National practice variation in pneumonectomy perioperative care among Canadian thoracic surgeons

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Abstract

OBJECTIVES: Our objective was to assess perioperative pneumonectomy practices among Canadian thoracic surgeons as part of a quality-improvement initiative to determine practice variability and identify areas for study/improvement.

METHODS: After several rounds of survey development and piloting, a 29-item survey was distributed using the Dillman method to all practicing members of the Canadian Association of Thoracic Surgeons.

RESULTS: The response rate was 87% (62 of 71). Median number of pneumonectomies performed annually was 3.5 (interquartile range 2.75–5.00). Routine preoperative workup was variable, but the most consistently reported tests were diffusing capacity of the lungs for carbon monoxide (87%, n = 54) and spirometry (85%, n = 53). Reported routine use of epidurals (84%, n = 52) was more prevalent than paravertebral blocks (18%, n = 11). Many (69%, n = 43) reported intraoperative restriction <2 l. Postoperatively, 84% (n = 52) reported daily fluid restriction <2 l. Regarding intraoperative protective ventilation strategies, respondents appeared more focused on minimizing peak airway pressures (55%, n = 34) rather than tidal volumes (18%, n = 11). Twenty-four percent (n = 15) reported using intraoperative steroids in attempts to decrease postoperative complications. Thirty-two percent (n = 27) do not routinely insert chest tubes, whereas the most common practice (44%, n = 27) was to insert chest tubes attached to conventional drainage systems without suction. Eighty-two percent (n = 52) reported willingness to participate in multicentre studies regarding perioperative pneumonectomy practices.

CONCLUSIONS: Our findings suggest significant variability in reported perioperative, intraoperative and postoperative care practices for pneumonectomy across Canada. This survey has a high response rate, representing the Canadian experience, and highlights several areas for study and quality-improvement initiatives. Many respondents report willingness to participate in multicentre initiatives.

Keywords: Pneumonectomy • Perioperative care • Quality improvement • Preoperative evaluation • Lung-protective ventilation

INTRODUCTION

Pneumonectomy is associated with a high risk of morbidity and mortality. Single-centre studies have reported complication rates between 39% and 59% and mortality in 9–12% of patients [1].

In multicentre trials, these rates are comparable to, but generally lower than, the Society of Thoracic Surgeons General Thoracic Database (STS GTDB), which reports a complication rate of 30.4% and mortality risk of 5.6% [2]. Comparatively, the multicentre French collaboration EPITHOR reported a mortality rate of 7.8% and cardiorespiratory complication rate of 25.6% [3]. Pneumonia, acute respiratory distress syndrome, empyema, bronchopleural fistula, post-pneumonectomy pulmonary oedema (PPE) and

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There is conflicting evidence around the perioperative strategies to reduce the risk of PPE and other cardiorespiratory complications. It has been shown that perioperative fluid restriction, conservative intraoperative ventilation and intraoperative steroids may lower the risk of these complications [4–7]. At present, the quality of evidence supporting these measures is inadequate to definitively direct principles of pneumonectomy management, leaving clinicians to rely on experience, prior teaching or their own interpretation of the data.

In Canada, fewer pneumonectomies are being performed, and those being done tend to be performed by surgeons at lower volume centres [8]. In Canada, lung resections and pneumonectomies are performed exclusively by general thoracic surgeons. Morbidity and mortality for pneumonectomy is highest among low-volume, non-cardiothoracic surgeons [9]. One potential explanation for the high risk of complications following pneumonectomy is the variability among surgeons in practice and opinion regarding perioperative management of pneumonectomy [10]. There is insufficient evidence to explain this variation in practice, although some evidence suggests that outcomes depend in part on how frequently a surgeon manages patients undergoing pneumonectomy [10]. The objective of this study is to assess perioperative management practices for pneumonectomy patients among Canadian thoracic surgeons as part of a quality-improvement initiative to determine practice variability and identify areas for study and improvement. The study focuses on perioperative techniques used by surgeons to reduce major complications including acute respiratory distress syndrome/PPE and respiratory failure.

MATERIALS AND METHODS

This study received institutional research ethics board approval. A cross-sectional survey was designed, piloted and refined by a multidisciplinary team comprising general thoracic surgeons, anaesthesiologists, critical care physicians and clinical epidemiologists. The survey development process began with item generation by the multidisciplinary team, followed by multiple iterations of piloting to allow for item reduction (down to a 29-item survey) and testing for clinical sensibility as well as face, content and construct validity. The Dillman or tailored design method was used to guide the development, administration and distribution of this survey [11]. After institutional research ethics board approvals, this survey was distributed electronically to all practicing members of the Canadian Association of Thoracic Surgeons (CATS) [12]. Three rounds of repeat invitations to participate were sent from the CATS Research Committee and also designated hospital site champions. Responses were anonymized and combined into frequency data. Analyses were performed using SPSS/PASW v.20 (IBM Corporation, Armonk, NY, USA).

RESULTS

The survey response rate was 87% (62 of 71). The rate of missing responses ranged from 0% to 24.2% (n = 15); the 24.2% missing response was for the question regarding location of practice. In our cohort, the median number of pneumonectomies performed per surgeon annually was 3.5 (interquartile range 2.75–5.00) (Fig. 1).

There was representation of respondents from all the 9 provinces of Canada that have Thoracic Surgery centres. There was a wide range of years in practice among respondents with a median of 15.0 years and an interquartile range of 8.25–21.5 years in practice. Routine preoperative workup was variable, but the most consistently reported tests were diffusing capacity of the lungs for carbon monoxide (DLCO) (87%, n = 54) and spirometry (85%, n = 53) (Fig. 2). There were 8 and 9 missing responses in these 2 questions, respectively; thus, 100% of those who actually responded to those 2 questions reported performing diffusion capacity and spirometry tests. A smaller proportion of respondents reported routine use of arterial blood gas (ABG) analysis (50%, n = 31) and echocardiography (48%, n = 30), with a minority performing routine ventilation–perfusion scans (VQ scans) (29%, n = 18), MIBI or cardiac stress testing (16%, n = 10), VO2 max testing (10%, n = 6) and 6-min walk testing (16%, n = 10).

Intraoperatively, lung-protective ventilation strategies focused on minimizing peak airway pressures (55%, n = 34) rather than tidal volumes (18%, n = 11) (Fig. 3). Interestingly, when asked...
Most respondents (82%, n = 52) reported willingness to participate in multicentre studies regarding perioperative pneumonectomy practices. The most common (57%, n = 4) rationale given for low interest in participating in such a trial was a perceived low annual pneumonectomy caseload.

**DISCUSSION**

This cross-sectional survey of Canadian thoracic surgeons identified significant variability in reported preoperative, intraoperative, and postoperative care practices for pneumonectomy across Canada. Significant heterogeneity in practice patterns is a potential indicator of quality gaps and can provide targets for quality improvement [13]. There are no previous studies describing variations in perioperative pneumonectomy practices either at the national or at the professional society level. The Canadian thoracic surgical community is a relatively small and cohesive group, with nearly all having received general thoracic surgery training within Canada from a small number of training centres. Thus, the significant variability we have identified in the perioperative practices of Canadian thoracic surgeons is likely to be greater in other settings/countries and thus our findings are likely relevant to other practice settings.

Preoperative assessment is important to ensure that only those fit for pneumonectomy undergo this high-risk procedure. Slinger [14] emphasizes the importance of cardiopulmonary function in 3 areas: respiratory mechanics, gas exchange and cardiopulmonary interaction. The most commonly used preoperative tests in our cohort are spirometry and diffusion capacity, at 85% and 87% adherence, respectively. Response profiles of those who did not report routine spirometry or DLCO showed that they also did not select other preoperative tests, likely reflecting a non-response in this 'preoperative assessment' question rather than a true lack of routine spirometry. Spirometric testing is the foundation of the North American Thoracic Anaesthetic Assessment for baseline respiratory mechanics [14, 15]. Postoperative morbidity has been shown to markedly increase in patients with forced expiratory volume in 1 s (FEV1) and DLCO less than 40% of the expected value [16]. Gas exchange and pulmonal function may be assessed using DLCO or by ABG sampling. DLCO is a better validated prognostic tool for outcomes following lung resection and is predictive of morbidity in patients undergoing pneumonectomy [15]. The routine use of ABG interpretation is controversial. ABG parameter-directed management is challenging, because evidence exists that lung resections can be successfully performed in patients not meeting these parameters; moreover, preoperative ABGs are less predictive of postoperative complication [14]. Preoperative assessment of cardiopulmonary interaction was uniformly low in our cohort, and the widest variation in practice we observed was in the choice of method used to assess this physiological reserve. VQ scans have maximal utility when used for patients with predictive postoperative FEV1 (ppoFEV1) between 30% and 40%, as this test can improve the accuracy of the prediction and better determine whether a patient is at high risk for postoperative complications [14]. Our study does not reveal the threshold for performing VQ scans among respondents; however, the finding that only 29% of respondents routinely perform VQ scans may suggest that it is being used selectively rather than universally. Cardiopulmonary testing is a well-validated means of predicting an individual's capacity to tolerate lung resection [17]. European Thoracic

![Graph](https://example.com/graph.png)
Surgery guidelines recommend routine cardiopulmonary exercise testing of patients undergoing lung resection [18]. The American College of Chest Physicians encourages the use of a stair-climb test or a walk test in patients with ppoFEV1 < 60% and the use of VO2 max testing in patients with ppoFEV1 < 30% [19]. It is unclear why there is such low utilization of cardiopulmonary exercise testing among our respondents. However, it may be related to low rates of ‘borderline cases’. Future studies should explore this in more detail.

Intraoperative management of patients undergoing pneumonectomy has been well studied. With respect to regional anaesthetics, thoracic epidural blocks are the most frequently used approach. Epidural use has been shown to reduce postoperative complications and improve recovery [20]. However, more recent evidence has suggested non-inferiority of paravertebral blocks, with some studies reporting a reduced risk of hypotension and complications [21, 22]. The limited use of paravertebral anaesthesia in our cohort may reflect lack of knowledge translation or it may reflect the intersecting (and possibly conflicting) decision making between the thoracic surgeons and the thoracic anaesthesiologists. Intraoperative restriction of fluid and blood products has been shown to reduce the risk of cardiorespiratory complications. Fluid administration has been shown to increase the risk of PPE in multiple studies [6, 23, 24], and fluid restriction to less than 2 l has been proposed to reduce this risk, although prospective studies identifying fluid administration thresholds do not exist. Although there appears to be a link between the fluid and the PPE, it remains at the discretion of the surgeon and the anaesthesiologist as how much fluid the patient will tolerate intraoperatively. Our study has identified that intraoperative fluid restriction is widely employed, but there is little consensus about fluid balance target.

Protective ventilation strategies propose to reduce injury to the lung by limiting alveolar distension and the subsequent release of inflammatory cytokines. It has been suggested that this inflammatory cascade contributes to the weakening of pulmonary capillary endothelium allowing for PPE to develop. Among our respondents, reduction in peak airway pressure was considered the most significant, with only 18% (n = 11) concerned about tidal volume. This is in opposition to the bulk of the existing literature, which cites volutrauma and alveolar over-distension as the ventilation-related component of acute lung injury [25–28]. The preferential emphasis reported on reducing airway pressures rather than volumes is also shared by many thoracic anaesthesiologists (unpublished survey data) and requires further elucidation with respect to the outcomes. This is an area of investigation (i.e. practice audit) that can be incorporated within the next steps of our quality improvement initiative.

Variation in practice may be harmful, expensive and inefficient, especially when practice deviates from the best available evidence. It remains to be seen how the variation in clinical practice identified in our study affects clinical outcomes in Canada. As aforementioned, the literature exists to guide pneumonectomy management, though the evidence in support of some of these treatments comes from theoretical animal models or small, underpowered clinical studies. These perioperative therapies with poor quality or equivocal evidence represent areas for further clinical research, locally and nationally. Some respondents are concerned that the overall case volume of pneumonectomies is so low that it renders studies focused on pneumonectomy perioperative practices not feasible. However, the reality is that pneumonectomy is increasingly performed by surgeons with lower volumes and with persistently high complication rates when compared with other complex surgeries. Furthermore, the mortality rates with pneumonectomy have remained stable over the years, despite concomitant decreases in other complex, high-risk surgeries (e.g. Whipple procedure) [8]. It is for these very reasons that pneumonectomy should in fact be studied and is a most appropriate substrate for quality improvement initiatives.

**Limitations**

The limitations of this study arise primarily as a result of the self-report nature of this survey. However, we would expect that the bias would operate in a ‘consensus’ direction rather than a ‘variability’ direction, as most people are likely to report practices that are more in line with what they perceive to be ‘standard’ or ‘accepted’ practices. This social desirability reporting bias suggests that the actual variations in practice are likely to be underestimated rather than over-reported [29, 30]. Although the majority of pneumonectomies in Canada are performed by thoracic surgeons who are part of the CATS, it is possible that we have missed sampling surgeons who are not part of the CATS. However, it is reasonable to expect that their responses would add to rather than reduce our reported variability in practice patterns. Although it would have strengthened our study to describe the number of other thoracic procedures performed annually by respondents, we do not have this data. However, because of regionalization of thoracic surgery into centres of excellence in Canada, virtually all thoracic surgery in a specific health region is performed by 1 or 2 high-volume centres. These high-volume centres typically perform more than 100 lung resections annually.

Another limitation of our survey-based study is that we have not identified whether reported practices are associated with actual indications and outcomes using epidemiological data. Our plan for the next step is to perform actual practice audits at specific centres to identify actual practice and how these practices affect the outcomes. The strengths of our study include rigorous and robust survey development methodology and a high response rate among our intended participants. Thus, this survey is likely representative of pneumonectomy practices among Canadian thoracic surgeons.

**CONCLUSION**

In conclusion, our findings suggest significant variability in reported preoperative, intraoperative and postoperative care practices for patients undergoing pneumonectomy procedures across Canada. The highest variability in practice was noted in preoperative workup of patients. This rigorously developed survey highlights several areas for further study and quality-improvement initiatives such as preoperative assessment, intraoperative protective ventilation and fluid management. The majority of respondents reported a willingness to participate in multicentre initiatives for quality improvement in pneumonectomy care. The next step of our quality-improvement process will be to identify discrete areas for practice audits at selected thoracic surgery centres and initiation of quality-improvement PDSA (Plan-Do-Study-Act) cycles.

**Conflict of interest:** none declared.
REFERENCES


