



## SHORT REPORT

# Identifying a pediatric cohort to prospectively evaluate ventilation strategies to mitigate postoperative pulmonary complications

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Lung-protective ventilation (LPV) may decrease postoperative pulmonary complications by minimizing driving pressure.<sup>1</sup> Lee and colleagues recently found that tidal volumes of 5 ml/kg and a PEEP of 10 most effectively optimize for driving pressure in patients  $\leq 6$  years old.<sup>2</sup> Despite this knowledge, adoption of LPV into current pediatric clinical practice is lagging and LPV has not been validated with large-scale randomized controlled trials (RCT).<sup>3</sup> In order to conduct a prospective RCT to evaluate LPV, the ideal study population needs to be defined. Children  $\leq 6$  years old experience the highest frequency of pulmonary complication,<sup>4</sup> making them a promising target population. Further delineation of subgroups within this cohort with the highest pulmonary complication rates is necessary to ensure an adequately powered RCT.

Utilizing the American College of Surgeons National Surgical Quality Improvement Program-Pediatric (NSQIP-P), we sought to identify the surgical procedures in which patients  $\leq 6$  years of age experience the highest incidence of postoperative pneumonia or reintubation. These national data were further augmented with institutional data including postoperative oxygen dependence.

The NSQIP-P is a prospectively collected, multicenter registry, which provides data on risk-adjusted outcomes to participating hospitals. Trained reviewers collect thoroughly standardized data through in-depth chart reviews and phone calls to patient families. The scope of data covers 147 different variables per patient, including patient demographics, comorbidities, intraoperative factors, and 30-day outcomes. The Ann & Robert H. Lurie Children's Hospital of

Chicago Institutional Review Board deemed this study exempt from review with waiver of signed patient consent. All analyses were performed using SAS version 9.3 (SAS Institute).

Patients who underwent surgery at a NSQIP-P hospital from January 1, 2014, to December 31, 2020, were examined ( $n = 523\,233$ ). Patients with emergent/urgent status or preoperative mechanical ventilation were excluded. Patients  $\leq 6$  years of age ( $n = 266\,523$ ) were included in the analysis. The occurrence of pneumonia or unplanned reintubation within 7 postoperative days was measured in the NSQIP-P dataset.<sup>5</sup> 1593 (0.6%) patients had pneumonia or unplanned reintubation. Univariable logistic regression was then used to identify surgical specialties at the highest risk as compared to Urology, which had the lowest incidence of pneumonia or unplanned reintubation. General surgery [Odds Ratio 9.49 (95% confidence interval 7.35–12.25);  $p < .0001$ ] had the strongest association with this outcome. Table 1 lists the top ten general surgical procedures with the highest incidence of this composite pulmonary outcome.

Data from June 9, 2021, to March 9, 2022 ( $n = 50$ ), were then collected from the authors' institution. Patients undergoing the general surgery procedures in Table 1 or procedures with equivalent severity were selected with the following procedural exceptions: laparoscopic gastrostomy tube placement and fundoplication (both commonly performed to address aspiration) and intrathoracic surgery, as these procedures were felt to potentially confound any effect from LPV. Patients  $\geq 7$  years old, on preoperative supplemental oxygen, or with

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**TABLE 1** General surgical procedures most associated with postoperative pneumonia or unplanned reintubation from the National Surgical Quality Improvement Project-Pediatric

Procedure Name	N	%
Laparoscopy, surgical; gastrostomy, without construction of gastric tube (e.g., Stamm procedure)	140	8.8
Laparoscopy, surgical, esophagogastric fundoplasty (e.g., Nissen, Toupet procedures)	96	6.0
Closure of enterostomy, large or small intestine; with resection and anastomosis other than colorectal	70	4.4
Esophagoplasty for congenital defect, thoracic approach; with repair of tracheoesophageal fistula	68	4.3
Esophagogastric fundoplasty partial or complete; laparotomy	32	2.0
Closure of enterostomy, large or small intestine	26	1.6
Enterectomy, resection of small intestine; single resection and anastomosis	24	1.5
Correction of malrotation by lysis of duodenal bands and/or reduction in midgut volvulus (e.g., Ladd procedure)	19	1.2
Gastrostomy, open; without construction of gastric tube (e.g., Stamm procedure)	19	1.2
Enteroenterostomy, anastomosis of intestine, with or without cutaneous enterostomy	16	1.0

active COVID-19 infection were excluded. Occurrence of oxygen dependence within 7 postoperative days was measured (reintubation, noninvasive positive pressure ventilation, high-flow nasal cannula, mask, and nasal cannula) in those patients. Of the 50 patients, 13 (26%) required postoperative pulmonary support.

In conclusion, patients  $\leq 6$  years old undergoing specific general surgical procedures were at particularly high risk for postoperative pulmonary complications. Those patients with sizable abdominal surgical insult comprised many of these patients, similar to what Foutier et al. identified as high pulmonary risk patients in adults.<sup>5</sup> By targeting patients based on only two variables, age and procedure type, research personnel may be able to focus enrollment efforts to optimally power an RCT designed to assess the impact of LPV strategies on postoperative pulmonary

complications. Based on these pilot data and using a two-sided significance level of  $p = .05$  and 80% power, a study population of 290 patients  $\leq 6$  years of age undergoing major abdominal surgery would be needed to detect a 50% reduction in postoperative pulmonary complications. Enrollment would thus be feasible for a multicenter RCT.

#### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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