

Improving Adherence to Intraoperative Lung Preventative Ventilation Strategy through Choice Architecture and Cognitive Aids



Michael A Persaud, Dani C Porter, Erik P Anderson, Chris Mayhew and S Patrick Bender*

Department of Anesthesia, University of Vermont, USA

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*Corresponding author: S Patrick Bender, Department of Anesthesia, Larner College of Medicine, University of Vermont, Burlington, Vermont, USA, Email: stephen.bender@uvmhealth.org

Abstract

Implementation of intraoperative lung preventative ventilation (LPV) strategy is one means to reduce morbidity associated with intraoperative mechanical ventilation. Populations most at risk to LPV non-adherence include female, obese, and short patients. Adherence to intraoperative LPV recommended strategy is slowly improving, yet remains institutionally variable. The University of Vermont Medical Center used targeted education, choice architecture, and cognitive aids to improve LPV strategy adherence. Improvement was seen in both overall and at-risk populations.

Keywords: Intraoperative; Lung preventative ventilation; LPV; Tidal VOLUME; Peep; Choice architecture; Cognitive aid; Quality improvement

Abbreviations: TV: Tidal Volume; PEEP: Positive End Expiratory Pressure; PBW: Predicted Body Weight

Introduction

The association between intraoperative lung protective ventilation (LPV) and postoperative pulmonary complications has been feverishly investigated in the recent literature. Intraoperative mechanical ventilation of healthy and at-risk adult patients has attributable risk for preventable postoperative pulmonary complications. These include atelectasis, pneumonia, acute lung injury and acute respiratory distress syndrome [1]. LPV strategy has been demonstrated to be safe [2]. Intraoperative use of LPV strategy may reduce postoperative pulmonary complications and morbidity. Previously published recommendations for intraoperative LPV strategy suggest healthy adult patients be ventilated with $TV \leq 10$ ml/kg PBW and $PEEP \geq 5$ cm H₂O [3]. Those with abnormal lung and/or lung injury risk factors are recommended to receive $TV \leq 6$ mL/kg PBW and $PEEP \geq 5$ cm H₂O [4].

Why Consider LPV Strategy?

Non-adherence to LPV strategy, including large TV or inadequate PEEP, is associated with poorer surgical outcomes and increased morbidity [5]. Overdistention of lung alveoli caused by high TV can increase proinflammatory cytokines, risking pathological changes in alveolar structure and concomitant fluid mechanics [6,7]. In contrast, a 2015 Cochrane Review found intraoperative TV adherent to LPV strategy reduced the need for post-operative ventilator support, with no associated harm caused by using lower

TV [8]. Maintaining adequate levels of PEEP intraoperatively reduces atelectrauma, alveolar coagulation, and levels of local inflammatory markers [3]. Sources of morbidity attributed to LPV strategy non-adherence include bronchospasm, atelectasis, pneumothorax, pleural effusion, aspiration pneumonia, pulmonary infection, and respiratory failure [9].

Current Adherence to LPV Strategy

Single center and multi-institutional studies have demonstrated that, despite improving, adherence to LPV strategy has not yet fully penetrated global practice patterns [10]. Lack of education and continuous reinforcement contribute to insufficient LPV strategy adherence [11]. Populations most at risk for over ventilation due to non-adherent LPV strategy include female, obese (BMI>30), and short-statured (height<165cm) patients [12]. Adherence to LPV strategy suffers from a common obstacle of medical research-the lag time between initial publications of an idea to its widespread implementation. Factors influencing delay in translation include initial skepticism, citation frequency of the publication, and perceived value of the addressed clinical issue [13].

Our Approach to Improve Departmental LPV Strategy Compliance

At the University of Vermont Medical Center (UVMCM), we instituted a quality improvement (QI) project to increase LPV

strategy adherence. This was done through targeted education, altering choice architecture by adjusting default ventilator settings, and creation and distribution of a TV cognitive aid. Education surrounding the benefits of LPV strategy was instituted through departmental grand rounds, staff meetings, and electronic dispersal of all educational material. Additionally, a laminated cognitive aid containing appropriate TV values based on patient sex, height, and desired TV (mL/kg PBW) was created and attached to every anesthesia machine for intraoperative reference. Finally, and in our opinion most importantly, default ventilator settings of TV and PEEP were adjusted to values consistent with LPV strategy. Prior to this QI project, default ventilator settings (the settings for TV and PEEP upon activation of the ventilator) were TV=600 mL and PEEP=0cm H₂O. These were adjusted to TV=440mL and PEEP=5cm H₂O. 440mL was selected as it represents 6ml/kg PBW for the average height male and 8mL/kg PBW for the average height female in the United States [14].

We compared the intraoperative ventilation strategy administered 6 months prior to (January-June 2015) the QI project with the ventilation parameters administered 6 months post (August 2015-January 2016) QI project commencement. Statistical significance was measured using Fisher's Exact Test. Across the total population, we saw a statistically significant improvement in LPV strategy adherence (TV \leq 10mL/kg PBW and PEEP \geq 5cm H₂O) from 46% to 91% (p < 0.001). Amongst previously identified risk populations we also demonstrated a significant improvement. Adherence to LPV strategy increased for female patients (39% to 90%, p < 0.001), obese patients (49% to 89%, p < 0.001), and short-statured patients (34% to 86%, p < 0.001). The most at-risk population of obese, short-statured females saw an improvement from 33% to 82% (p < 0.001).

Discussion

Historically, provider self-assessment and self-improvement may take a much greater time than we have achieved with this project. Some studies have suggested it can take over a decade to transition from publication to widespread implementation of best practice [13]. Our department created a quality improvement project able to improve intraoperative LPV strategy adherence rates more rapidly than seen in a previously published study by the Multicenter Perioperative Outcomes Group [15]. We believe this significant improvement is attributable to not only topic-targeted education, but more importantly, the creation of proper choice architecture to steer providers toward the desired practice. This new choice architecture was created by altering default ventilator settings. Previously, providing LPV adherent care required the provider to purposefully adjust from the default ventilator settings.

Now, to provide non-LPV adherent care, the provider must intentionally manipulate default ventilator settings away from these LPV adherent settings, something far less likely to occur. The TV cognitive aid attached to each machine provided clinicians with real-time access to sex and height-specific tidal volumes to

facilitate their choosing of appropriate settings. Another approach we advocate for would be requiring ventilators to mandate clinician input of patient sex, height, and desired TV (in mL/kg PBW) prior to commencement of positive pressure ventilation. We believe this would lead to a more thoughtful approach to appropriate intraoperative ventilation on a case-by-case basis, as opposed to a single and same TV and PEEP appearing at the beginning of each case. This would create the choice architecture to force the clinician to consider LPV adherence in each particular case.

Conclusion

Intraoperative ventilation including large TV or inadequate PEEP is associated with poorer perioperative outcomes, namely increased postoperative pulmonary complications. Adherence to intraoperative LPV strategy is one way to reduce these ventilator-associated sources of morbidity. Creation of

- a. Proper choice architecture through appropriate default ventilator settings
- b. Implementation of cognitive aids, and
- c. Topic-specific education regarding the clinical importance of LPV strategy all assisted with overcoming the barriers to more rapid improvement towards our goal of consistent intraoperative LPV strategy. We offer this structured approach to assist other institutions with their LPV adherence.

Conflicts of Interest

All authors declare no conflicts of interest in this manuscript.

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