BJA

British Journal of Anaesthesia, ■ (■): 1–9 (2018)

doi: 10.1016/j.bja.2018.04.048
Advance Access Publication Date: xxx
Clinical Investigation

CLINICAL INVESTIGATION

Adoption of Lung Protective ventilation IN patients undergoing Emergency laparotomy: the ALPINE study. A prospective multicentre observational study

X. Watson[1,*], M. Chereshneva[2], P. M. Odor[3], I. Chis Ster[4], Pan-London Perioperative Audit and Research Network (PLAN)[5], M. Cecconi[1]

[1]Adult Critical Care Directorate and Department of Anaesthesia, St George's University Hospitals NHS Foundation Trust, St George's University of London, London, UK, [2]Department of Anaesthesia, Frimley Park Hospital, Frimley, Surrey, UK, [3]Department of Anaesthesia, St George's University Hospitals NHS Foundation Trust, London, UK and [4]Institute of Infection and Immunity, St George's University of London, London, UK

*Corresponding author. E-mail: ugm2xw@doctors.org.uk

[5] Please see the Appendix section for the list of collaborators.

Background: Emergency abdominal surgery is associated with a high risk of postoperative pulmonary complications (PPCs). The primary aim of this study was to determine whether patients undergoing emergency laparotomy surgery are ventilated using a lung-protective ventilation strategy comprising of tidal volume ≤8 ml kg^{-1} ideal body $weight^{-1}$, PEEP >5 cm H_2O, and recruitment manoeuvres. The secondary aim was to investigate the association between ventilation factors (lung-protective ventilation strategy, intraoperative FiO_2, and peak inspiratory pressure) and the occurrence of PPCs.

Methods: Data were collected prospectively in 28 hospitals across London as part of routine National Emergency Laparotomy Audit. Patients were followed up for 7 days. Complications were defined according to the European Perioperative Clinical Outcome definition.

Results: Data were collected from 568 patients. The median [inter-quartile range (IQR)] tidal volume observed was 500 ml (450–540 ml), corresponding to a median tidal volume of 8 ml kg^{-1} ideal body $weight^{-1}$ (IQR: 7.2–9.1 ml). An lung-protective ventilation strategy was employed in 4.9% (28/568) of patients and was not protective against the occurrence of PPCs in the multivariable analysis (hazard ratio=1.06; P=0.69). A peak inspiratory pressure of <30 cm H_2O was protective against the development of PPC (hazard ratio=0.46; confidence interval: 0.30–0.72; P=0.001). The median FiO_2 was 0.5 (IQR: 0.44–0.53) and an increase in FiO_2 by 5% increased the risk of developing a PPC by 8% (2.6–14.1%; P=0.008).

Conclusions: Both intraoperative peak inspiratory pressure and FiO_2 are independent factors significantly associated with the development of a postoperative pulmonary complication in emergency laparotomy patients. Further studies are required to identify their causality effect and to demonstrate if their manipulation could lead to better clinical outcomes.

Keywords: emergency laparotomy surgery; lung-protective ventilation; postoperative pulmonary complications

Editorial decision: 23 May 2018; **Accepted:** 23 May 2018

Editor's key points

- Emergency abdominal surgery is associated with a high risk of postoperative pulmonary complications (PPCs), but the use of 'protective' ventilation in these patients is uncertain.
- In this prospective observational study, 48% of patients developed a PPC after emergency laparotomy.
- PPCs were associated with increased age, use of high fractional inspired oxygen concentration, and high peak inspiratory airway pressures.
- Lung-protective ventilation was used in <5% of patients, and had no effect on the incidence of PPCs.

Emergency laparotomy surgery is associated with a high risk of morbidity and mortality. Postoperative pulmonary complications (PPCs) are the second most common surgical complication and are a significant cause of adverse perioperative outcome.[1] The proportion of patients who develop a PPC following major surgery is variable, but has been estimated to occur in up to 40% of patients undergoing abdominal surgery.[2]

Lung-protective ventilation (LPV), defined as the use of tidal volumes ≤8 ml kg^{-1} ideal body weight $(IBW)^{-1}$, PEEP of ≥5 cm H_2O, recruitment manoeuvres, and maintenance of plateau pressure <30 cm H_2O, is a well-established standard of care in ventilated patients with acute respiratory distress syndrome (ARDS) in the ICU.[3] Recently, there has been an emerging interest in its application in the perioperative setting to reduce the occurrence of PPCs in patients undergoing general anaesthesia for elective surgery. Clinically significant ventilator-induced lung injury occurs from a combination of volutrauma, barotrauma, atelectrauma, biotrauma, and shear strain. It is thought to most likely occur in patients with concurrent physiological insults, such as sepsis, trauma, or major surgery, which preconditions the immune system for an inflammatory response to mechanical lung injury.[4] The ventilator strategies employed in patients undergoing emergency surgery currently remain unknown. Identification of intraoperative strategies that could potentially reduce the development of PPCs in this high-risk group is therefore of considerable clinical importance.

The primary aim of the study was to determine whether patients undergoing emergency laparotomy surgery are ventilated using an LPV strategy comprising of tidal volume ≤8 ml kg^{-1} IBW^{-1}, PEEP ≥5 cm H_2O, and use of recruitment manoeuvres. The secondary aim was to investigate the association between ventilation factors [LPV strategy, intraoperative FiO_2, and peak inspiratory pressure (PIP)] and the occurrence of PPCs. We hypothesise that the majority of patients are not ventilated using an LPV strategy, but that implementation of the bundle may lead to a reduced occurrence of PPCs.

Methods

The Adoption of Lung Protective Ventilation in Patients Undergoing Emergency Laparotomy (ALPINE) was a prospective multicentre observational study undertaken in collaboration with the National Emergency Laparotomy Audit (NELA) and delivered by the Pan-London Perioperative Audit and Research Network. The study was undertaken between October 31, 2016 and March 31, 2017 with 28 hospitals across London participating.

The study was approved by the Joint Research and Enterprise Office at St George's University Hospitals NHS Foundation Trust, UK. Research registration and patient consent were not required, as data collection was limited only to data used for routine clinical care. This was confirmed by the online National Research Ethics Service decision tool. All data collection was independent of patient management, and no additional tests or investigations were performed. All patients undergoing an emergency laparotomy during the specified period were identified. Intraoperative data were collected as an extension of routine NELA data collection. All data were completely anonymised prior to entering into the electronic database. Institutional approval was obtained for each participating site, which had the study registered as a service evaluation in their department.

All patients over the age of 18 who underwent expedited, urgent, or emergency laparotomy surgery as per NELA guidelines were included.[5] This comprised any open, laparoscopic, or laparoscopically assisted procedures on the gastrointestinal tract. Any elective or diagnostic procedures were excluded.

Intraoperative data collected included patient characteristics, height, and weight in order to calculate the IBW. The IBW was calculated as per the formula used in the ARDSNet trial {♂=50+2.3 [height (in.)]−60)/(♀=45.5+2.3 [height (in.)]−60}.[6] Other variables recorded included the duration of anaesthesia in minutes and the grade of the most senior anaesthetist present (consultant *vs* trainee). The mode of ventilation, tidal volume delivered, PEEP, PIP, use of recruitment manoeuvres, and intraoperative FiO_2 were recorded. Data for each ventilation parameter were recorded manually by the anaesthetist onto a *pro forma* by recording the most documented value from the anaesthetic chart for each whole procedure. The development of PPCs was recorded on a daily basis until Day 7 postoperatively by reviewing the patient's notes, routine biochemical results, and radiographs if undertaken. PPCs were defined according to the European Perioperative Clinical Outcome definition, and included respiratory failure, respiratory infection, atelectasis, bronchospasm, pneumothorax, and aspiration pneumonia.[7] Admission and mode of ventilation in the Intensive Care Unit (ICU) were also recorded. We were unable to collect data on co-morbidities, but data were collected for five out of the seven variables used in Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) score, a well-validated risk assessment tool for the perioperative development of PPCs, and data were adjusted in the multivariable regression model for these variables.[8]

LPV was defined as low tidal-volume ventilation (≤8 ml kg^{-1} IBW^{-1}), application of PEEP of ≥5 cm H_2O, and use of recruitment manoeuvres. A recruitment manoeuvre was defined as 30 s of 30 cm H_2O CPAP every 30 min. The definition of LPV for this study was as per the randomised controlled study conducted by Futier and colleagues.[9]

The collected variables were explored both graphically and by summary statistics. Descriptive statistics as per the main binary outcome (defined as experiencing at least one PPC or not within 7 days after surgery) are presented in Table 1. Variables are summarised as means, standard deviations, percentiles for continuous variables, and proportions for categorical/binary data. Additional simple statistical tests have been added as appropriate for a quick assessment of