was analyzed for this analysis in order to make it easier to view.

Table 1. The litelature include in this study

Author	Origin	Method	Sample	Result
Colquhoun, DA et al., 2022[9]	USA	We merged Society of Thoracic Surgeons Database and Multicenter Perioperative Outcomes Group intraoperative data for lung resection procedures using one lung ventilation across five institutions from 2012 to 2016.	3232	3,232 cases were available for analysis. Tidal volumes decreased modestly during the study period (6.7 ml/kg to 6.0 ml/kg, $p < 0.001$) and positive end expiratory pressure increased from 4 to 5 cm H_2O ($p < 0.001$). Despite increasing adoption of a "protective ventilation" strategy (5.7% in 2012 versus 17.9% in 2016), the prevalence of pulmonary complications did not change significantly (11.4% to 15.7%, $p = 0.147$). In a propensity score matched cohort (381 matched pairs), protective ventilation (mean tidal volume 6.4 vs 4.4 mL/kg) was not associated with a reduction in pulmonary complications (adjusted odds ratio 0.86, 95% confidence interval 0.56, 1.32). In an unmatched cohort, we were unable to define a specific alternative combination of positive end expiratory pressure and tidal volume that was associated with decreased risk of pulmonary complications.
Liu X & Wang, L., 2022[10]	China	From June 2019 to December 2021, the clinical data of 96 patients undergoing	44	At 1 hour and 4 hours of ventilation, the peak airway pressure (Ppeak), Pmean mean airway pressure (Pmean) and airway resistance (Raw) of the OG were lower than those of

		thoracic surgery in Cangzhou Central Hospital were retrospectively analyzed.		the CG, and the dynamic lung compliance (Cdyn) was higher than that of the CG (P<0.05). There were no statistically significant differences in mean arterial pressure (MAP), heart rate (HR), blood oxygen saturation (SpO_2), PH, arterial partial pressure of oxygen (PaO_2), arterial partial pressure of carbon dioxide ($PaCO_2$) between the OG and CG at 1 hour and 4 hours of ventilation respectively (P>0.05). The serum levels of pulmonary surfactant associated protein A (SP-A), human Clara cell protein (CC16) and serum ferritin (SF) in the OG were lower than those in the CG (P<0.05). The incidence of VAP in the OG (3.85%) was lower than that in the CG (15.91%) (P<0.05).
Kiss,T et al., 2019[11]	Germany	PROTHOR is an international, multicenter, randomized, controlled, assessor-blinded, two-arm trial initiated by investigators of the PROtective VEntilation NETwork. In total, 2378 patients will be randomly assigned to one of two different intraoperative mechanical ventilation strategies.	2378	PROTHOR is the first randomized controlled trial in patients undergoing thoracic surgery with OLV that is adequately powered to compare the effects of intraoperative high PEEP with RM versus low PEEP without RM on PPC. The results of the PROTHOR trial will support anesthesiologists in their decision to set intraoperative PEEP during protective ventilation for OLV in thoracic surgery.
Kremer, R et al., 2019[12]	Israel	This is a prospective study of 30 adult patients undergoing elective video assisted thoracoscopic lung lobectomy. Each patient was ventilated in four modes: two lung ventilation, OLV, OLV + CPAP	30	Oxygenation during OLV+ CPAP was significantly lower that OLV + DLV ($p = 0.018$). There were insignificant alterations of pH, PCO2 and HCO3 during the different ventilating modes. The surgeons' assessments of interference in the field exposure between OLV + CPAP or OLV + DLV was found to be insignificant ($p = 0.073$).

		and OLV + DLV.		
Li, X et al., 2024[13]	China	Five hundred ninety-three patients with esophageal cancer who underwent elective MIE with two-field lymph node dissection were analyzed. Patients in the TLV group were intubated using a single-lumen endotracheal tube and underwent surgery using TLV with artificial CO_2 pneumothorax.	593	The TLV and OLV group comprised 513 and 80 patients, respectively. PSM matched 197 TLV group and 73 OLV group patients. Incidence of pneumonia within the first 3 days of surgery was higher in the TLV group (11.7% *vs.* 4.1%) but the difference was not significant (P=0.06). The incidence of infiltrates on chest radiography was 36.0% in the TLV group and 28.8% in the OLV group (P=0.26). Incidence of other major PPCs requiring treatment and major non-pulmonary postoperative complications did not significantly differ between the groups. Length of hospital stay was significantly longer in the TLV group (13.0 *vs.* 11.0 days; P=0.03).
Wang, YP et al., 2021[14]	China	We retrospectively analyzed the clinical data of infants aged 2 to 12 months who underwent extratracheal bronchial blockage for OLV in our center between January 2017 and August 2020. The infants were divided into two groups according to the OLV pattern: group G (n=30, receiving PCV-VG) and group V (n=28, receiving VCV).	58	We retrospectively analyzed the clinical data of infants aged 2 to 12 months who underwent extratracheal bronchial blockage for OLV in our center between January 2017 and August 2020. The infants were divided into two groups according to the OLV pattern: group G (n=30, receiving PCV-VG) and group V (n=28, receiving VCV).
Guay, J et al., 2018[15]	Canada	We searched the Cochrane Central Register of Controlled Trials (CENTRAL 2017, Issue 5), MEDLINE (OvidSP) (from 1946 to 19 May 2017), Embase	1548	In total, we included 19 studies in the review (776 participants in the low tidal volume group and 772 in the high volume group). There are four studies awaiting classification and three are ongoing. All included studies were at some risk of bias. Participants were scheduled for abdominal surgery, heart surgery, pulmonary

		(OvidSP) (from 1974 to 19 May 2017) and six trial registries.		thromboendarterectomy, spinal surgery and knee surgery. Low tidal volumes used in the studies varied from 6 mL/kg to 8.1 mL/kg while high tidal volumes varied from 10 mL/kg to 12 mL/kg.
Templeton, TW et al., 2022[16]	USA	The Multicenter Perioperative Outcomes database and a local quality improvement database were queried for documentation of one-lung ventilation in children 2 months to 3 yr of age inclusive between 2010 and 2020.	306	Three hundred six cases from 15 institutions were included for analysis. Hypoxemia and severe hypoxemia occurred in 81 of 306 (26%) patients and 56 of 306 (18%), respectively. Hypercarbia occurred in 153 of 306 (50%). Factors associated with lower risk of hypoxemia in multivariable analysis included left operative side (odds ratio, 0.45 [95% CI, 0.251 to 0.78]) and bronchial blocker use (odds ratio, 0.351 [95% CI, 0.177 to 0.67]). Additionally, use of a bronchial blocker was associated with a reduced risk of severe hypoxemia (odds ratio, 0.290 [95% CI, 0.125 to 0.62]).

DISCUSSION

Every year an estimated 1.25 million patients undergo cardiac surgery with cardiopulmonary bypass (CPB) worldwide. Despite fast-track protocols, postoperative pulmonary complications, ranging from mild hypoxemia to acute respiratory distress syndrome, are common after on-pump cardiac surgery. Such postoperative complications have been shown to extend intensive care unit (ICU) stays, increase in-hospital mortality, and lead to adverse financial outcomes in health care.[17,18]

Roughly 230 million major surgical operations are conducted annually throughout the world. For many patients, postoperative recovery will unfortunately be complicated by perioperative lung injury. Between 11% and 59% of patients have a postoperative pulmonary complication (PPC), leading to a significantly higher likelihood of serious morbidity, mortality, and increased use of hospital resources. The most severe form of perioperative lung injury, acute respiratory distress syndrome (ARDS), has been historically reported in 0.4-3% of surgical patients at high risk, leading to a significantly greater risk of postoperative mortality. Consequently, decades of research have assessed strategies to minimize the impact of perioperative lung injury.[19,20]

Preventing postoperative pulmonary complications with the use of low-tidal-volume ventilation (6 to 8 ml per kilogram of predicted body weight [PBW]) is now an established consensus (protective ventilation). However, low tidal volumes promote alveolar collapse in poorly ventilated, dependent regions of the lung. As a result, atelectrauma, secondary to the repetitive collapse and reopening of alveolar units, contributes to ventilator-induced lung injury. The open-lung ventilation strategy corresponds to the use of recruitment maneuvers (‘open the lung’) associated with high levels of positive end-expiratory pressure (PEEP) in order to prevent alveolar collapse (‘keep it open’). This approach has been shown to improve pulmonary mechanics. However, its clinical benefit is still uncertain in surgical patients.[17,21,22]

Lung isolation, a technique largely used to facilitate access during thoracic surgery, can create some difficulty in maintaining a patient’s blood gas balance. Strategies have been used to overcome the ventilation-perfusion mismatch associated with one-lung ventilation (OLV). However, such strategies may induce volutrauma, barotrauma and atelectotrauma in the ventilated lung, leading to acute lung injury (ALI) and/or acute respiratory distress syndrome (ARDS). Different ventilatory parameters have been used to improve the safety and efficacy of OLV, with the use of high or low tidal volumes (VT) being the most contentious.[23–25]

CONCLUSION

In conclusion, low tidal volumes (defined as less than 10 mL/kg) decreases pneumonia and the need for postoperative ventilatory support (invasive and non-invasive).

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