Understanding the Current Practice in Chest Tube Management Following Lung Resection–A Canadian National Survey

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AIM: Timing of chest tube removal post lung resection is variable in practice and often based on personal experience rather than evidence. The current practice in chest tube management among thoracic surgeons across Canada is so far unknown. Our primary aim was to assess the current status of chest tube removal in Canada in order to uncover potential shortcomings.

METHODS: An online anonymous survey was emailed to members of Canadian Association of Thoracic Surgeons in order to better understand the *status quo* of the chest tubes' removal policy in the different departments preparing the grounds for suggesting a future uniformity. Data were collected and analysed with descriptive statistics. A linear regression analysis was performed in order to understand the factors related to chest tube removal.

RESULTS: Sixty responses were received (44.4% response rate). Most surgeons place a single chest tube in both open (75%, 45/60) and minimally invasive lobectomies (93.3%, 56/60). Digital drainage systems are used by half of the surgeons surveyed. A quarter of the respondents report removing chest tubes regardless of drainage output. This practice was independent of the surgeons' number of years in practice ($p = 0.127$), number of lobectomies performed annually ($p = 0.877$), proportion of lobectomies performed minimally invasively ($p = 0.259$), whether digital drainage system is used ($p = 0.141$) and whether the surgeon is aware of the Enhanced Recovery after Surgery (ERAS) guideline ($p = 0.374$). Of those who remove chest tubes based on fluid output, thresholds vary widely; a significant proportion (86%, 37/43) uses a volume lower than the 450 mL/24 h threshold set out ERAS. Most respondents (77%) were interested in a clinical trial studying chest tube removal independent of drainage volume.

CONCLUSIONS: This study demonstrated ongoing diverse practice amongst thoracic surgeons in Canada with regards to post-operative chest tube management, indicating a much-needed area of research.

Keywords: chest tube; Canadian survey; lung resection

Introduction

The use of chest tubes following lung resection is ubiquitous but post-operative management of chest tubes has been variable in practice and often based on personal experience or institutional historical practices [1] (Fig. 1). Over the years, many studies have been attempted to provide evidence on the various aspects of chest tube management, including need of external suction, removal criteria, and use of digital drainage system in order to determine an optimal algorithm [2–7].

Chest tubes are often a barrier to early mobilization and significantly extend the length of stay. An optimal management of chest drains in the post operative phase is crucial to counteract post operative complications and therefore it's a cornerstone of Enhanced Recovery after Surgery (ERAS) principles.

ERAS and the European Society of Thoracic Surgery (ESTS) have recently set out the following recommendation guidelines on post-operative chest tube management: routine application of external suction should be avoided, digital drainage systems should be used, chest tubes should be removed if daily serous effusion volume is less than 450 mL, and a single tube should be used instead of two after a routine anatomical lung resection [8].

The degree to which the ERAS guidelines are adopted in Canadian clinical practice is so far unknown. To better understand the current practice patterns, we decided to disseminate a national survey to thoracic surgeons across Canada. We believe that a better understanding of ongoing variability in clinical practice will help identify barriers to adoption and areas needing improvement for developing best practice.

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Fig. 1. Different types of chest tubes.

Methods

We developed an online survey consisting of fifteen questions that queried each surgeon's operative volume, post-operative chest tube management including suction setting, use of digital drainage device, and how drainage volume influences decision on chest tube removal, as well as surgeon's awareness of and attitude towards ERAS recommendations. The survey was emailed to members of Canadian Association of Thoracic Surgeons (CATS), excluding trainee members. Three monthly email reminders were sent spanning between 22 January and 22 March, 2020. Ethics committee approval was not required according to the Hamilton Integrated Research Board's regulation due to the absence of patients' data. Implied consent was presumed based on participant's voluntary and anonymous responses. The study was conducted in accordance with the Declaration of Helsinki.

Statistical Analysis

All data were collected into a database, with descriptive data summarized as frequencies with absolute numbers and percentages. Responses were analyzed using SPSS software (©IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0, IBM Corp, Armonk, NY, USA). A linear regression analysis was performed. $p < 0.05$ was considered significant.

Results

Demographics

Sixty responses were received out of 135 surgeon members of CATS (response rate 44.4%). 33.3% of the respondents have been in practice for less than 10 years while 16.7% reported more than 30 years' experience. Fifty-five percent of the surgeons were performing less than 50 lobectomies per year and the majority (78.3%) used in more than 75% of the cases a minimally invasive technique (Table 1).

Chest Tube Management

Most surgeons report placing a single chest tube in open lobectomies (75%, 45 of 60), with the rest placing two (Table 2). Almost all surgeons place a single chest tube in Video Assisted Thoracoscopic Surgery (VATS) lobectomies (93.3%, 56 of 60), with a small percentage (3.3%, 2 of 60) that place two and only two respondents who do not place any post-operatively.

Table 1. Characteristics of survey respondents.

Characteristics	Responses n (%)
Years in practice	60 responses
<10	20 (33.3)
10–19	15 (25.0)
20–29	15 (25.0)
≥30	10 (16.7)
No. of lobectomies per year	60 responses
0–10	1 (1.7)
11–30	14 (23.3)
31–50	18 (30.0)
51–75	11 (18.3)
76–100	11 (18.3)
>100	5 (8.3)
Percentage of lobectomies performed with minimally invasive technique	60 responses
0–25	5 (8.3)
26–50	1 (1.7)
51–75	7 (11.7)
>75	47 (78.3)

The majority of surgeons apply external suction on chest tubes (73.3%, 44 of 60). Of those who routinely place chest tubes on suction, variable practice is seen in terms of placing chest tube to water-seal prior to removal, with most waiting chest tube to be off suction for 12–24 h (36.4%, 16 of 44) (Table 2).

Digital drainage systems are used by half of the surgeons surveyed (30 of 60). Of those who do not use digital drainage systems, the most commonly cited reasons are unavailability at the institution (43.3%, 13 of 30) and cost being prohibitive (30.0%, 9 of 30) (Table 2). A minority of respondents (10.0%, 3 of 30) do not feel that digital drainage systems provide advantages over traditional drainage systems.

Chest Tube Removal

In terms of chest tube removal, 25% (15 of 60) of respondents report removing chest tubes regardless of the drainage output. This practice was independent of the surgeon's number of years in practice ($p = 0.127$), number of lobectomies performed annually ($p = 0.877$), proportion of lobectomies performed via minimally invasive technique ($p = 0.259$), whether digital drainage system is used ($p = 0.141$) and whether the surgeon is aware of the ERAS guidelines ($p = 0.374$) (Table 3).

Of those who remove chest tubes based on drainage volume, a significant proportion (86%, 37/43) uses a volume lower than the threshold set out by ERAS (450 mL/24 h) (Fig. 2). Seventy-seven percent of respondents are interested in a clinical trial studying chest tube removal independent of drainage volume (Fig. 3).

Enhanced Recovery after Surgery

More than three-quarters of surgeons (75%, 45 of 60) are aware of the ERAS recommendation of removing chest tube at a threshold of less than 450 mL/24 h, and 53.3% (24 of 45) of surgeons follow the recommendation. Of those who are aware of the guideline but do not follow it, the most commonly cited reasons are preference to continue with current practice (42.9%, 9 of 21), not convinced by the evidence supporting the guidelines (19.0%, 4 of 21), and experienced adverse outcomes when the guidelines were followed (14.3%, 3 of 21) (Fig. 4). Of those not aware of the ERAS guideline, most (73.3%, 11 of 15) would be interested in adopting it.

Discussion

Historically, post-operative chest tube management has been dictated largely by personal or institutional experience rather than evidence. Over the years, attempts were made to provide an evidence basis for chest tube management in order to unify and carry out best practice. Recommendation guidelines were recently published by Enhanced Recovery after Surgery (ERAS) and the ESTS [8]. As with all new guidelines, initial uptake may not be uniform, we decided to create a survey to better understand current practice and perception of the guidelines amongst thoracic surgeons in Canada.

A longstanding historical practice for drainage of the pleural space after lung lobectomy is to place two chest drains, an apical and basal one. However, evidence from several clinical trials over the years has shown that placing a single chest tube is as safe and efficacious as two drains with no differences in need for re-intervention while decreasing post-operative pain, amount and duration of chest drainage and costs [9,10]. The ERAS guidelines support the usage

Table 2. Chest tube management: number of chest tubes, external suction and digital drainage system usage.

Chest tube management	Response n (%)
Number of chest tubes after elective open lobectomy	
1	45 (75.0)
2	15 (25.0)
Other	0
Number of chest tubes after elective inimally invasive lobectomy	
1	56 (93.3)
2	2 (3.3)
Other	2 (3.3)
Apply external suction routinely	
No	16 (26.7)
Yes	44 (73.3)
Length of time off suction prior to removal	
0 hour	5 (11.4)
12 or less hours	13 (29.5)
12–24 hours	16 (36.4)
More than 24 hours	2 (4.5)
Did not specify/patient-dependent	8 (18.2)
Use digital drainage system	
No	30 (50.0)
Yes	30 (50.0)
Reason for not using digital drainage system	
Not available at institution	13 (43.3)
Cost	9 (30.0)
Not interested	3 (10.0)
No reason provided	5 (16.7)

Table 3. Linear regression analysis of factors influencing chest tube removal.

Variables	Unstandardized B	Coefficients standard error	Standardized coefficient beta	*t*	*p*
Years in practice	4.822	3.113	0.199	1.549	0.127
Number of lobectomies	1.667	10.706	0.20	0.156	0.877
Percentage of minimally invasive lobectomies	–8.156	7.147	–0.148	–1.141	0.259
Use of the digital system	0.222	0.149	0.192	1.494	0.141
Awareness of ERAS guidelines	–0.111	0.124	–0.117	–0.896	0.374

ERAS, Enhanced Recovery after Surgery.

of a single tube instead of two after a routine anatomical lung resection (moderate evidence level; strong recommendation). Our data showed that most surgeons do indeed place a single chest tube after lung resection but noticed that a higher proportion of surgeons place two chest tubes in open surgeries compared to minimally invasive procedures (25% vs 3.3%). This is interesting given that the evidence supporting single chest tube placement was based on trials involving open lobectomies. Although the rationale behind the difference in practice was not directly interrogated, thoracotomies potentially cause more pleural irritation and fluid production and may be the driving factor behind a higher frequency of two chest tubes being placed in open procedures.

Digital drainage systems became available over the last decade, offering portability and providing continuous, objective measurements on amount of air leak and pleural fluid drainage that help reduce interobserver variability. There have been multiple Randomized controlled trials and observational studies comparing the efficacy of digital chest drainage system, with conflicting results with respect to decreasing length of chest tube duration and length of stay [5,6,11–13]. A recent meta-analysis demonstrated that digital chest drainage system significantly reduced the risk of prolonged air leak and shortened the duration of chest drainage and hospital stay in patients after pulmonary resection [14]. There is also evidence to support increased patient satisfaction [11,15]. ERAS guidelines recommend the use of digital drainage systems as they remove variability in clinical decision-making and facilitate early mobilization (low evidence level; strong recommendation) [8]. In our survey, half of the respondents reported using dig-

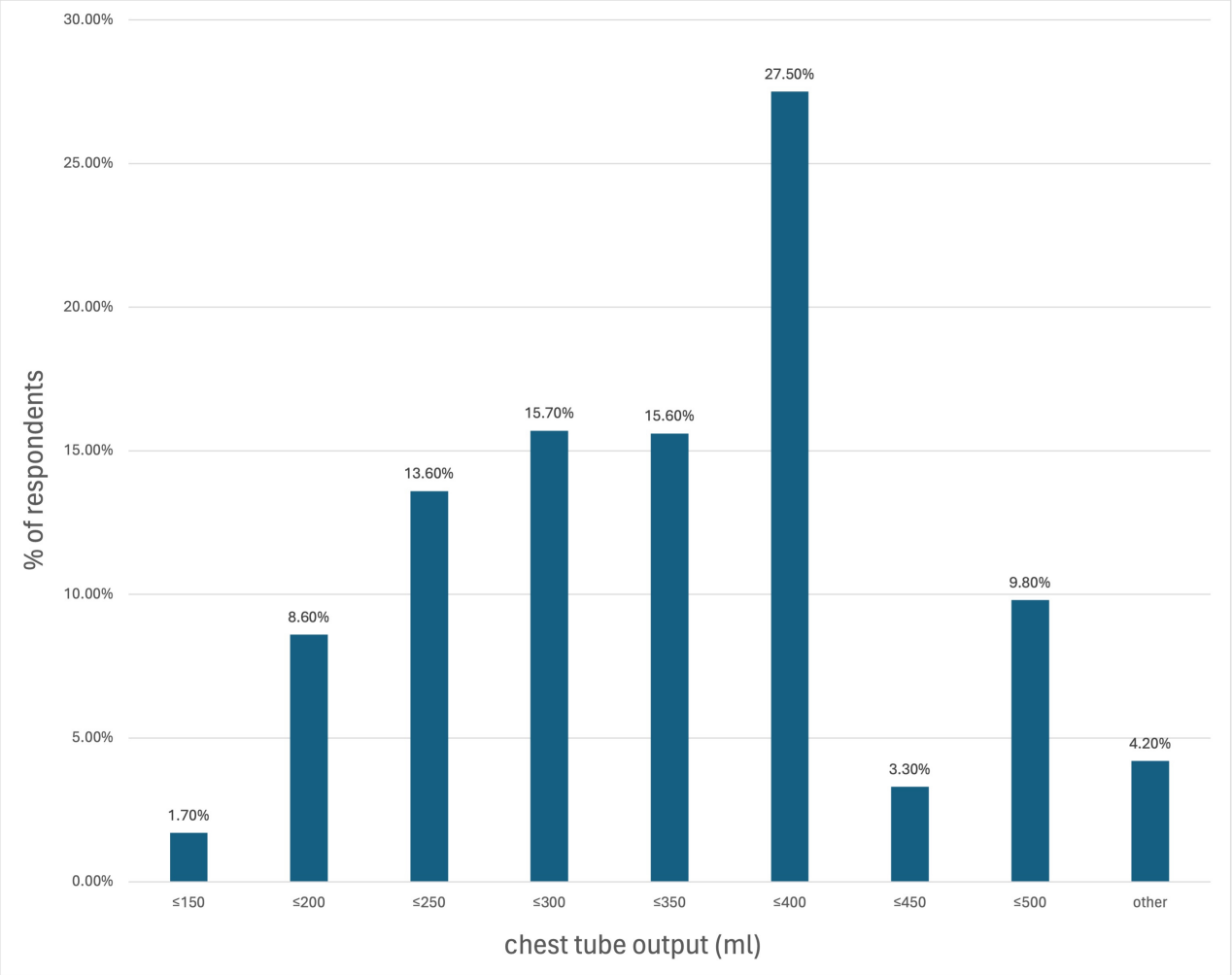

Fig. 2. Chest tube output per 24 hours at which surgeons deem safe for chest tube removal. 'Other' refers to weight-based threshold.

ital drainage systems. Of those who do not use digital drainage systems, cost was a major prohibitive factor. Only a minority of the responders do not feel that digital drainage systems offer advantage over traditional systems. An economic evaluation performed by National Institute for Health and Care Excellence (NICE) in the United Kingdom estimated a cost-saving of £111 (Canadian Dollars (CAD) $197, 133 Euros) per patient per hospital stay, with savings mainly achieved through reduced length of stay. With an estimated 6000 resections for lung cancer performed in Canada each year, this may amount to at least CAD $1,140,000 (766,610 Euros) of savings annually [16]. Another significantly variable aspect highlighted from our survey is the use of external suction on chest tubes. The ERAS guidelines asserts that routine application of external suction offers no advantages and should be avoided (low evidence level; strong recommendation) [8]. Most surgeons who responded to the survey practice differently from the guidelines and place chest tubes on external suction post-operatively. Furthermore, there is less of a consensus in terms of the length of time off external suction prior to removal, with a large proportion waiting 12–24 h off suction prior to removal. The argument favouring suction application is that it promotes pleural apposition between the lung and the chest wall which is believed to help seal air leak. Suction is also sometimes necessary to drain large air leak causing substantial pneumothorax or subcutaneous emphysema. On the other hand, external suction increases air flow from the lung parenchyma when an air leak is present and may potentially worsen the extent or duration of alveolo-pleural fistula. Various Randomized controlled trials (RCTs) have been carried out in the past to compare suction versus no suction, and the majority showed either no difference in reducing incidence or duration of air leak, or a modest advantage in the no suction groups, with exception of one study who demonstrated external suction reduces the rate of prolonged air leak after anatomic lung resection in a subgroup analysis [3,17–20]. The conflicting evidence and patient-dependent nature of the dilemma (i.e., presence and degree of air leak) likely contribute to the variability in practice. An individualized approach for application of suction based on a patient's predictive score for prolonged air leak had previously been proposed [2].

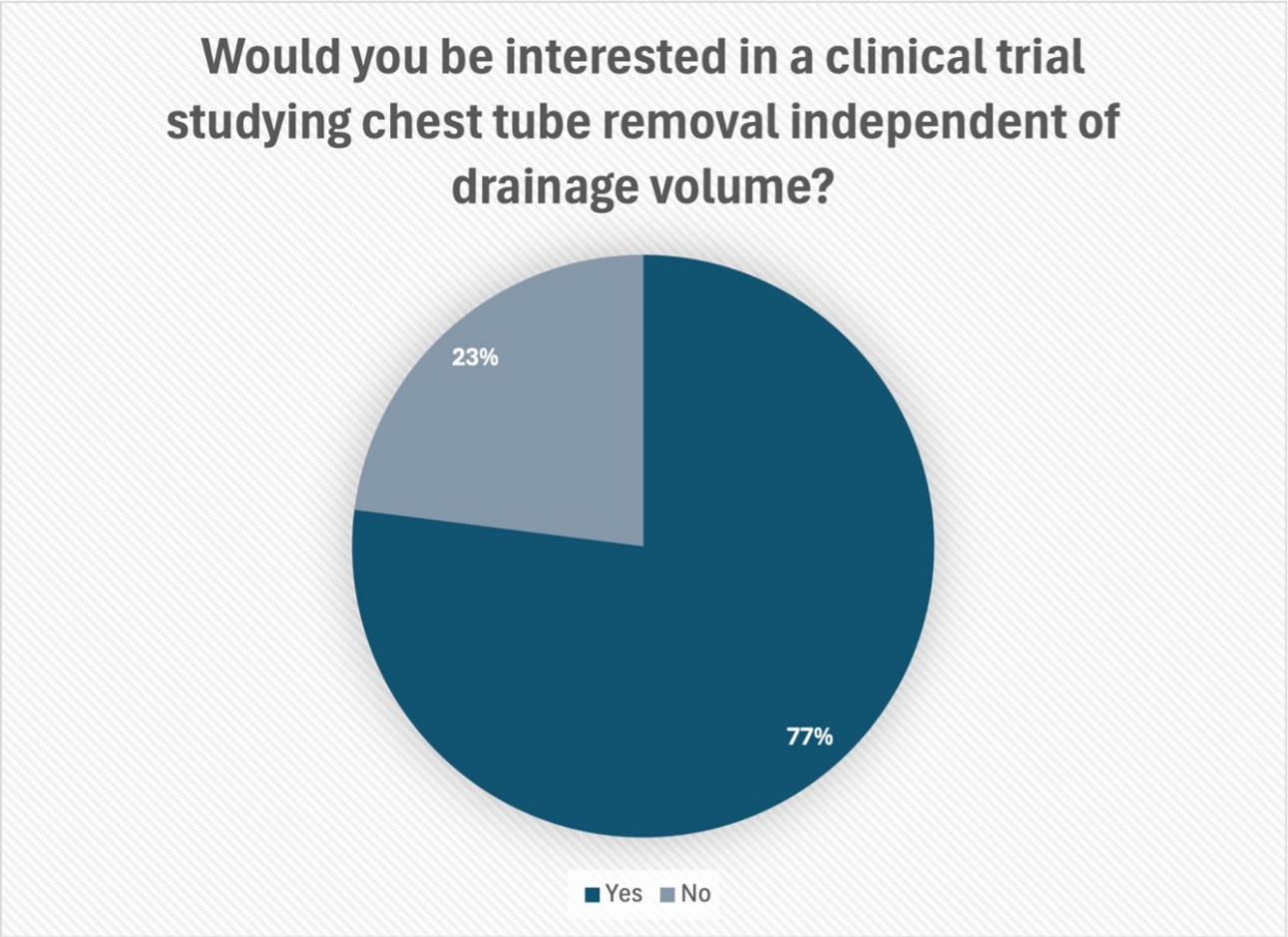

Fig. 3. Interest showed in participating in a new trial.

Another common point of contention in the post-operative management of chest tubes is the fluid drainage threshold below which chest tube removal is considered safe. There is increasing evidence that chest tube removal at a drainage volume higher than what has traditionally been accepted (typically 100–200 mL/24 h) is safe. Cerfolio and Bryant [7] reported removal of chest tube with drainage up to 450 mL/24 h resulted in few readmissions for symptomatic recurrent effusion after open lung resections. McKenna *et al*. [21] demonstrated that removal of chest tube at threshold of 300 mL in a 24-h period as part of a fast-tracking protocol after VATS resections was safe with no incidence of reinsertion of chest tube for effusion. A more recent prospective cohort study demonstrated chest tubes removed at 500 mL/24 h following VATS lobectomy was associated with a low reintervention rate [4].

ERAS guideline recommends that chest tubes should be removed even if the daily serous effusion is of high volume at up to 450 mL/24 h (moderate evidence level; strong recommendation) [8]. Interestingly, about a quarter of the surgeons responding to the survey removed chest tubes regardless of the output as long as there are no contraindications (i.e., no chylous or bloody drainage and/or air leak). This was an unexpected finding as we had anticipated most surgeons to be guided by a specific volume threshold. We found that this practice was not influenced by the surgeon's number of years in practice, operative volumes, proportion of lobectomies performed via minimally invasive vs open, whether digital drainage system is used, and whether the surgeon is aware of ERAS guideline. Of those who do remove chest tubes based on drainage volume, the majority uses volumes *lower* than the maximal threshold set out by ERAS, indicating that surgeons are still considerably conservative with regards to chest tube drainage.

On further analysis, we found that the majority of the surgeons were aware of the ERAS recommendation of removing chest tube at a threshold of 450 mL/24 h, but only half of them follow the recommendation. Preference to continue with current practice was the most commonly cited reason. In particular, some surgeons referred to the pleural fluid resorption physiology which is estimated as a fraction of whole-body lymphatic flow, and felt that an individualized, weight-based approach was more appropriate in determining chest tube removal. Some respondents were not convinced by the evidence behind the guideline, while others stated that they experienced adverse outcomes (i.e., devel-

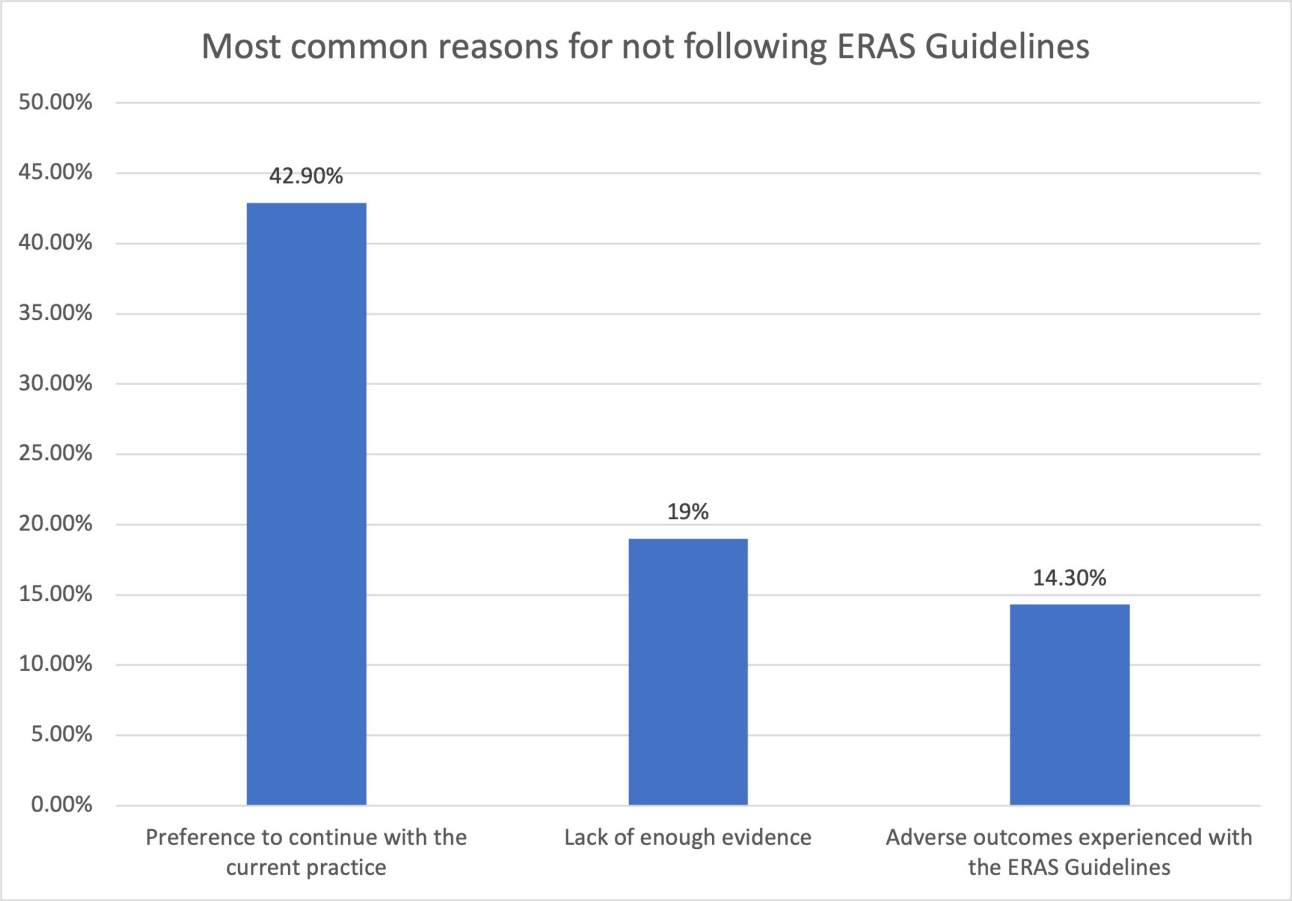

Fig. 4. Most common reasons for not following ERAS guidelines.

opment of symptomatic effusion post-removal) when the guideline was followed. Whether the rate of adverse outcome was anecdotal or higher than the rate reported in literature and the actual intervention rate is unclear. Of those not aware of the ERAS guidelines, most would be interested in following the guideline on chest tube removal.

Despite a more liberal approach set out by the ERAS guidelines with a higher fluid output limit compared to traditional volumes, the threshold of 450 mL/h is ultimately arbitrarily set in the limited literature available. We challenge the prevailing concept that a fixed fluid output threshold is of clinical significance and propose that the quality (serous versus not) rather than quantity of chest tube output should be the determinant in chest tube removal. Rather than focusing on extending upper limit of what is considered a safe fluid output threshold, we posit that it may be safe to remove chest tubes regardless of the volume, provided there are no contraindications and no air leak in the last 24 hours. Mesa-Guzman *et al*. [22] has shown in a retrospective single-surgeon series where chest tubes were removed without fluid volume criteria did not have significantly different re-intervention rate compared to weight-based fluid volume criterion. A randomized controlled study is required to further support the safety of this practice, and a large number of survey respondents were interested in a clinical trial studying chest tube removal independent of drainage volume.

In the last years, several surgeons, taking a step forward, questioned the need of routine use of chest tube after lung surgery [23–27].

Blewett and colleagues [23] published in 2001 a retrospective study showing that an open lung biopsy without chest tube insertion was safe, effective, and practicable as an outpatient procedure. Satherley and colleagues [24] also reported a reduced length of stay in patients undergoing minimally invasive lung biopsy without chest drains inserted compared with those who received one. No major complications and minimal morbidity were observed in a series of patients from Shanghai Pulmonary hospital undergoing wedge resection [25].

Abdul Khader and colleagues [27] showed that on-table chest tube removal decreases postoperative pain scores enabling a short length of hospital stay without any immediate readmissions or need for interventions. However, despite the promising results, studies with a large number of patients and long term follow up are lacking and therefore we are not able so far to recommend tubeless lung surgery.

Strengths and Limitations

One strength of this survey is the high response rate, considering that usually medical surveys gain response rates between 10.3% and 61% [28]. Moreover, the inclusion of several experienced surgeons practicing at different hospitals across the country offers an updated and representative real-life scenario on this subject.

However, this study has some limitations. Primarily, the data reported are originated from a questionnaire and not from an observation of current clinical practice. Therefore, recollection bias could not be avoided. However, we tried to counteract this bias inviting experienced surgeons in each department and excluding the trainees. Secondly, even if the response rate (44.4%) could be considered high, we still missed 75 responses.

Conclusions

Chest tubes cause pain and inhibit pulmonary function. A standardized, evidence-based approach to post-operative chest tube management is essential for decreasing chest tube duration while not compromising patient safety. Our survey demonstrates ongoing variability in clinical practice despite the publication of ERAS guidelines, in part likely due to lack of high-level evidence behind some of the recommendations and resistance to paradigm shifts in current practice. Furthermore, there remains room for optimization in chest drain management, particularly surrounding the use of a fluid threshold to dictate chest tube removal. A randomized controlled study would be necessary to form the evidence basis behind this concept and help provide uniform, safe clinical practice in post-operative chest tube management.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

FM: data curation, formal analysis, investigation, writing-original draft, writing-review & editing. EL: data curation, investigation, writing-original draft, writing-review & editing. HB: data curation, formal analysis, investigation, writing-review & editing. YS: conceptualization, data curation, resources, software, supervision, writing-original draft, writing-review & editing. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Ethics committee approval was not required according to the Hamilton Integrated Research Board's regulation due to the absence of patients' data. Implied consent was presumed based on participant's voluntary and anonymous responses. The study was conducted in accordance with the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

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