ORIGINAL ARTICLE

Protective ventilation during anaesthesia reduces major postoperative complications after lung cancer surgery

A double-blind randomised controlled trial

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BACKGROUND Thoracic surgery for lung resection is associated with a high incidence of postoperative pulmonary complications. Controlled ventilation with a large tidal volume has been documented to be a risk factor for postoperative respiratory complications after major abdominal surgery, whereas the use of low tidal volumes and positive end-expiratory pressure (PEEP) has a protective effect.

OBJECTIVE To evaluate the effects of ventilation with low tidal volume and PEEP on major complications after thoracic surgery.

DESIGN A prospective, double-blind, randomised controlled study.

SETTING A multicentre trial from December 2008 to October 2011.

PATIENTS A total of 346 patients undergoing lobectomy or pneumonectomy for lung cancer.

MAIN OUTCOME MEASURES The primary outcome was the occurrence of major postoperative complications (pneumonia, acute lung injury, acute respiratory distress syndrome, pulmonary embolism, shock, myocardial infarction or death) within 30 days after surgery.

INTERVENTIONS Patients were randomly assigned to receive either lung-protective ventilation (LPV group) [tidal volume 5 ml kg\(^{-1}\) ideal body weight + PEEP between 5 and 8 cmH\(_2\)O] or nonprotective ventilation (control group) (tidal volume 10 ml kg\(^{-1}\) ideal body weight without PEEP) during anaesthesia.

RESULTS The trial was stopped prematurely because of an insufficient inclusion rate. Major postoperative complications occurred in 23/172 patients in the LPV group (13.4%) vs. 38/171 (22.2%) in the control group (odds ratio 0.54, 95% confidence interval, 0.31 to 0.95, \(P = 0.03\)). The incidence of other complications (supraventricular cardiac arrhythmia, bronchial obstruction, pulmonary atelectasis, hypercapnia, bronchial fistula and persistent air leak) was also lower in the LPV group (37.2 vs. 49.4%, odds ratio 0.60, 95% confidence interval, 0.39 to 0.92, \(P = 0.02\)). The duration of hospital stay was shorter in the LPV group, 11 [interquartile range, 9 to 15] days vs. 12 [9 to 16] days, \(P = 0.048\).

CONCLUSION Compared with high tidal volume and no PEEP, LPV combining low tidal volume and PEEP during anaesthesia for lung cancer surgery seems to improve postoperative outcomes.

TRIALS REGISTRATION ClinicalTrials.gov number: NCT00805077.

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Introduction

Thoracic surgery is an important step in the treatment of lung cancer patients. However, major postoperative complications, especially respiratory complications, are common after thoracic surgery.\textsuperscript{1,2} In-hospital postoperative pulmonary complications reduce long-term survival and increase the cost of health care.\textsuperscript{3,4} In recent years, it has been shown that controlled ventilation during anaesthesia may change the incidence of postoperative pulmonary complications. Large tidal volumes were initially recommended to prevent the occurrence of atelectasis and hypoxaemia during general anaesthesia for major abdominal and thoracic surgery.\textsuperscript{5,6} However, ventilation with high tidal volumes has been shown to be deleterious, inducing repetitive lung overdistension that releases inflammatory cytokines and can thus promote ventilation-induced lung injury (VILI).\textsuperscript{7} In ICU patients suffering from acute respiratory distress syndrome (ARDS), decreasing the tidal volume and increasing the level of positive end-expiratory pressure (PEEP) have been reported to reduce the incidences of mortality and pulmonary complications.\textsuperscript{8,9} In patients scheduled for major abdominal surgery, the use of low tidal volume ventilation, PEEP and lung recruitment manoeuvres during anaesthesia improves postoperative clinical outcomes.\textsuperscript{10}

Patients scheduled for thoracic surgery represent a high-risk population for postoperative pulmonary complications. They require special ventilator settings during surgery, including selective one-lung ventilation. Protective ventilation may consequently lower the incidence of respiratory complications and may have additional benefits including shorter hospital stay and lower rates of postoperative morbidity and mortality. Retrospective studies have indicated that the use of low tidal volumes may decrease the incidence of respiratory complications after thoracic surgery.\textsuperscript{11-13} However, Blank et al.\textsuperscript{14} recently published a retrospective study and documented that during thoracic surgery a large proportion of patients still had general anaesthesia maintained using high tidal volume ventilation and that tidal volume was inversely related to the incidences of respiratory complications and major postoperative morbidity.

The aim of this randomised, prospective clinical study, the Pulmonary Surgery with Protective Ventilation (PPV) trial was to evaluate the benefit of lung-protective ventilation (LPV) in patients scheduled for thoracic surgery for lung cancer. We hypothesised that the use of lower tidal volumes and PEEP during anaesthesia for lung surgery would decrease postoperative complications.

Methods

We designed a prospective, multicentre, double-blind, randomised (1 : 1), controlled study comparing LPV with low tidal volume + PEEP (LPV group) vs. nonprotective (large tidal volume and no PEEP) mechanical ventilation (control group) in patients undergoing thoracic surgery for lung cancer.

Patients between the ages of 18 and 90 years, who were scheduled for elective thoracic surgery (lobectomy or pneumonectomy) for nonsmall-cell lung cancer in one of the 13 French participating centres, were considered eligible. All the patients received verbal and written information and gave their written informed consent for participation prior to surgery. Eligibility criteria were modified by a protocol amendment (accepted by the Ethics Committee on 14 September 2009).

Exclusion criteria were lung resection for noncancer disease or metastasis, urgent surgery, wedge and atypical lung resections, use of positive pressure ventilation before surgery (e.g. continuous positive airways pressure for sleep obstructive apnoea syndrome), liver cirrhosis (Child B or C), chronic renal failure with dialysis, patient’s refusal or inability to give informed consent.

Intraoperatively, the anesthetist in charge of the patient collected data during surgery. Ventilator settings recorded during anaesthesia were concealed in the case report form. The surgeon in charge of the patient was not informed of the ventilator settings. Physicians, not involved in the patient’s care during anaesthesia and surgery, carried out postoperative evaluation, so as to preserve the double blinding. Anaesthesia recordings and ventilator settings during surgery were also concealed from the postoperative physicians (i.e. surgeons, intensivists, anaesthetists) and nurses.

Once full eligibility was confirmed, the investigator randomly assigned patients in a 1 : 1 ratio to receive nonprotective or lung protective ventilation (Fig. 1). Randomisation was stratified according to the regional analgesic technique and the centre.

Patients were assigned to groups with computer-generated block randomisation, prepared by the statistical department.

Patients were allocated randomly to receive volume-controlled mechanical ventilation during anaesthesia using either nonprotective ventilation with a tidal volume of 10 ml kg\textsuperscript{-1} predicted ideal body weight (IBW) and zero PEEP, or LPV with a tidal volume of 5 ml kg\textsuperscript{-1} predicted IBW and a PEEP level between 5 and 8 cmH\textsubscript{2}O. Predicted body weight was calculated for each patient using a previously defined formula.\textsuperscript{8} During one-lung ventilation, the tidal volume was not changed except when the plateau pressure exceeded 30 cmH\textsubscript{2}O, in which case the tidal volume was decreased to remain below this threshold. The PEEP level was not changed during one-lung ventilation. The PEEP applied to the dependent lung was zero in the control group and between 5 and 8 cmH\textsubscript{2}O in the LPV group. Lung expansion manoeuvres were performed in both groups at the discretion of the

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physicians in charge of the patient (anaesthetist and surgeon). Ventilatory rate was fixed to maintain end-tidal CO$_2$ below 6 kPa (45 mmHg). Intravenous fluid infusion, blood transfusion, inspired oxygen fraction ($F_{I\text{O}_2}$) setting, antibiotic prophylaxis, type of anaesthesia (volatile or intravenous), thromboprophylaxis and postoperative care management were determined according to local protocols and physicians’ expertise.

The primary outcome was the occurrence of major pulmonary and nonpulmonary complications or death, during the first 30 days after surgery. Major pulmonary complications included pneumonia, acute respiratory failure (ARF) requiring noninvasive or invasive mechanical ventilation, and pulmonary embolism. Nonpulmonary complications included acute myocardial infarction (MI) and haemodynamic shock.

Pneumonia was defined by the occurrence of new infiltrates on the chest radiograph and at least two of the following criteria: fever (>38.5 °C) or hypothermia (<35.5 °C); leucocyte count less than $4 \times 10^9$ l$^{-1}$ or more than $124 \times 10^9$ l$^{-1}$; or purulent sputum. ARF was defined as a respiratory rate more than 25 bpm and/or pH less than 7.25 and the need for noninvasive or invasive ventilation. Acute lung injury (ALI) was defined by ARF and by $PaO_2/F_I\text{O}_2$ less than 40 kPa (mechanical ventilation) or $PaO_2$ less than 8 kPa during spontaneous breathing with a high oxygen concentration-supplying facemask. ARDS was defined by ARF and by a $PaO_2/F_I\text{O}_2$ less than 26.7 kPa (mechanical ventilation). Pulmonary embolism was defined by the presence of clots on chest spiral computed tomography angiography. Shock was defined as the need for a continuous infusion of a vasopressor agent for more than 12 h. Acute MI was defined by the occurrence of new Q-waves or ST elevation on the ECG and an increase in myocardial enzyme (creatine phosphokinase-MB, troponin I or T) plasma concentrations.

Secondary outcomes were the duration of hospital stay and the incidence of other complications occurring within 30 days after surgery [supraventricular cardiac dysrhythmia, bronchial stasis (bronchial hypersecretion requiring chest physiotherapy or tracheo-bronchial endoscopy), atelectasis (new pulmonary infiltrates with loss of aeration and displacement in interlobar fissures on chest radiograph that necessitated bronchoscopy and/or chest physiotherapy and/or mechanical ventilation), hypercapnia ($P_a\text{CO}_2 > 7.3$ kPa), surgical site infection, myocardial damage (level of troponin I or T above 99th percentile), persistent air leak and bronchial fistula]. Intra-operative hypoxaemia was defined by arterial oxygen saturation less than 90% on pulse oximetry while receiving 100% inspired oxygen.

**Ethics**

Ethical approval for this study (Comité de Protection de Personnes, Paris IDF 6, ID RCB 2007-A00821-52) was provided by the Ethical Committee CPP Ile de France VI of Pitie Salpétrière Hospital, Paris, France (Chairperson Dr L. Capelle) on 15 April 2008. This trial was funded by a national grant (Programme Hospitalier de Recherche Clinique PHRC 0744) and is registered on ClinicalTrials.gov under the number NCT00805077.
Sample size and statistical analysis
We assumed that the incidence of major complications would be 10% in the control group and estimated that the number of patients should be 900 to provide 80% power for detecting a relative difference of 50% in the primary outcome at a two-sided α level of 0.05, allowing a 5% drop-out rate. No interim analysis was planned or performed.

Statistical analysis for the primary and secondary outcomes was performed blind to the allocation group. Baseline categorical characteristics were described as numbers (%) and quantitative variables as mean ± SD or median [interquartile range]. A χ² test was used for the primary outcome analysis. For secondary outcomes, a χ² test or Fisher’s test was used when appropriate to compare dichotomous variables. Continuous variables were compared using the t test or Wilcoxon rank-sum test, when appropriate. Results are presented as proportion and odds ratio (OR) with 95% confidence interval (CI).

We explored the effect of ventilation setting during anaesthesia on the primary outcome, using a Cox model survival analysis. A logistic regression model was performed to identify relevant baseline characteristics associated with the primary outcome, independently from the stratification variables (use or nonuse of epidural analgesia and study centre). Variables were selected for multivariate analysis if the P value was less than 0.1. Known risk factors for complications were also included in the multivariate analysis (smoking status, alcohol abuse, forced expiratory volume in 1 s/forced vital capacity (FEV₁/FVC) ratio less than 70%, side and duration of the surgery, fluid infusion and blood transfusion).

A two-sided P value of less than 0.05 was considered to indicate statistical significance.

All analyses were performed using R software (http://www.r-project.org).

Results
Three hundred and forty-six patients were included and randomised in 13 thoracic surgical centres over a 33 month period. The decision to stop patient recruitment prematurely was taken at the end of this period because the recruitment goal was unattainable. Three patients were excluded after randomisation; surgery was cancelled in two and one was randomised in error (major violation of exclusion criteria). Thus, 343 patients were included in a modified intention-to-treat analysis (Fig. 1). Baseline characteristics were comparable between the two groups (Table 1). Lobectomy was performed in most cases. In eight cases, lung resection was cancelled peroperatively due to excessive cancer extension. Per-protocol analysis excluded these eight patients who had only an exploratory thoracotomy. Thoracic lymph node resection and staging was performed in 138 patients in each group.

Bronchial adenocarcinoma (n=161; 47%) was the most

Table 1  Baseline patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>Control group, n=171</th>
<th>LPV group, n=172</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63 ± 9</td>
<td>62 ± 11</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>123 (71.9%)</td>
<td>123 (71.9%)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170 ± 9</td>
<td>170 ± 9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73 ± 14</td>
<td>70 ± 14</td>
</tr>
<tr>
<td>Predicted ideal body weight (kg)</td>
<td>65 ± 9</td>
<td>64 ± 9</td>
</tr>
<tr>
<td>BMI (kg m⁻²)</td>
<td>25 ± 4</td>
<td>24 ± 4</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsmoker</td>
<td>23 (13.5%)</td>
<td>29 (16.9%)</td>
</tr>
<tr>
<td>Former smoker</td>
<td>109 (63.7%)</td>
<td>114 (66.3%)</td>
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<tr>
<td>Current smoker</td>
<td>39 (22.8%)</td>
<td>29 (16.9%)</td>
</tr>
<tr>
<td>Pack-years</td>
<td>40 ± 23</td>
<td>42 ± 17</td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>33 (19.5%)</td>
<td>26 (15.4%)</td>
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<tr>
<td>Dependent functional status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent</td>
<td>170</td>
<td>172</td>
</tr>
<tr>
<td>Partially dependent</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Exercise tolerance (climbing two flights of stairs)</td>
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<tr>
<td>Yes</td>
<td>150 (92.0%)</td>
<td>139 (90.3%)</td>
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<tr>
<td>No</td>
<td>12 (7.4%)</td>
<td>15 (8.7%)</td>
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<tr>
<td>Spirometry</td>
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<tr>
<td>FEV₁ (ml)</td>
<td>2489 ± 669</td>
<td>2430 ± 675</td>
</tr>
<tr>
<td>FEV₁/FVC (%)</td>
<td>73 ± 14</td>
<td>73 ± 13.2</td>
</tr>
<tr>
<td>Cardiovascular disease*</td>
<td>20 (11.7%)</td>
<td>16 (9.3%)</td>
</tr>
<tr>
<td>Drug treatment</td>
<td></td>
<td></td>
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<tr>
<td>Antiplatelet agent</td>
<td>38 (22.2%)</td>
<td>38 (22.2%)</td>
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<tr>
<td>Beta-blocker</td>
<td>25 (14.6%)</td>
<td>27 (15.7%)</td>
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<tr>
<td>Statin</td>
<td>53 (31.0%)</td>
<td>49 (28.5%)</td>
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<td>Aerosol therapy</td>
<td>24 (14.3%)</td>
<td>25 (14.8%)</td>
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<tr>
<td>Steroid</td>
<td>4 (2.4%)</td>
<td>11 (6.5%)</td>
</tr>
<tr>
<td>Preoperative chemotherapy</td>
<td>28 (16.6%)</td>
<td>30 (22.8%)</td>
</tr>
</tbody>
</table>

Values are mean ± SD, or number (%). FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity; LPV, lung-protective ventilation. *Cardiovascular disease history of angina pectoris, myocardial infarction, heart failure, transient ischaemic attack or stroke.
common histological type followed by squamous cell lung carcinoma (n=102; 30%). Sixty-seven patients had had chemotherapy before surgery.

The two groups did not differ in terms of type and duration of surgery, volume of fluids infused and the need for blood transfusion (Table 2). Total intravenous anaesthesia (combining propofol with an opioid) was the technique most frequently used. Techniques of regional analgesia (epidural analgesia, paravertebral block or spinal analgesia) were used in 80% of the cases to control postoperative pain and were comparably distributed between the two groups.

Tidal volume, peak and plateau pressures and driving pressure were significantly decreased in the LPV group, whereas respiratory rate, end-tidal CO₂ and PEEP were significantly higher (Table 2). No difference was observed in the other respiratory parameters (Table 2).

During one-lung ventilation, plateau pressure exceeded 30 cmH₂O in 13 patients in the nonprotective mechanical ventilation group vs. none in the LPV group.

A major postoperative complication occurred in 23/172 (13.4%) patients in the LPV group and in 38/171 (22.2%) patients in the control group (OR 0.57, 95% CI, 0.32 to 1.00, P = 0.03) (Fig. 2). Multivariate logistic regression analysis revealed that the ventilatory setting (LPV vs. control)
In this randomised, double blind trial conducted in thoracic surgical patients, lung-protective mechanical ventilation using a low tidal volume and PEEP compared with high tidal volume and no PEEP during anaesthesia seems to improve outcomes by decreasing the rate of major postoperative complications. Lung-protective mechanical ventilation also specifically reduced the risk of pulmonary complications and shortened the duration of hospital stay compared with nonprotective lung ventilation.

The use of low tidal volumes and PEEP during mechanical ventilation has been shown to decrease the risk of VILI. Low tidal volumes prevent overdistension of lung...
alveoli and avoid alveolar barotrauma, whereas an increased end-expiratory pressure prevents the development of dependent lung collapse and atelectasis. Several studies have described a benefit of LPV in critical care patients suffering from ARDS. In contrast to ICU patients, surgical patients require mechanical ventilation for only a few hours. Observational studies including a large number of patients have noted that ventilator settings with large tidal volumes during anaesthesia impaired postoperative outcomes. A randomised study published in 2013 in 400 patients undergoing major abdominal surgery found that the use of a LPV strategy decreased the incidence of postoperative complications. Of note, during periods of one-lung ventilation occurring during thoracic surgery, ventilator settings remain unchanged most of the time, provided that insufflation pressures are not too high, meaning that the lung which remains ventilated receives the same tidal volume as both lungs in the preceding period to maintain close to normal values of end-tidal CO\textsubscript{2}. Compared with the settings during abdominal surgery with both lungs ventilated, this may carry an additional risk of alveolar overdistension and barotrauma. Furthermore, during one-lung ventilation, the dependent lung tends to develop atelectasis.

All of these conditions and the fact that patients scheduled for lung surgery commonly have an underlying lung disease make the ventilated lung more fragile and may increase the risk of developing VILI. Protective ventilation of the dependent lung may play a role during one-lung ventilation to decrease the risk of VILI. Lower tidal volume reduces the shear stress resulting from the cyclic overstretching of alveolar areas. PEEP applied to the dependent lung may prevent atelectasis and minimises the injury from repetitive closing and opening of lung units. Both are likely to be required to protect the lung during thoracic surgery. Indeed, in a retrospective study performed in a single centre in a large cohort of patients, Blank et al. suggested that decreasing tidal volume without PEEP was associated with an increase in post-operative respiratory complications. These results highlight the fact that low tidal volume without PEEP may promote the occurrence of atelectasis.

Before our study, the benefits of LPV during thoracic surgery had been evaluated and documented in randomised trials that considered only surrogate outcomes such as lung cytokine plasma concentrations, PaO\textsubscript{2}/FiO\textsubscript{2} ratio or lung consolidation visualised on chest radiograph. However, as the sizes of the samples were small, these trials were unable to demonstrate a decrease in the incidence of major complications. This was demonstrated only by pooling randomised trials and observational studies in meta-analyses. One might therefore argue that the heterogeneity of studies and ventilator settings could prevent any definite conclusion as to the benefit of low tidal volumes in thoracic surgery. Our large, randomised, controlled trial using the same ventilator settings in 13 different thoracic surgical centres confirms that lung protective ventilation applied during anaesthesia reduces major postoperative complications in lung cancer surgery, especially pulmonary complications.

The occurrence of complications was analysed during the first 30 postoperative days. This 30-day period is recommended as the most appropriate follow-up period for the occurrence of adverse events in peri-operative medicine. The occurrence of complications during this period is also related to long-term mortality in lung cancer patients, making it clinically relevant to assess the impact of peri-operative techniques and treatments on patient outcomes. Major complications were also decreased at day 7 after surgery. Similar results have been observed when low tidal volume ventilation was used during anaesthesia for abdominal surgery.

Our trial has several limitations. In our sample size calculation we underestimated the rate of complications in the control group. The rate we used based on the incidence of complications reported in the French national database. Thirty-day morbidity varied from 20 to 30% in this database but included numerous items such as pneumonia and ARDS, but also atrial fibrillation, urinary tract infection and wound complications, which were not included in our composite outcome. Observational studies are vulnerable to measurement and selection bias. In large databases, the definition of complications may vary among data providers and participating centres. Some data may be missed, and all patients cannot be as extensively studied as in prospective randomised controlled trials. However, the rate of pulmonary complications in the control group of our study was consistent with previously reported incidences in previous prospective trials concerning thoracic surgical patients. The rate of major complications was reduced by 51% in our study when tidal volume was reduced from 10 to 5 ml kg\textsuperscript{-1} of IBW. A decrease in pulmonary complications from 36 to 18.5% has also been documented in the IMPROVE trial conducted in patients undergoing major abdominal surgery and in a systematic review concerning abdominal surgery.

Our trial was interrupted prematurely before the target sample size was reached. The sponsor decided to stop the trial, but this decision was not based on interim analyses. The decision to stop the recruitment of patients was related to difficulties with timely recruitment at some participating centres. Furthermore, during the recruitment phase, a growing body of evidence was pointing towards a beneficial effect of lung protective ventilation in surgical patients. Statistical analyses were performed independently and before the blinding codes were broken. Stopping a trial before all the patients had been recruited is a limiting factor for drawing definite conclusions. Consequently, the results of the PPV trial...
should be considered as preliminary. The benefit of lung protective ventilation could have been overestimated by our study. Indeed, the use of large tidal volume, that is 10 ml kg\(^{-1}\) of IBW with no PEEP during thoracic surgery may not be considered as the standard of care, but, on the contrary, carries a risk of promoting lung injury. The protocol of our study was written in 2006 and funding was applied for the same year. At this time, the value of large tidal volumes for thoracic surgery was a matter of controversy, but many institutions maintained high tidal volume ventilation for their patients.\(^{2,33}\) Currently, determining the ‘gold standard’ value for tidal volume in thoracic surgery still remains an issue. In addition, Amar et al.\(^{34}\) recently published a cohort of 1080 patients undergoing pulmonary resection. No differences were observed in the incidences of pneumonia and/or ARDS between patients with tidal volumes less than or at least 8 ml kg\(^{-1}\).

Low tidal volume and PEEP between 5 and 8 cmH\(_2\)O were administrated as a bundle for LPV during anaesthesia. These two parameters were not studied separately. Our study was not designed to evaluate the respective roles of low tidal volume and PEEP in the lung-protective strategy. Further studies are required to determine whether a limited tidal volume, with or without significant levels of PEEP, could generate comparable results. Ongoing studies such as PROTECTOR (NCT02963025) will help to clarify this question.

A third limitation may be that lung recruitment manoeuvres were not standardised. Each centre could use different techniques for expansion of the ventilated lung when appropriate (lobectomy) at the end of the surgical procedure, including or not manual inflation of the lung. Low tidal volume, PEEP and lung recruitment manoeuvres are the three components of intra-operative LPV.\(^{20,35}\) The protective role of each one of these factors on postoperative complications may be different. The PROVILHO trial investigated the role of high levels of PEEP and lung recruitment manoeuvres in patients receiving mechanical ventilation with low tidal volume during anaesthesia for open abdominal surgery. A strategy restricted to the use of a high level of PEEP and lung recruitment without low tidal volumes failed to decrease postoperative pulmonary complications, suggesting the importance of low tidal volume for LPV.\(^{36}\) In our study, tidal ventilation was not changed during the procedure, including during the change from two-lung to one-lung ventilation. Low tidal volume, that is 5 ml kg\(^{-1}\) of IBW, was used during all the procedures in the LPV group. The benefit of decreasing this volume during one-lung ventilation was not evaluated.

Intra-operative data, except for ventilator settings, did not differ between groups. Peri-operative and postoperative care were not standardised. For the postoperative period, we aimed to decrease this risk by concealing peri-operative anaesthetic care from the physicians (who were not involved in the anaesthetic care) looking after the patient postoperatively.

In conclusion, the PPV trial provides preliminary evidence that lung protective ventilation with low tidal volume and PEEP rather than high tidal volume and no PEEP during anaesthesia for lung cancer surgery seems to improve postoperative outcomes and to decrease the duration of hospital stay.

Acknowledgements relating to this article

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Conflict of interest: none.

Presentation: preliminary data were presented at the national meeting of SFAR (Société Française d’Anesthésie et de Réanimation).

References

Lung protective ventilation and thoracic surgery


