Review Article

Thoracic drainage management strategies in postoperative lung surgery: a narrative review

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Background and Objective: Pulmonary resection poses a risk of complications, such as postoperative air leakage, bleeding, and chylothorax, which impact patient outcomes and healthcare costs. Operative procedures are crucial for preventing postoperative complications; however, postoperative drainage management is equally important. In most cases, thoracic drainage management strategies are determined based on tradition and personal experience. This narrative review explores three key aspects of thoracic drainage to provide an overview of the evidence: digital versus traditional systems, optimal intrathoracic pressure, and acceptable effusion amount to remove the drainage tube.

Methods: Publications were identified through searching the PubMed database. Studies published in languages other than English were excluded. Searches were conducted from July 2023 to October 2023, and no restriction was placed on the year of publication of the articles.

Key Content and Findings: First, despite the advantages of air leakage monitoring, early drain tube removal, early discharge, reduced interobserver variability, and early mobilization, the accurate intrathoracic pressure control provided by digital drainage systems might prevent the cessation of air leakage. Thus, the impact of these systems on patients with air leakage should be carefully considered. Second, water seal and lower intrathoracic pressure can reduce the duration of air leakage compared with stronger suctioning. An exception might be patients with a collapsed lung and/or seroma, for whom suction may be beneficial. Third, aggressive strategies for drainage tube removal (pulmonary effusion ≤450–500 mL/day) may be acceptable with careful effusion evaluation.

Conclusions: Further research in the above areas is needed to optimize postoperative thoracic drainage management in lung surgery.

Keywords: Digital drainage system; pleural effusion; prolonged air leakage (PAL); intrathoracic pressure; water seal

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Introduction

Background

Postoperative thoracic drainage promotes lung reinflation by draining air and effusion, and provides information about the thoracic cavity. However, the placement of a thoracic drainage tube could lead to chest pain, reduced patient mobility, and prolonged hospital stay. Drainage management following lung resection differs from postoperative management in other areas in that it deals with both fluid and air. In addition, the pressure in the intrathoracic cavity is negative. Considering these characteristics, the management of thoracic drainage should be carefully considered based on evidence. However, no uniform or best drain management method is known, and drain management methods are likely to be determined based on the experience and tradition of each facility and each physician.

Rationale and knowledge gap

Pulmonary resection poses an inherent risk of complications represented by air leakage. Prolonged air leakage (PAL), generally defined as air leakage with a duration of more than five or seven days, occurs in 5.6–17.6% of cases (1-5). PAL has been associated with longer hospital stay, increased hospital costs, and postoperative complications (6-8). Because PAL is a frequent and troublesome complication, controlling air leakage is considered to be the key to postoperative drainage management. Similarly, the volume of the pleural effusion is a significant factor in determining the timing of drainage tube removal.

Objective

The purpose of this review was to provide an overview of the available evidence related to the following three key points: (I) differences between digital and traditional drainage systems; (II) optimal intrathoracic pressure for the postoperative lung; and (III) acceptable effusion amount for safe drainage tube removal. We present this article in accordance with the Narrative Review reporting checklist (available at https://shc.amegroups.com/article/view/10.21037/shc-23-41/rc).

Methods

Searches were conducted through PubMed from July 2023 to October 2023, using the following keywords; “drainage management”, “digital drainage system”, “thoracic pressure”, “water seal” and “lung resection”. No restriction was placed on the year of publication of the articles. Any type of literature was included. Articles published in languages other than English were excluded. The narrative review was created from PubMed search results, along with the authors’ personal knowledge of the literature (*Table 1*).

Do digital drainage management systems offer advantages?

Three-bottle drainage system was introduced to collect fluids, to keep water seal, and to regulate the amount of suction, and currently, used broadly. Recently, several digital drainage systems were invented, and there have been reports that showed the features of these digital systems as below. The significant feature of a digital system is its ability to monitor air leakage and effusion. Managing air leakage is pivotal in thoracic drainage, and a digital drainage system allows for chronological and objective monitoring, thus facilitating early drainage tube removal and early discharge (9,10). Prior meta-analyses have revealed that digital drainage systems reduce the duration of chest tube placement [−0.72 days; 95% confidence interval (CI): −1.03 to −0.40; P<0.001] and the length of hospital stay (−0.97 days; 95% CI: −1.46 to −0.48; P<0.001) (11,12). These systems can also reduce interobserver variability (13), promoting teamwork despite varying levels of expertise. Depending on the type of machine, another feature is that they are more compact and portable than traditional machines. On the other hand, traditional drainage systems have a long history and allow for intuitive evaluation of the amount of air leakage. When transitioning from traditional to digital systems, surgeons may initially find it challenging to interpret the digital system’s leakage data.

From a cost perspective, digital drainage systems themselves are more expensive (14,15). However, digital drainage systems reduce the length of hospital stay, resulting in cost savings of EUR 430–751 per patient (12,16,17). Treatment-related costs are primarily calculated based on the duration of hospital stay, and cost considerations should not be isolated. For example, in Japan, the insurance system determines the ideal length of hospital stay for each disease. Hence, many hospitals routinely discharge patients on a prescheduled day, even if the drainage tube was early removed. Such hospitals would probably not gain a merit in the length of hospital stay and cost. Therefore, it may

Table 1 The search strategy summary

Items	Specification
Date of search	July–October, 2023
Databases and other sources searched	PubMed
Search terms used	"Drainage management", "digital drainage system", "thoracic pressure", "water seal", "lung resection"
Timeframe	Up to October 2023
Inclusion and exclusion criteria	Inclusion criteria: all peer-reviewed studies and article types were acceptable
	Exclusion criteria: non-English language articles or full text unavailable
Selection process	First author (K.S.) performed article selection

be necessary to weigh approximately one day reduction in drain placement time against the cost of using a digital system to decide which system to use in those hospitals.

When introducing digital drainage systems, particular attention should be paid to the relationship between the thoracic cavity pressure and air leakage. One of the features of digital systems is the precise intrathoracic pressure control. However, when air leakage occurs, the negative intrapleural pressure accelerates air leakage from the fistula. The intrathoracic air generated from the fistula increases the pressure above the preset level of the digital system, and the system increases the suction power to maintain the intrapleural pressure to the preset level. The increased suction pressure accelerates air leakage, leading to PAL. While this mechanism poses no risk to patients without air leakage, those with air leakage could be at risk. Although prior meta-analyses revealed no differences in the incidence of PAL, these studies did not consider the amount of air leakage. Adachi *et al.* demonstrated that the use of water seal systems resulted in shorter air leakage duration compared with that with digital systems (2.5 *vs.* 4.0 days, P=0.008), and that the use of digital systems was a significant risk factor for PAL (hazard ratio, 1.4; 95% CI: 1.01–1.9, P=0.045) (15). Therefore, it may be preferable to distinguish between patients with and those without air leakage, as accurate intrathoracic pressure control with a digital drainage system might prevent the cessation of air leakage. Digital drainage systems may still be useful for patients with air leakage provided they can set the thoracic pressure at levels lower than those obtained with a water seal (18). The potential harm or benefit of digital drainage systems should be a subject of careful consideration, necessitating further research.

What is the optimal level of negative thoracic pressure for the postoperative lung?

External suction has been applied to chest drain tubes based on the theory that suction promotes lung expansion and maintains contact between the visceral and parietal pleura, facilitating the sealing of air leakage. However, suction management may actually prolong air leakage duration. A randomized control study comparing suction to water seal demonstrated that chest tubes based on water seal were superior to those based on suction in stopping air leakage (19,20). Subsequent studies also reported that water seal was superior to suction management for stopping air leakage (21,22). Three meta-analyses have found no significant differences in the duration of air leakage and hospital stay, suggesting that suction is not essential (23-25). Moreover, the intrathoracic pressure with water seal systems was negative after lobectomy (average pressure: –13 to –11 cmH_2O, maximum pressures: –8 to –4 cmH_2O, minimum pressures: –20 to –15 cmH_2O) (26). Lowering the suction level (–2 cmH_2O) compared with a conventional digital drainage level (–10 cmH_2O) resulted in shorter drainage duration (27.4 *vs.* 47.5 h, P=0.047) and shorter median time to consistent air leakage (<20 mL/min) (5.2 *vs.* 23.7 h, P<0.001) (18). These findings suggest that a lower intrathoracic pressure is more beneficial, or at least not harmful, for stopping air leakage than a higher negative pressure. An exception might be patients with a collapsed lung and/or seroma, for whom suction may be beneficial. Several studies have reported contrasting results; however, in one of them, both groups switched to Heimlich valves on the third postoperative day (27), and in the other, suctioning was performed only during daytime (28). Consequently,

many studies support the idea that water seal or lower negative intrathoracic pressure is helpful for stopping air leakage.

What is the threshold of thoracic fluid volume for safe drainage tube removal?

The threshold for removing a drainage tube based on the thoracic effusion volume is generally set at less than 200 mL/day (29). However, more aggressive strategies have been proposed. For example, a pleural effusion volume of less than 450 mL/day is considered acceptable for removing a drainage tube, with a 0.5% readmission rate for symptomatic pleural effusion after thoracotomy (30). Similarly, less than 500 mL/day is deemed acceptable, with drainage required in 2.8% of cases undergoing video-assisted thoracoscopic lobectomy (31). Early removal of thoracic drainage tubes leads to less pain, improved mobility, and shorter hospital stays. However, it should be noted that one hospital that changed the threshold for drainage tube removal to 450 mL/day reported that 15% of discharged patients were readmitted due to pleural effusion (32).

Furthermore, some authors have advocated for drainage tube removal on the same day of surgery (33). This practice necessitates a meticulous evaluation of the air leakage and pleural effusion within a tight timeframe, which may require more labor and effort. For example, evaluation for air leakage should ideally be performed after the patient has fully recovered from anesthesia and is able to walk, and the absence of chylothorax should be confirmed after eating. While this may not be a burden in hospitals where patients can be weaned on the day of surgery, meals can be started, and subsequent drain evaluations can be performed appropriately, some hospitals may have these issues to address first. If the drain is removed before adequate evaluation and later air leakage or chylothorax becomes apparent, the drain will need to be reinserted. Consequently, drainage tube removal on the day of surgery may have things to be solved but can offer potential benefits.

More aggressive strategies for drainage tube removal: 450 or 500 mL/day is acceptable to remove drainage tube; drainage tube removal on the same day of surgery, may be safe and beneficial in select patients and in facilities. Nevertheless, the available evidence is scant and should be interpreted with caution.

Conclusions

While digital drainage systems have the advantages of air leakage monitoring, early drain tube removal, and early discharge, their impact on patients with air leakage should be carefully considered. Lower intrathoracic pressure settings can contribute to reduced air leakage duration. Aggressive strategies for drainage tube removal based on effusion amount may be acceptable with careful evaluation. Further research is needed to optimize postoperative thoracic drainage management in lung surgery.

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Footnote

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://shc.amegroups.com/article/view/10.21037/shc-23-41/rc

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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.

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