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The Potential Dangers of Recruitment Maneuvers During One Lung Ventilation Surgery

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ABSTRACT

Background: Existing evidence regarding lung-protective ventilation (LPV) during one-lung ventilation (OLV) focuses on surrogate outcomes. Our objective was to assess whether an LPV protocol during OLV surgery is associated with reduced respiratory complications.

Materials and methods: This was a matched control retrospective cohort study of patients undergoing pulmonary resection at a tertiary Canadian hospital. The experimental group ($n = 50$) was derived from primary data of two crossover RCTs, which utilized protocolized LPV strategies with varying levels of positive end-expiratory pressure and recruitment maneuvers. The control group was drawn from a prospectively maintained database; these patients received conventional nonprotocolized ventilation (2000-2010). Each experimental group patient was matched 1:1 with a control group patient with respect to clinically relevant variables (age, sex, diagnosis, smoking status, cardiovascular disease status, co-morbidity, BMI, preoperative forced expiratory volume in 1 s, surgery type). Major respiratory complications were defined as composite of acute respiratory distress syndrome, need for new positive-pressure ventilation, and atelectasis requiring bronchoscopy. Paired and unpaired statistical tests were used.

Results: Patients appeared well matched. Major respiratory complications occurred in 8% ($n = 4$) and 2% ($n = 1$) of patients in experimental and control groups, respectively ($P = 0.50$). There was a trend toward increased mortality (4 *versus* 0, $P = 0.06$) with protocolized LPV. The patients who died had respiratory complications; one had acute respiratory distress syndrome and two had profound hypoxemia.

Conclusions: There was a nonsignificant trend toward increased mortality with LPV during OLV. Although limited by a small sample size, our findings identify a potential danger to excessive recruitment maneuvers. Larger studies, with clinically important outcomes are needed to better define the risk/benefit trade-offs for LPV during OLV.

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Introduction

Lung-protective ventilation (LPV) strategies in one-lung ventilation (OLV) have been variably adopted in thoracic anesthesia, but the exact nature of their components is not clearly defined nor is the outcomes associated with them.[1,2] Execution of LPV strategies varies in clinical practice, and research continues to define their beneficial and harmful elements in OLV.[2] LPV was initially used in the intensive care environment to prevent acute lung injury (ALI) and acute respiratory distress syndrome (ARDS). LPV reduced the absolute risk of mortality from 71% to 38%.[3] Historically, high tidal volumes of 10-15 mL/kg were used but the mortality in the ARDS patient cohort was high.[4] The components of the original LPV strategy were to achieve: 1) tidal volume of 6 mL/kg, 2) respiratory rate to maintain optimal minute ventilation, aiming for SpO2 88-95% or PaO2 55-80 mmHg, 3) increasing positive end-expiratory pressure (PEEP) (5-24cmH2O) if there was a need to increase FiO2, and 4) plateau pressures less than 30cmH2O.[3,5] Atelectasis prevention with recruitment, volutrauma-prevention with low tidal volumes, and barotrauma-prevention with plateau pressure thresholds were proposed as physiologic explanations of the mortality reduction observed with LPV.[2] The LPV strategy from these landmark trials has been adapted and applied in the general anesthesia and thoracic anesthesia population, with mounting evidence of its benefits.[2,6,7] LPV demonstrated benefits in decreasing postoperative pulmonary complications, decreasing postoperative pulmonary inflammation, and improving oxygenation intraoperatively.[8-11] Adapting LPV strategies to OLV is an active area of research. LPV studies during OLV are few in number and focus on surrogates of lung dysfunction rather than clinical- and patient-important outcomes.[2,6,7] Ventilatory priority-setting in lung-protective one-lung ventilation (LP-OLV) continues to be an area of active investigation. The tendency for poor oxygenation from administering low-tidal volumes to a restricted and shunted respiratory system during OLV has led to increased use of recruitment maneuvers in LP-OLV.[6,7] However, recent evidence suggests that the risk of ALI from recruitment outweighs its oxygenation benefit.[1]

The purpose of this study was to assess whether a LPV protocol during OLV surgery is associated with reduced respiratory adverse events. Our hypothesis is that LPV reduces respiratory adverse events after OLV thoracic surgery. Establishing the clinical outcomes of LP-OLV is necessary to determine ventilatory management priorities and to ensure the safety of ventilation in thoracic anesthesia.

Materials and methods

Design

This study received approval from the institutional Research Ethics Board. Informed consent was obtained for the experimental group for the secondary use of data. This was a matched control retrospective cohort study at a tertiary, academic Canadian hospital. The experimental group was derived from the primary data of patients ($n = 75$) who participated in two crossover RCTs (unpublished, clinicaltrials.gov NCT01495936). These RCTs utilized protocolized LPV strategies with varying levels of PEEP, continuous positive airway pressure (CPAP), and recruitment maneuvers (RMs) (see Figure and ventilator management section). The control group was drawn from a prospectively maintained general thoracic surgery database and included patients who had received conventional nonprotocolized ventilation between 2000 and 2010. Waiver of consent was approved for retrospective analysis of this database data. The RCTs occurred between 2007 and 2010. We abstracted age, gender, diagnosis, procedure type, smoking status, home O_2, the presence of coronary artery disease, the presence of pulmonary hypertension, BMI, their length of stay, and preoperative lung function tests (forced expiratory volume in 1 s and diffusing capacity), and other comorbidities related to calculating a Charlson comorbidity index. Each experimental group patient was matched 1:1 with a control group patient. This was accomplished by performing 1:1 manual nearest neighbor matching according to the following matching criteria: age to within 10 y, same gender, same diagnosis, same smoking status, same coronary artery disease status, similar Charlson index (within 1 point), similar BMI, similar preoperative forced expiratory volume in 1 s to within 20%, and type of surgical procedure. Surgical procedures were categorized as open or video-assisted thoracoscopic surgery—wedge resection, lobectomy, bilobectomy, or pneumonectomy.

Population

Patients enrolled were 18 y or older and were booked for an open or video-assisted thoracoscopic surgery pulmonary resection. The experimental group excluded patients if they were unable to give consent, pregnant, unable to have an arterial line inserted, had significant pulmonary impairment, significant cardiovascular disease, altered liver function (Child-Pugh scale $\geq$ B), or had the presence of bullous lung disease. Pulmonary impairment was defined as PaO2 on room air <50 mmHg, PaCO2 >50 mmHg, or known pulmonary hypertension defined as a mean PAP >25 mmHg. Thus, due to matching, our control group also excluded these patients although the general thoracic surgery database-collected data on all consecutive patients undergoing thoracic surgery at our center.

Ventilator management

The experimental group all underwent a specific protocol of LPV. A double lumen tube of appropriate size was placed, and the position was verified in both the supine and lateral decubitus position with fiber optic bronchoscopy. Positive-pressure ventilation was commenced using a Datex/Ohmeda S/5 anesthesia delivery unit (Datex-Ohmeda, Bromma, Sweden), using tidal volumes of 6 mL/kg based on the ideal body weight and volume-controlled ventilation. The respiratory rate was titrated to produce a normal arterial partial pressure