Original Article

Outcomes of chest drain management using only air leak (without fluid) criteria for removal after general thoracic surgery—a drainology study

Ashiq Abdul Khader[1], Aina Pons[1], Abigail Palmares[1], Sarah Booth[1], Alexander Smith[1], Chiara Proli[1], Paulo De Sousa[1], Eric Lim[1,2]

[1]Department of Thoracic Surgery, Royal Brompton and Harefield Hospitals, Part of Guy's and St Thomas NHS Foundation Trust, London, UK; [2]Academic Division of Thoracic Surgery, Imperial College and The Royal Brompton Hospital, London, UK

Contributions: (I) Conception and design: A Abdul Khader, C Proli, P De Sousa, E Lim; (II) Administrative support: All authors; (III) Provision of study materials or patients: A Abdul Khader, A Pons, A Palmares, C Proli, P De Sousa, E Lim; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: A Abdul Khader, A Pons, A Palmares, C Proli, E Lim; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Professor Eric Lim, MB, ChB, MD, MSc, FRCS(C-Th). Academic Division of Thoracic Surgery, The Royal Brompton Hospital, Sydney Street, London SW3 6NP, UK. Email: e.lim@rbht.nhs.uk.

Background: Chest drain management is a variable aspect of postoperative care in thoracic surgery, with different opinion for air and drain volume output. We aim to study if acceptable safety was maintained using air leak criteria alone.

Methods: A 9-year retrospective analysis of protocolised chest drain management using digital drain air leak cut off less than 20 mL/min for more than 6 h for drain removal in patients undergoing general thoracic surgery. We excluded patients if a chest drain was not required nor removed during admission or if patients underwent volume reduction or pneumonectomy. Withdrawal criteria were suspected bleeding or chylothorax. Postoperative films were reviewed to document post-drain removal pneumothorax, pleural effusion, and reintervention (drain re-insertion).

Results: Between 2012 and 2021, 1,187 patients had thoracic surgery under a single surgeon. Following exclusion and withdrawal criteria, 797 patients were left for analysis. The mean age [standard deviation (SD)] was 61 [16] years and 383 (48%) were male. Median [interquartile range (IQR)] duration of drain insertion was 1 [1–2] day with a median length of hospital stay of 4 [2–6] days. Post-drain removal pneumothorax was observed in 141 (17.7%), post-drain removal pleural effusion was observed in 75 (9.4%) and re-intervention (reinsertion of chest drain) required in 17 (2.1%).

Conclusions: Our results demonstrate acceptable levels of safety using digital assessment of air leak as the sole criteria for drain removal in selected patients after general thoracic surgery.

Keywords: Chest drain; thoracic surgery; air leak; removal criteria

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Introduction

Chest drain removal is a variable aspect of post-operative management in general thoracic surgery. As chest drain duration is a significant factor influencing the length of hospital stay, it is important to optimise timing of chest drain removal for patient safety (1).

Currently there is no universally accepted protocol governing timing of chest drain removal, and most thoracic surgeons manage drains according to personal experience (2).

The main parameters used in chest drain management

are drain volume output and the (absence of) air leak (3). While volume output is easily measured, there is little agreement on the acceptable output (4). Air leak assessment by underwater seal (bubble counting) is subjective, but with the introduction of digital drainage (Thopaz, Medela), air leaks are now objectively quantified. Digital drains also provide real time data as well as retrospective data with a 24 h air leak graph providing accurate data for air and fluid volumes (5).

In 2015, our group, Mesa-Guzman *et al.* (6), published a retrospective analysis of patient outcomes following chest drain removal over a period of 6 years [2007–2012]. Across time, progressively permissive fluid output and air leak criteria were applied with no differences in the incidence of pneumothorax, pleural effusion or re-interventions (measured by drain re-insertions), while median drain and hospital stay both reduced. The final permissive criteria for drain removal in this study was air leak of less than 20 mL/min for 6 h or more as the sole criterion for drain removal—concluding that chest drains could be safely removed using this, without fluid criteria. The present study is a continuation of the work.

Since 2012, chest drain removal at our institution is governed on air leak criteria alone (less than 20 mL/min for more than 6 h), with all our patients managed with digital chest drains. The aim of the current study is to determine long term safety of chest drain removal using only air leak (without blood or chyle) as a sole criterion. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1810/rc).

Highlight box

Key findings

- We report a 2.1% drain re-intervention with air leak criteria alone for chest drain removal.

What is known and what is new?

- Chest drain duration is a significant factor influencing the length of hospital stay, it is important to optimise timing of chest drain removal. Chest drain management is a variable aspect of postoperative care in thoracic surgery, with no universally accepted protocol for timing of drain removal currently.
- We report a protocolised management of chest drain removal in thoracic surgical patients, using only air leak as the criterion for removal.

What is the implication, and what should change now?

- Air leak as the sole criteria for chest drain removal can safely be used in postoperative management of general thoracic patients.

Methods

We conducted a retrospective study on consecutive patients undergoing thoracic surgical procedures under a single surgeon at the Royal Brompton Hospital, London, United Kingdom, between January 2012 and April 2021. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Royal Brompton institutional board of Quality and Safety Department as ID 004550 and individual consent for this retrospective analysis was waived. Patient population database was retrieved from electronic hospital records. Baseline demographics included gender, age, length of hospital stay. All post-operative chest films were reviewed with the following variables recorded: number of chest drains, duration of chest drain insertion. Post-drain removal X-rays were then reviewed to document pneumothorax (measured from apex to cupola), pleural effusion (measured from the apex of contralateral diaphragm to fluid level) and re-insertion of chest drain.

Patient's drain management

All patients' drains were connected to a digital drain (Thopaz, Medela, Switzerland) to give objective measurements of air leak. The criteria for drain removal were air leak less than 20 mL/min for more than 6 h (Figure S1). In most cases, surgical registrars decide on drain removal, however, the clear protocol with strict adherence also allows wider members of the surgical team to make this decision after review of the digital drain.

Patients were excluded from drain protocol management if they underwent pneumonectomy or lung volume reduction surgery, did not require a surgical chest drain after surgery (e.g., bronchoscopy, mediastinoscopy) or if the drain was removed on table. After 3 days, patients with air leak more than 200 mL/min are taken off the protocol and placed on a Portex bag (flutter valve) with a planned discharge (n=33) and those with an air leak less than 200 mL/min remain on protocol (n=132). Patients were withdrawn if there was suspected bleeding, chylothorax or in-hospital death.

Post-operatively, patients have daily chest films and all patients would have a post-drain removal chest x-ray. Patients also had additional chest films if drain re-insertion was required for the presence of a progressive post-drain

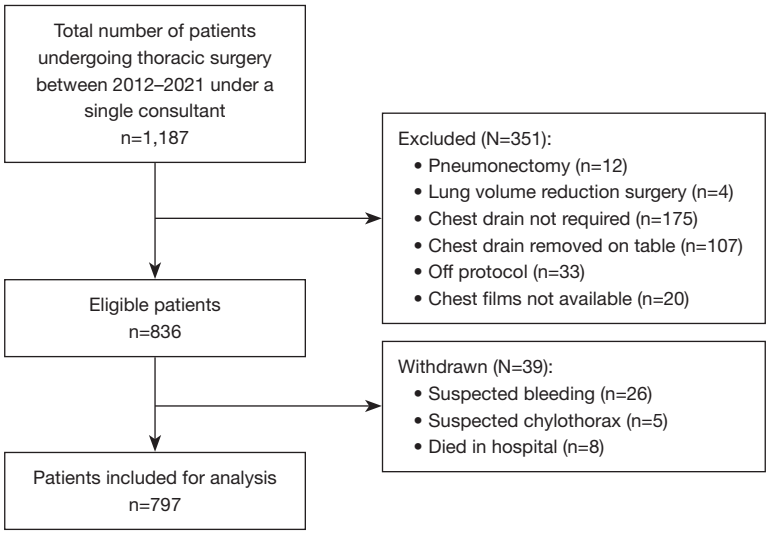

Figure 1 Patient flow diagram.

removal pneumothorax.

Statistical analysis

Baseline characteristics were presented as mean and standard deviation (SD) or median and interquartile range (IQR) for normally and non-normally distributed data respectively. Frequency data were presented with numbers and proportions. Statistical analysis was performed using Stata 16 (Stata Corp. 2019. College Station, TX, USA: StataCorp LLC).

Results

Between 2012 and 2021, 1,187 patients had thoracic procedures under a single consultant. A surgical chest drain was not required in 175 patients, drains were removed on table in theatre in 107 patients, drain management was off protocol (placed on a Portex bag) in 33 patients, postoperative X-rays were unable to be retrieved in 20 patients, lung volume reduction surgery (n=4) or pneumonectomy (n=12) was performed in 16 patients and withdrawal criteria with suspected bleeding (n=26), chylothorax (n=5), or in hospital death (n=8) was met in 39 patients, leaving 797 patients for analysis (*Figure 1*).

The mean age was 61 [16] years and 383 (48%) patients were male (*Table 1*). Over the 9-year period the median duration of drain insertion was 1 [1–2] day and median hospital stay was 4 [2–6] days, as shown in *Table 2*. Post-drain removal pneumothorax frequency was 141 (17.7%), post-drain removal pleural effusion frequency was 75 (9.4%) and re-intervention with reinsertion of chest drain frequency was 17 (2.1%). The median size of immediate post-drain removal pneumothorax, when present, measured from the apex of the lung to the top of the chest was 14.9 [10.3–24.2] mm, while median size of pleural effusion, measured from apex of contralateral diaphragm to the fluid line was 24.7 [19.1–33.5] mm. Of the patients with post drain removal pleural effusion, the median amount of fluid output in the first 24 h prior to removal was 315 [175–600] mL with a mean of 5.9 (4.4) mL/kg.

Discussion

The results of our study reinforce the safe and effective use of digital drainage systems in the postoperative management of thoracic surgical patients with perceived advantages for patients of less pain and greater mobility.

Video-assisted thoracoscopic surgery (VATS) is associated with shorter hospital stay compared to open surgery (7,8), as the landscape of thoracic surgery is changing with increased popularity of minimally invasive surgery, the contribution of duration of chest drain on length of stay becomes more influential. Pompili *et al.* (9) performed a randomised trial of Thopaz digital *vs.* traditional chest drains following lobectomy/segmentectomy in patients across 4 international centres, showing a reduced duration of drain placement and length of hospital stay in those with digital drains. Digital drain usage offers earlier patient mobilisation and improved physiotherapy (10) associated with less pain, owing to the

Table 1 Baseline demographics

Variables	Values
Mean age (years) [SD]	61 [16]
Male, n (%)	383 (48.0)
Procedure, n (%)	
Anatomic lung resection	418 (52.4)
Wedge resection	161 (20.2)
Pleural surgery	61 (7.7)
Other	157 (19.7)

Other includes: bronchoscopy, thymectomy and mediastinal surgery. SD, standard deviation.

Table 2 Outcomes of inclusion population

Outcomes	Result
Sample size (n)	797
Median drain duration (days) [IQR]	1 [1–2]
Median length of stay (days) [IQR]	4 [2–6]
Post-drain pneumothorax, n (%)	141 (17.7)
Median size (mm) [IQR]	14.9 [10.3–24.2]
Post-drain pleural effusion, n (%)	75 (9.4)
Median size (mm) [IQR]	24.7 [19.1–33.5]
Re-intervention, n (%)	17 (2.1)

IQR, interquartile range.

reduced chest drain duration (9), which supports enhanced recovery for patients (11-13).

Digital drainage now has a huge impact on patient care. Compared to conventional surgical chest drainage, users find digital drain monitors safe and user-friendly (14). Traditional "bubble" monitoring with underwater seal to detect air leak often leads to interobserver variability, even amongst experienced surgeons (15,16) and can lead to unnecessary prolonged chest drain duration and thus hospital stay (17,18).

At our institution, nurses, junior surgeons, and surgical care practitioners are allowed to make drain removal decisions and instructions based on the protocol, empowering decision making throughout the surgical healthcare team. These factors contribute to a paradigm of enhanced recovery programme for patients, underlined by reduced length of stay in hospital.

Digital drainage use has been shown to result in lower rates of re-intervention, even when using only air leak criteria as a cut-off (6,19). It has previously been proposed that fluid output criteria is not needed for chest drain removal (20), or perhaps even drains aren't required at all for minimally invasive surgery (21). Our results represent a large series of patients over a 9-year period with acceptable safety of low rates of re-intervention following chest drain removal. From our experience, we know that the principal determinant of duration of drain is the fluid criteria (as the bottle neck) on the first post-operative day, and the more restrictive (lower volume) the criteria the less chance of drain removal (6). Unless this mindset of evaluation and audit is achieved to safely eliminate fluid criteria, the air leak component does not usually come into the decision process (i.e., most air leaks resolve within the first day). As shown by our previous work and present study demonstrating low rates of clinically significant pneumothorax requiring re-intervention when drains are removed following a median duration of 1 day (6), whilst air leak duration can also be influenced by patient factors, type of resection and intraoperative findings. When fluid criterion is lifted, then digital drainage (time of air leak cessation) becomes the rate limiting step for drains to be removed (less than 24 h) on the first post-operative morning.

Our incidence of post-drain removal pneumothorax is comparable to similar studies, while our re-intervention rate represents an acceptable safety profile, compared to rates as high as 8% previously reported (22,23). The incidence of pneumothorax on post-drain removal is dependent on nursing expertise and technique of removal (24), while re-intervention is the real measure of continuing or delayed (missed) air leak. Furthermore, early removal of chest drains can lead to the presence of pneumothorax, but the majority of the time these are small apical which can be managed conservatively. These radiographic abnormalities, including presence of post drain removal pleural effusion do not always correlate clinically, and hence the clinically pertinent outcome is need for re-intervention. The indication for drain re-intervention was due to presence of progressive or persistent pneumothorax as seen on chest films, surgical emphysema, or following surgery for primary spontaneous pneumothorax.

Integral to our results are strict protocol adherence with minimal, if any, deviations. To change surgeon mindset from "personalised" experience of optimal timing of chest drain removal to replicate similar results, protocol must

be strictly adhered to. We adhere to protocol even for pneumothorax surgery, for which there was no evidence of increased recurrence, and pleural effusion surgery, where there were only occasional readmissions for high output effusions. With low post-drain removal pleural effusion rate in our series, the necessity for fluid output to comprise part of drain removal criteria is negated. It is important to note that our air leak criteria exclude any blood or chyle output. Previous uncertainty regarding optimum air flow criteria for digital drain removal to minimise rate of drain re-insertion post removal has been reported (25). We present a safe rate of re-intervention with a cut off less than 20 mL/min for greater than 6 h. Our drain protocol fits with optimal post-operative recovery in our institution. The median duration of drain placement of 1 day means other aspects of our patients post-operative management, routine pain monitoring on the first post-operative day (as the effective intercostal block wears off) can occur in tandem, allowing for effective post-operative recovery strategy.

Moving forward, we are questioning the routine need for chest drains in most thoracic surgical procedures (our results for on-table drain removal will be presented separately).

Limitations

This is a single in-hospital series of patients from a single consultant surgeon. While this ensures standardisation of protocol adherence, it does contribute to case selection bias (although all cases that fit the inclusion criteria were managed similarly). Post-discharge results such as longer-term readmission or re-intervention for pneumothorax or pleural effusion within 90 days of discharge would have added to our results, however this data was not consistently available and thus could not be included in this series. To the best of our knowledge and information through our referral sources, this was rare.

Conclusions

In our study we demonstrate that long term safety is maintained with the selective use of digital drainage using only air leak cut as criteria for removal. We encourage others to evaluate similar protocolised chest drain management strategies to safely minimise chest drain duration to optimise post-operative patient recovery after thoracic surgery.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1810/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1810/coif). EL reports personal fees from Johnson and Johnson/Ethicon, Covidien/Medtronic, Guardant Health, Beigene, Roche, and BMS, grants and personal fees from AstraZeneca, Boehringer Ingelheim, Medela and Lilly, outside the submitted work. In addition, EL has patent P52435GB and patent P57988GB issued to Imperial Innovations and CI for VIOLET NIHR HTA (13/04/03), CI for MARS 2 NIHR HTA (15/188/31), CI for RAMON NIHR HTA (131306) and is the founder of My Cancer Companion Healthcare. PDS reports conference fees from Lilly and Takeda Oncology, personal fees from Vitae Professionals and Boheringer Ingelheim, outside the submitted work. AS was a recipient of the 2021 Society for Cardiothoracic Surgery and AstraZeneca Thoracic Oncology Fellowship. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Royal Brompton institutional board of Quality and Safety Department as ID 004550 and individual consent for this retrospective analysis was waived.

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