Guideline

The Society for Translational Medicine: clinical practice guidelines for the postoperative management of chest tube for patients undergoing lobectomy

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Abstract: The Society for Translational Medicine and The Chinese Society for Thoracic and Cardiovascular Surgery conducted a systematic review of the literature in an attempt to improve our understanding in the postoperative management of chest tubes of patients undergoing pulmonary lobectomy. Recommendations were produced and classified based on an internationally accepted GRADE system. The following recommendations were extracted in the present review: (I) chest tubes can be removed safely with daily pleural fluid of up to 450 mL (non-chylous and non-sanguinous), which may reduce chest tube duration and hospital length of stay (2B); (II) in rare instances, e.g., persistent abundant fluid production, the use of $PrR_{P/B}$ <0.5 when evaluating fluid output to determine chest tube removal might be beneficial (2B); (III) it is recommended that one chest tube is adequate following pulmonary lobectomy, except for hemorrhage and space problems (2A); (IV) chest tube clearance by milking and stripping is not recommended after lung resection (2B); (V) chest tube suction is not necessary for patients undergoing lobectomy after first postoperative day (2A); (VI) regulated chest tube suction [–11 (–1.08 kPa) to –20 (1.96 kPa) cmH_2O depending upon the type of lobectomy] is not superior to regulated seal [–2 (0.196 kPa) cmH_2O] when electronic drainage systems are used after lobectomy by thoracotomy (2B); (VII) chest tube removal recommended at the end of expiration and may be slightly superior to removal at the end of inspiration (2A); (VIII) electronic drainage systems are recommended in the management of chest tube in patients undergoing lobectomy (2B).

Keywords: Chest tube; lobectomy; drainage system; GRADE system; recommendation

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Introduction

The appropriate postoperative management of chest tubes seems to influence chest tube duration, hospital length of stay, healthcare costs and helps to reduce pain and ventilatory function (1). However, there is lack of evidence-based consensus on the postoperative management of chest tubes as this is largely based on individual protocols from surgeons and nurses. In 2011, ESTS, AATS, STS, and GTSC published a collaborative proposal based on available evidence and panel experience (2). Since then several new studies have been conducted in this field and consensus guidelines should therefore be updated. The Society for Translational Medicine and The Chinese Society for Thoracic and Cardiovascular Surgery conducted a systematic review of the literature as an attempt to improve our understanding on the postoperative management of chest tube in patients undergoing lobectomy based on current published data.

Methods

A systematic review of electronic databases including PubMed, Scopus and ISI Web of science was performed by using the following searching strategy: ((chest tube[Title/Abstract] AND Clinical Trial[ptyp])) AND ((((lung resection[Title/Abstract]) OR lobectomy[Title/Abstract]) OR pulmonary resection[Title/Abstract]) AND Clinical Trial[ptyp]). The initial search revealed 56 citations. Additional studies were added following an expert opinion.

The quality of evidence and recommendations were produced adopting a grading system as reported by the American College of Physicians Task Force (*Table 1*) (3,4). The recommendations were first drafted by one author (Z.Z) and then were reviewed by a panel of experts in the field. Any disparities were settled with discussions.

Results

Timing of chest tube removal after lobectomy

There is no sufficient evidence on the timing of chest tube removal after lobectomy. Physiologically, daily pleural fluid filtration is estimated to be 350 mL, hence, many authors suggest removing them when daily recorded drainage volume

Table 1 Grade recommendation

Grade of recommendation	Description	Benefit versus risk	Methodology	Implications
1A	Strong recommendation, high quality evidence	Benefits clearly outweigh risk	RCTs without important limitations	Apply to most patients without reservation
1B	Strong recommendation, moderate quality evidence	Benefits clearly outweigh risk	RCTs with important limitations	Apply to most patients without reservation
1C	Strong recommendation, low quality evidence	Benefits clearly outweigh risk	Observational studies or case series	May change with high evidence available
2A	Weak recommendation, high quality evidence	Benefits closely balanced with risks	RCTs without important limitations	Best action may differ in different circumstances
2B	Weak recommendation, moderate quality evidence	Benefits closely balanced with risks	RCTs with important limitations	Best action may differ in different circumstances
2C	Weak recommendation, low quality evidence	Benefits closely balanced with risks	Observational studies or case series	Other alternatives may be equivalent

is less than 300 mL. Others suggest that chest tube removal is safe with a higher threshold of 400–450 mL/day (5-7). One retrospective study, involving 2,077 patients, showed that chest tube removal is acceptable with up to 450 mL/day non-chylous drainage (8). Bjerregaard *et al.* removed chest tubes with a daily fluid production of 500 mL, and experienced recurrence of effusion requiring re-intervention in 17 patients (2.8%) (9). However, other study showed that chest drains can be safely removed without fluid criteria and air leak of less than 20 mL/min with median drain duration of 1 day, associated with a reduced length of hospital stay (10). However, these studies are either prospective observational or retrospective and the results need to be confirmed in clinical trials.

More recently, randomized controlled trials have shown a benefit in early chest tube removal with accepted daily fluid volumes of 300 mL compared to 100 mL (11,12). In these studies early chest tube removal did not show any increase in the rate of pleural effusions or the need for drainage. Sample sizes are, however, limited in these studies (n=70). Furthermore, the study was not of high quality and key elements of RCT such as allocation concealment, blinding and power calculation were not fully addressed (11).

Another RCT randomizing 150 patients to thresholds of 150, 300 and 450 mL/day showed significantly shorter chest tube duration with increasing volume threshold up to 450 mL/day. However, almost 20% (10/51) of patients in the highest threshold group underwent thoracentesis for hydrothorax (13). Authors therefore conclude that a threshold of 300 mL/day is feasible and safe without increasing the risk of thoracentesis or prolonging hospital stay.

An additional point for deciding on the timing of chest tube removal seems to be the chemical profile of the pleural fluid. A recent RCT has showed that pleural fluid-to-blood protein ratio ($PrR_{P/B}$) of less than 0.5 is a good indicator of safe chest tube removal (14). Furthermore chest tube removal can only occur when the output is non-hematic and non-chylous.

Recommendations

- Chest tubes can be removed safely with daily pleural fluid of up to 450 (non-hematic, non-chylous), which may reduce chest tube duration and hospital length of stay (2B).
- Use of $PrR_{P/B}$ <0.5 to determine removal of chest tube might be beneficial (2B).

Number of chest tubes

Conventional textbooks often recommend the use of two chest tubes after lobectomy. Various combinations of apical and basal tubes have been advocated with unjustified evidence regarding safe drainage of air and fluid from the pleural space. However, there is no strong evidence that two chest tubes are superior to one chest tube (15-18). A consensus guideline was published five years ago recommending the use of one chest tube (2). According to the clinical evidences, the use of 2 chest tubes currently appears to be reasonable when a bilobectomy is performed, to allow a complete lung re-expansion, avoiding the risk of

pleural spaces development, which is intrinsically present in this surgical procedure. A recent RCT, comparing patients with one or two chest tubes following lobectomy, demonstrated that there was no statistically significant difference in thoracentesis, the number of cases with pleurodesis, the amount and duration of drainage or the pain of the patients between one-tube and two-tube groups (19). The authors concluded that a single chest tube had advantages in cost savings and hospital length of stay, and was favorable compared to two tubes (18). However, in situations of hemorrhage and space problem, more number of tubes may be required. Also, it is important to differentiated between one tube is required versus most air leaks are contained with one tube.

Recommendation

- ❖ One chest tube is adequate following pulmonary lobectomy (2A).

Chest tube clearance

Chest tube clearance by milking or stripping to promote drainage of the thoracic cavity is a routine practice in cardiac surgery. This technique is employed mainly to dislodge clots in the system by temporarily creating a high negative pressure and increase vacuum within the tube (20). In Thoracic Surgery, this technique was introduced historically in patients who had drainage of empyemas. Early studies highlighted the importance to drain blood clots after thoracic surgery (21).

Subsequently, several studies questioned the effectiveness of chest tube milking after cardiac surgery (22-25). These showed that chest tube stripping did not result in better outcomes. Only one RCT has been identified involving patients undergoing pulmonary lobectomy. This has shown no difference in the extend of pleural effusion identified by X-ray, postoperative air leak, chest tube blockage, morbidity and mortality (26).

Recommendation

- ❖ Chest tube clearance by milking and stripping offers no advantages in patients after lobectomy (2B).

Chest tube suction following pulmonary lobectomy

Suctioning of chest tubes has the theoretical advantage of improving apposition of visceral pleura to the parietal pleura. Furthermore it may alleviate progressive subcutaneous emphysema (27). However, the persistent high negative intrathoracic pressure may also maintain the airflow through an alveolar pleural fistula (28). There are several studies which have investigated the effectiveness of chest tube suction on reducing air leak duration (28-38). Furthermore, three systematic review and meta-analyses were performed in this area (29,38,39). Collectively, these studies showed that external suction had no advantage over simple water seal in terms of incidence of persistent air leak, drainage time, length of postoperative hospital stay, and postoperative pneumothorax. However, these studies are based on traditional drainage systems which have shown high variability in maintaining preset intrathoracic pressure (40), and therefore conclusions may have limited value on digital drainage systems . Furthermore only two studies showed superiority of water seal compared to suctioning (28,30), and results need to be confirmed in a modern thoracic setting.

Modern digital drainage systems are able to detect air leaks accurately and maintain preset intrathoracic pressure ("regulated pressure"). One recent RCT showed that regulated seal (–2 cmH_2O) was safe and effective compared to regulated tailored suction (where the suction varied according to the type of lobectomy from –11 to –20 cmH_2O) for patients undergoing lobectomy by thoracotomy when analysing duration of air leak (41). In this study the level of pressure in both the regulated suction and regulated seal groups were maintained stable using an electronic device.

Recommendations

- ❖ Routine chest tube suction offers no advantage for patients undergoing lobectomy, and may only be indicated in case of progressive subcutaneous emphysema (2A).
- ❖ Regulated seal is as effective as regulated suction (–11 to –20 cmH_2O, depending on the type of lobectomy) when an electronic drainage system to maintain preset intrathoracic pressure is used after lobectomy by thoracotomy (2B).

Techniques to remove chest tubes

There is no evidence based consensus on the correct timing through the respiratory cycle, when a chest tube can safely be removed; hence, tubes are removed either on full inspiration or expiration, with or without assisted

Valsalva maneuver, depending on surgeon preference and service tradition. The pressure at the end of expiration is close to 0 cmH_2O compared to end of inspiration which is close to –8 cmH_2O. The objective is the prevention of pneumothorax following chest tube removal. Two RCTs compared the outcome following chest tube removal based on the timing within the respiratory cycle (38,39). Bell and coworkers concluded that removal of chest tubes at the end of inspiration or at the end of expiration had a similar rate of post-removal pneumothorax (42). In contrast, Cerfolio and coworkers found that removal of chest tubes at full expiration resulted in a lower incidence of pneumothorax than at the end of inspiration (19% *vs.* 32%, P=0.007) (43). However, only 5 (3%) in the inspiration group *vs.* 2 (1%) in the expiration group required intervention (P=0.78). This evidence suggests that chest tube removal at the end of inspiration or at the end of expiration results in similar patient-important clinical outcomes. What matters is to offer a standardized technique with patient coordination.

Recommendation

- There is no clear evidence indicating when during the respiratory cycle the chest tube should be removed (2A).

Electronic drainage system

Electronic drainage systems are able to quantify air leak and intrathoracic pressure for patients following lobectomy, thereby providing objective standards for chest tube removal. The systems have demonstrated the ability to reduce inter-observer variations and thus standardise the decision to remove chest tubes (44,45).

We identified seven RCTs comparing traditional drainage devices with electronic devices, as summarized in *Table 2*. The most commonly used electronic system in these studies was the Thopaz® (Medela AG, Baar, Switzerland) (46,51,52). Other electronic drainage systems were used with sample sizes ranging between 61 and 381 patients. Most patients had undergone elective pulmonary resection, but those with pneumonectomy were excluded. One study included patients with moderate COPD undergoing lobectomy (47). Electronic drainage system was found to reduce chest tube duration and length of hospital stay in 5 studies (8,46-48,52). Other studies reported shortened chest tube duration and hospital length of stay but statistical significance was not reached (45,51). Electronic drainage systems were found to be associated with lower total cost and improved satisfaction from nurses and patients (45,47,48,52). However, one recent study found that "although digital devices decreased tube clamping trials, the impact on duration of chest tube drainage and hospital stay was not statistically significant, even after stratifying by postoperative air leak status" (54). Collectively, an electronic drainage system is a useful tool for the management of postoperative chest tubes in patients undergoing lobectomy.

Recommendation

- Electronic drainage systems are recommended in the management of chest tube in patients undergoing elective lobectomy, as it helps reducing the clinical variability of its management (1B).

Summary

The postoperative management of chest tubes in patients undergoing lobectomy cannot be emphasized enough. The present study aimed to provide the most up to date evidence and recommendations for the management of chest tubes. Overall, the sample sizes in randomized controlled trials were relatively small and conclusions should be further tested in larger multicenter trials.

There is no doubt that the Thoracic Surgical community increasingly utilizes a fast track approach with early removal of chest tubes and overall reduction of number of chest tubes utilized following pulmonary resection.

There is currently a well-evidenced interest in the use of digital drainage systems with validated effectiveness through several trials.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Table 2 Clinical studies investigating the effectiveness of electronic drainage system

Studies	Design	Sample size	Study population	Type of electronic drainage system	Control	Improved outcomes with electronic device	Negative outcomes
Bertolaccini 2011 (45)	RCT	98	Pulmonary resection, except pneumonectomy	Drentech Palm [Redax S.r.l., Mirandola (MO), Italy]	TG, standard water seal pleural chamber	Time rating air leak; inter-observer variability; patient satisfaction	Air leak, hospital stay; chest tube duration
Pompili 2014 (46)	RCT	381	Lobectomy/ segmentectomy	Thopaz, Medela Healthcare, McHenry, IL	Traditional one	Air leak duration; chest tube duration; postoperative length of stay; improved ability to arise from bed; system convenience	Days from air leak cessation to tube removal
Filosso 2010 (47)	RCT	31	Patients with moderate COPD undergoing lobectomy	–	–	Chest tube duration; hospital stay; cost saving;	–
Brunelli 2010 (48)	RCT	159	Lobectomy	DigiventTM, Millicore AB, Dan- deryd, Sweden	Pleur Evac A-6002-08, Teleflex Inc., Research Triangle Park, NC, USA	Chest tube duration; hospital stay; cost saving;	Air leak days
Varela 2009 (49)	RCT	61	Pulmonary resection, except pneumonectomy	Millicore AB DigiVent	Water seal pleural chamber	Agreement related to the indication to remove chest tubes	–
Cerfolio 2008 (50)	RCT	100	Elective pulmonary resection	Sahara S-11000, Teleflex, Research Triangle Plus, NC.	Millicore, Sweden	Chest tube duration; length of hospital stay	Discharged home in device
Lijkendijk 2015 (51)	RCT	105	Lobectomy	Thopaz® (Medela AG, Baar, Switzerland)	Thora-Seal® (Covidien, Mansfield, MA, USA)	–	Chest tube duration; length of hospital stay
Mier 2010 (52)	Prospective observational	75	Elective pulmonary resection	Thopaz®, Medela, Switzerland; or Digivent®, Millicore, Sweden,	Pleur-Evac® A-6000 Series, Teleflex, NC	Chest tube duration; satisfaction from patients and nurses;	–
Anegg 2006 (53)	Prospective observational[¶]	204	Pulmonary resection	AIRFIX® device	No	No	No

[¶]A single arm study without comparison. No clinical outcomes were reported in this study. COPD, chronic obstructive pulmonary disease; RCT, randomized controlled trial; TG, traditional group.

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