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How soon should we remove a chest drain following anatomic lung resection?

Ashiq Abdul Khader [a] and Eric Lim [a,b,*]

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

* Corresponding author. Academic Division of Thoracic Surgery, The Royal Brompton Hospital, Sydney Street, London SW3 6NP, UK. Tel: +44-2073518591; e-mail: e.lim@rbht.nhs.uk (E. Lim).

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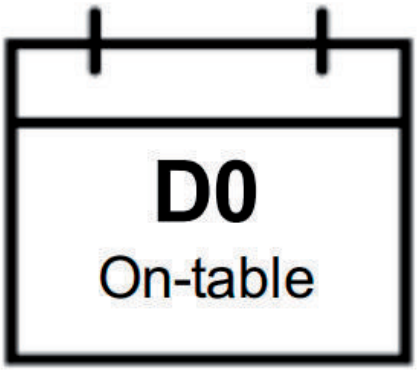
How soon should we remove a chest drain following anatomic lung resection?

Summary

- Chest drain duration has a key influence on recovery post thoracic surgery.
- There is no universally accepted protocol determining timing of chest drain removal.
- We aim to review and discuss the factors that determine how soon chest drains can be removed following anatomic lung resection.

Digital drainage utilising air leak alone as removal criteria facilitates earlier drain removal.



We should be aiming toward on-table drain removal in future

Legend: D0 - post-operative day 0

Abstract

OBJECTIVES: Chest drain duration has a key influence on recovery post-thoracic surgery. There is no universally accepted protocol determining the timing of chest drain removal. We aim to review and discuss the factors that determine how soon chest drains can be removed following anatomic lung resection.

METHODS: Fluid output and air leak are the main determinants of chest drain removal. We reviewed the literature to determine which cut offs have been proposed and the use of protocol for decision-making in chest drain removal.

RESULTS: Use of air leak alone as the determinant for chest drain removal optimizes chest drain management, and studies that have utilized this protocol can achieve drain removal on the 1st postoperative day in most cases. Moving forward, surgery without routine chest drains can help move towards day case thoracic surgery, even for anatomic lung resection.

CONCLUSIONS: Utilizing digital drainage with a strict air leak protocol helps to minimize drain duration post lung resection. The future landscape of chest drain management should focus on the usage of chest drains on an as required basis for air leak, even for anatomic lung resection.

Keywords: Chest drain • Drain protocol • Drain removal • Thoracic surgery • Lung resection

ABBREVIATION	
ERAS	Enhanced Recovery After Surgery

IMPORTANCE OF CHEST DRAIN MANAGEMENT POST RESECTION

Chest drain management is key to recovery after lung resection. Duration of chest drain is one of the most important determinants of length of hospital stay after anatomic lung resection [1]. To minimize the duration of chest drainage, Enhanced Recovery After Surgery (ERAS) guidelines [2] advocate single chest tube, digital drainage without the routine need for suction. The premises for the recommendation are that chest drains can be painful interventions, and pain may contribute to ineffective coughing, increasing the risk of atelectasis and pneumonia [3, 4] while increasing opioid usage that potentially impedes mobility [2, 5].

We searched the literature using key terms such as 'chest drain removal', 'protocol', 'air leak criteria' and 'fluid criteria' to review existing studies evaluating drain removal criteria utilizing air leak and/or fluid output criteria. Those that best addressed the question of timing of removal post anatomic lung resection were selected and discussed in this review. The key results of different post-drain removal criteria discussed are summarized in Table 1.

PURPOSE OF CHEST DRAINAGE

In view of the potential harm and limitation to postoperative recovery, it is important that surgeons understand clearly why drains are required in the 1st place. The 2 principal reasons are to remove excess fluid and air from the thoracic cavity (amounts that the body cannot cope with, and the patient comes to harm without intervention). Therefore, it naturally follows that fluid output and air leak become determinants for chest drain removal.

For air, the goal of air leak criteria is safety—i.e. to remove the drain at a time that minimizes the risk of progressive pneumothorax due to ongoing significant air leak requiring drain re-insertion. There is no universal agreement for the cut off for air leak. This is because different hospitals use different methods to assess air leak (underwater seal, bubble count or digital quantification), and the amount of air leak (it does not have to be 0) that is acceptable is related to the risk tolerance for chest drain re-insertion.

The threshold for amount of fluid output per day in the drain removal decision is also calibrated on the risk of pleural effusion requiring drain re-insertion. Commonly, this can range between 100 and 450 ml/day with the most permissive protocols having no upper limit at all (in the absence of blood or chyle output) [6, 7].

Before any protocol can be defined, clinicians 1st need to determine what is an acceptable level of risk for re-intervention in exchange for reduced pain, increased mobility and shorter length of hospital stay. This needs to be undertaken in the knowledge that effusion or pneumothorax *per se* are not 'adverse outcomes', as the majority of post-drain removal pneumothoraces or pleural effusions do not cause any symptoms nor require any intervention. Pragmatically, we would consider re-intervention (rather than the observation of pneumothorax or effusion alone) required for the definition of 'failure' for any drain management protocol.

OPTIMIZING DRAIN MANAGEMENT

The primary aim of any drain removal protocol is to minimize drain duration without a compromise to defined levels of 'safety'. The protocol should be the most important determination of postoperative management, and if it cannot be followed consistently, then it would be impossible to evaluate the safety and/or efficacy of such efforts. If a protocol is followed carefully, then, in our observation, fluid criteria is usually the rate-limiting step for drain removal in the early postoperative period [1].

At our institution, we compared different protocols, becoming progressively permissive with fluid output thresholds: 5, 6 and 7 ml/kg over 24 h and eventually no requirement for fluid output (using only air leak of $<$20 ml/min for $>$6 h). It is only at this point where air leak becomes a contributing factor.

Currently, there is no universally accepted protocol for drain removal criteria in lung resection. Reported protocols for air leak thresholds vary; $<$20 ml/min [8], $<$40 ml/min for 6 h [9] and 0 ml/min for 6–12 h have all been suggested [6, 10], and each threshold will be associated with a different risk of postoperative drain reinsertion for progressive pneumothorax. Reviewing reported protocols on drain removal post lung resection, the majority of timing of removal was within the first 24 h, particularly in those that do not include fluid output as part of protocol criteria [11]. Utilizing air leak alone criteria for drain removal with digital drainage is beneficial, when air leak is the limiting factor, digital drainage allows safe drain removal even when air leak is not zero, as evidenced with our criteria of $<$20 ml/min for 6 h.

As our department protocol became more permissive, median drain duration and length of hospital stay decreased without any significant increase in post drain removal pneumothorax, pleural effusion or re-intervention [1]. Our method of evaluating protocols through auditing allowed us to delineate an 'acceptable' level of harm in a less resource intensive manner than randomized control trials (that are only at liberty to propose 1 set of air and fluid criteria per evaluation) [12, 13].

Randomized control trials comparing digital drainage with traditional underwater seal drains in patients undergoing anatomic lung resection have shown both significant and non-significant reduction in duration of chest drain with digital drainage [14, 15]. Not all trials are able to demonstrate benefits of digital drainage, as implementation and adherence to protocol is the most important determinant of drain duration.

Table 1: Postoperative outcomes of different drain removal protocols

Study	Criteria for drain removal	Number of patients meeting criteria (*n*)	Post-drain removal re-insertion (%)	Post-drain removal pneumothorax (%)	Post-drain removal pleural effusion (%)	Average drain duration, days
Mesa-Guzman *et al.*, 2015 [1]	Progressively permissive:					Median (IQR)
	1. Fluid 5 ml/kg, AL >24 h	1. 126	1. 3%	1. 20%	1. 14%	1. 3 [2–5]
	2. Fluid 6 ml/kg, AL >24 h	2. 109	2. 1%	2. 12%	2. 20%	2. 2 [2–5]
	3. Fluid 7 ml/kg, AL >24 h	3. 100	3. 3%	3. 12%	3. 13%	3. 3 [2–4]
	4. AL <20 ml/min for >6 h	4. 109	4. 5%	4. 11%	4. 12%	4. 1 [1–2]
Filosso *et al.*, 2015 [8]	1. Underwater seal: Fluid output <250 ml/24 h and no AL on UWS	1. 40	N/A	N/A	N/A	Mean (SD): 1. 3 (1.5)
	2. Digital drainage: Fluid output <250 ml/24 h and AL <20 ml/min >6 h	2. 40				2. 4 (1.9)
Pfeuty and Lenot, 2020 [18]	AL <20 ml/min >4 h	45	2.2%	11%	22%	0
McCormack *et al.*, 2023 [17]	Postoperative day 0, between 4 and 12 h AL <30 ml/min or negative pleural assessment on Centese systems	375	2%	2.7%	N/A	0
Abdul Khader *et al.*, 2023 [16]	AL <20 ml/min >6 h	797	2.1%	17.7%	9.4%	Median (IQR) 1 [1–2]
Abdul Khader *et al.*, 2023 [19]	On-table drain removal if AL <20 ml/min	107	0.9%	21%	5.6%	0

AL: air leak; UWS: underwater seal; N/A: not applicable or not reported.

FUTURE—SURGERY WITHOUT ROUTINE CHEST DRAINS

We utilized air leak alone (<20 ml/min for >6h) as our drain removal protocol, reporting a re-intervention incidence of only 2.1% and average drain duration of 1 day, in a series of 797 patients over a 9-year period [16], demonstrating a safe early drain removal protocol.

Outcomes of very early chest drain removal has been reported by McCormack and colleagues with chest drain removal on the day of surgery, within 4–12 h after anatomic lung resection (lobectomy and segmentectomy) [17]. In total, 68.5% of patients were able to have drains removed at this time, with a 2% re-intervention rate. This series represents acceptable levels of safety with the utilization of a clear, strict protocol. A number of other centres may find this practice difficult to replicate as drains will be needed to be removed overnight after surgery as protocol timing extends to 12 h postoperatively. Pfeuty and Lenot [18] also similarly studied early chest drain removal, utilizing an air leak criteria of <20 ml/min for >4 h to remove drains on postoperative day 0, presenting no requirement for chest drain re-insertion in those who fulfilled the removal criteria.

We are currently evaluating whether chest drains are routinely needed after all forms of thoracic surgery, including anatomic lung resection. We studied a 5-year protocolized management for chest drain removal on-table in patients predominantly undergoing sublobar/wedge lung resections [19]. At the end of the operation, a 28-Fr drain was inserted, lung re-inflated and connected to a digital drainage; if the rate of air leak was <20 ml/min upon finishing of skin closure, the drain was removed on-table. Our results demonstrated a chest drain re-insertion rate of 0.9%, median length of hospital stay of 1 day, with some patients able to be discharged on the same day of surgery. Our low re-intervention rate and the fact that patients were asymptomatic and well enough for discharge reinforces that this protocol is safe, even with the question that those may only have an air leak that presents on postoperative day 1 or later, highlighting this would not be of clinical significance.

Whilst some institutions propose smaller chest drains (20, 16 and 12 Fr), we are proposing an advancement for a no-drain strategy. Smaller drains would still exhibit limitations of reduced mobility and pain; therefore, a more progressive no-drain strategy would complement an enhanced recovery principle stronger.

We now are evaluating the safety of chest drain placement on an as required basis in the presence of air leak immediately after chest closure (we currently define as more than 20 ml/min), and if not then we would remove all the drains including for anatomic lung resection. As this is protocol-driven, there are no specific patient or surgical factors that would inhibit drain removal as long as the air leak criteria are met. The advantages are surgeon control of the drain removal, easier movement to recovery, less burden for nursing care of an additional drain and an excellent cosmetic result with skin closure on-table, but ultimately, the aim would be to move the speciality towards day case thoracic surgery for anatomic lung resection.

We are closely monitoring safety outcomes in our protocol, with regular auditing and service evaluation. Continual monitoring of outcomes even after protocol has been established ensures overall patient safety is maintained and allows for adverse events to be analysed to establish if there is a connection with the adherence of protocol and indeed if any modifications need to be made.

CONCLUSION

Minimizing chest drain duration post anatomic lung resection is one of the most important factors in enhancing postoperative recovery and facilitating early discharge. Chest drain removal on-table is achievable and safe when utilizing digital drainage with a strict air leak protocol.

The future landscape of chest drain management should focus on the usage of chest drains on an as required basis for air leak, even for anatomic lung resection.

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Conflict of interest: Eric Lim 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, Eric Lim 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 founder of My Cancer Companion Healthcare. The other author reports no disclosures.

DATA AVAILABILITY

No new data were generated or analysed in support of this research.

Author contributions

Eric Lim: Conceptualization; Data curation; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing. **Ashiq Abdul Khader**: Data curation; Investigation; Methodology; Project administration; Resources; Software; Visualization; Writing – original draft; Writing – review & editing.

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REVIEW