Original Article

Early chest tube removal within 6 hours after thoracic surgery results in improved postoperative prognosis and no adverse effects

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Background: Advances in minimally invasive surgery and drainage systems have caused earlier chest-tube-removal. This retrospective study aimed to assess the safety of early chest tube removal using the institution's new criteria 6 hours after thoracic surgery.

Methods: Elective thoracic surgery patients from 2017 to 2023 were reviewed for meeting or not meeting the newer institutional requirement for early chest tube removal; (I) no air leak detected under the digital drainage device observation; (II) no fluid drainage of ≥100 mL/h; (III) no ≥3 combined risks [male, chronic obstructive pulmonary disease (COPD), body mass index (BMI) of <18.5 kg/m^2, severe pleural adhesion, upper lobe lobectomy, or left upper division segmentectomy]. The incidence of adverse events, including chest tube replacement, subcutaneous tube placement, and postoperative thoracentesis, were investigated for 1 month postoperatively. Perioperative outcomes and factors involved in conventional chest tube removal were also assessed.

Results: Of the 942 patient charts reviewed, 244 (25.9%) met the criteria for chest tube removal within 6 hours postoperatively. This patient group did not experience adverse events. They also demonstrated shorter postoperative hospital stay (4 *vs.* 6 days, P<0.001), and lesser postoperative complications (7.4% *vs.* 25.6%, P<0.001) compared to those for whom early chest tube removal was not done. A correlation with thoracotomy, COPD, and steroid and/or immunosuppressant use was observed for patients in the conventional chest tube removal group.

Conclusions: Early chest tube removal after 6 postoperative hours was deemed safe for a selected group of patients who met the criteria for early chest tube removal. This study would support the potential expansion of our early removal criteria.

Keywords: Video-assisted thoracoscopic surgery (VATS); thoracotomy; lung resection; chest tube; chronic obstructive pulmonary disease (COPD)

Submitted Dec 27, 2023. Accepted for publication Apr 07, 2024. Published online May 20, 2024.
doi: 10.21037/jtd-23-1905
View this article at: https://dx.doi.org/10.21037/jtd-23-1905

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Introduction

Chest tube drainage after thoracic surgery provides information on postoperative bleeding or air leak. In addition, the drainage helps minimize the extent of clinical impact for the patient if complications occur. Traditionally, indications for chest tube removal after thoracic surgery are (I) no air leak, (II) no active bleeding, (III) ≤200 mL/day of chest tube drainage, and (IV) no chylothorax or empyema (1,2). However, prolonged chest tube duration generally decreases patient quality of life and risks secondary complications such as empyema and delirium (3).

Surgical approaches have become less invasive in recent years (4), and energy devices (5), preoperative risk assessment (6,7), drainage systems (8), and intraoperative repairing methods (9-11) have evolved. Recent reports that deviate from the conventional chest tube guidelines are increasing (1,12-19), making the reconsideration of these previous criteria a research area worth exploring.

This study aimed to examine the safety of our criteria for chest tube removal within 6 hours after thoracic surgery. We investigated the factors associated with perioperative outcomes and conventional criteria to further refine the criteria. The novelties of this study include (I) comparative analysis of perioperative risk reports for specific criteria within 6 hours after thoracic surgery in comparison to conventional chest tube removal guidelines; (II) connecting to a digital drainage device under 10 cmH_2O suction; (III) including surgical procedures other than anatomical pulmonary resection; (IV) assessing the expansion of our criteria. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1905/rc).

Highlight box

Key findings

- No adverse events were observed when removed chest tube within 6 hours after thoracic surgery under the specific criteria: (I) no air leak detected under the digital drainage device observation; (II) no fluid drainage of ≥100 mL/h; (III) no ≥3 combined risks (male, chronic obstructive pulmonary disease, body mass index of <18.5 kg/m^2, severe pleural adhesion, upper lobe lobectomy, or left upper division segmentectomy).

What is known and what is new?

- The conventional criteria for removing a chest tube were established during the era of thoracotomy and are still applied even now.
- This study presented new drainage removal criteria aligned with the era of minimally invasive approaches, along with the associated outcomes.

What is the implication, and what should change now?

- When the criteria are met, early postoperative chest tube removal should be considered safe.

Methods

This study included all patients who underwent elective thoracic surgery and were admitted to the Kurobe City Hospital (Toyama, Japan) and Toyama University Hospital (Toyama, Japan) from November 2017 to March 2023. This retrospective study was conducted following the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of Kurobe City Hospital (Toyama, Japan; 228-3). The requirement for informed consent was waived due to the study's retrospective design.

Cases that involved resection of extrathoracic organs, empyema, trauma, hemostasis, collar incision, median sternotomy, mediastinoscopic approach, and pneumonectomy were excluded from the study, as well as patients with missing data.

Criteria and safety evaluation for chest tube removal within 6 hours after thoracic surgery

Based on our clinical pilot experience and previous reports (1,12-19), we have established our own criteria for early chest removal of chest tube: (I) no air leak (0 mL/min) detected under the digital drainage device observation (Thopaz, Medela, Baar, Switzerland); (II) no fluid drainage of ≥100 mL/h; (III) no ≥3 combined risks [male, chronic obstructive pulmonary disease (COPD), body mass index (BMI) of <18.5 kg/m^2, severe pleural adhesion, upper lobe lobectomy, or left upper division segmentectomy] [Supplementary file (Appendix 1)]. Patients who met the following criteria and were able to remove the chest tube within 6 hours after surgery were named "early chest tube removal." Patients who could not meet these criteria were uniformly named patients with "conventional" chest tube removal: (I) no air leak; (II) no active bleeding; (III) ≤200 mL/day of chest tube drainage; and (IV) no chylothorax or empyema.

Safety endpoint factors (potential adverse events) monitored after early or conventional chest tube removal included re-drainage, subcutaneous tube placement, and postoperative thoracentesis. These factors were observed for one month postoperatively.

Follow-up strategy

Postoperative follow-up included routine blood tests and chest X-ray examinations on postoperative day 1, 2, 4, 2 weeks, and 1 month. Additionally, a chest X-ray examination was conducted on the day following chest tube removal. As needed, these examinations were also performed on other days. The re-drainage (chest tube replacement, subcutaneous tube placement, and thoracentesis) after chest tube removal was performed if a patient had subjective symptoms and pleural effusion, pneumothorax, or subcutaneous emphysema was identified on chest X-ray.

Preoperative tests and management

Simple chest radiography, contrast-enhanced computed tomography, blood tests, urine tests, electrocardiograms, and pulmonary function tests were performed in all patient cases. Cerebral magnetic resonance imaging and positron emission tomography were also performed in cases with lung cancer. Patients aged >80 years with one or more risk factors for coronary artery disease underwent preoperative cardiac echography and cardiac stress testing. Preoperative antithrombotic drugs were withdrawn according to each drug. Patients with high thrombotic risk received a continuous heparin infusion (5,000 units/day) immediately postoperatively. Patients taking steroids were controlled to ≤20 mg/day and perioperatively covered with steroids for preoperative risk assessments (20). Immunosuppressants were discontinued 2 weeks before the operation, and patients were controlled with steroids by endocrinologists.

Surgical strategy

The surgical approach and the indications were different according to the phase (4). Before 2018, patients underwent 3- or 4-port video-assisted thoracoscopic surgery (VATS) with 5- or 10-mm ports for the multiport VATS (M-VATS) procedure. Starting in 2018, we introduced robot-assisted thoracoscopic surgery (RATS) and uniportal VATS (U-VATS). Patients underwent 4- or 5-port VATS with 8- or 12-mm ports for RATS. A thoracoscope was used with a 30° 5- or 10-mm camera. A one-port incision was extended to approximately 3 cm during specimen extraction. U-VATS port positions were placed by extending each thoracoscope port of M-VATS forward by a 3-cm incision. Complicated or procedures that were not progressing within a reasonable timeframe were converted to thoracotomy. Guidelines for conversion to thoracotomy included significant adhesion and unexpected hemorrhage that could not be controlled using a thoracoscopic procedure. Advanced bipolar devices were the energy devices mainly used in the thorax (5).

General anesthesia was maintained using single-lung ventilation with a double-lumen endotracheal tube despite surgical approaches. Patients were placed in the lateral decubitus position.

Intraoperative air leak test and management

An intraoperative water sealing test was routinely performed to detect air leaks after lung resection during all procedures. Warm distilled water (1 L) was administered to the thoracic cavity after the procedure. Air leaks were detected by immersing the lung in water after reinflation of the operated lung (peak pressure of 15 cmH_2O) and rated as no evidence of air leak; mild air leaks, characterized by non-coalescent single bubbles; and severe air leaks, with coalescent bubbles or multiple air leaks. The distilled water was aspirated, and subsequently, saline was administered and aspirated. The fistula was covered using a polyglycolic acid (PGA) sheet (Neoveil, Gunze, Japan) plus fibrin glue (PF method) in the case of mild air leakage. The PF method was applied by spraying fibrin glue on the PGA sheet placed over the pleural defect after rubbing fibrinogen on the pulmonary air leak area (9). The PF method was applied after using gauze to wipe the moisture around the fistula. Free pericardial fat pad suturing was performed with 4-0 Prolene (Ethicon, Somerville, NJ, USA) and coated using the PF method for severe leaks. A chest tube with a 20-Fr Argyle trocar double-lumen catheter (Cardinal Health, Dublin, OH, USA) was inserted despite the surgical approach. The Thopaz drainage system was used and set at –10 cmH_2O. Autologous blood patch therapy was performed if a postoperative air leak was observed (21). Combined adhesion therapy with OK-432 (Picibanil; Chugai Pharmaceutical Co. Ltd., Tokyo, Japan) and minocycline was performed if an air leak was not sealed after a maximum of three autologous blood patch therapy applications.

Variables and assessments

The following patient characteristics, surgical characteristics, and follow-up parameters were recorded from the preoperative period until 1 month postoperatively: age,

sex, BMI, smoking history, comorbidity (hypertension, hyperlipidemia, hyperuricemia, diabetes, interstitial pneumonia, COPD, and asthma), preoperative medication (steroid, immunosuppressant, hypnotic medication, and anti-thrombogenic agents), diagnosis, diseased side, procedure type (partial resection, segmentectomy, lobectomy, mediastinal tumor resection, others), systematic lymph node dissection (LND), surgical approach (M-VATS, U-VATS, RATS, and thoracotomy), intraoperative bleeding, operative time, intraoperative findings (severe adhesion and intraoperative air leak), chest tube duration, postoperative nausea and vomiting, postoperative complications (e.g., prolonged air leak defined as an air leak lasting for >5 days), post chest tube removal adverse events (pneumothorax or pleural effusion with chest tube replacement or thoracentesis, or subcutaneous emphysema with subcutaneous tube placement) and postoperative hospitalization. Complications were any deviation from the normal postoperative course and were graded following the Clavien-Dindo classification (22). Severe pleural adhesion was defined as the need for adhesiolysis requiring >30 minutes (23).

Data management and statistical analysis

This retrospective study used data collected, including operation records, anesthesia records, surgical videos, and medical charts, at Kurobe City Hospital and Toyama University Hospital.

Intergroup differences were evaluated using the nonparametric Wilcoxon rank-sum test for the univariate analysis. The χ^2 or Fisher's exact test was used to compare categorical variables as appropriate. A two-sided P value of <0.05 was considered statistically significant. Continuous variables are presented as mean ± standard deviation for normally distributed data and as median with interquartile range for non-normally distributed data. Categorical variables are presented as sample size and percentage [n (%)].

The multivariate analyses included factors selected based on the univariate analyses, statistical independence, and clinical significance. Multivariate logistic regression was used to identify independent risk factors of early chest tube removal failure. A nominal logistic regression was initially performed with preoperative and intraoperative variables that were significant univariate predictors of the outcome being modeled. Variables with P values of <0.1 were included in the multivariate logistic regression models due to the rarity of the outcome events being modeled. All statistical analyses were performed using JMP pro version 16.2 (SAS Institute Inc., Cary, NC, USA).

Results

Of the total 942 patients, 244 (25.9%) had drains removed within 6 h postoperatively (*Figure 1*, *Table 1*). None of the patients with early chest tube removal had pneumothorax or pleural effusion with chest tube replacement or thoracentesis, or subcutaneous emphysema with subcutaneous tube placement. These patients demonstrated significant differences compared to the conventional removal group in the following: shorter postoperative hospitalization (4 *vs.* 6 days, P<0.001), lesser postoperative complications (7.4% *vs.* 25.6%, P<0.001), and lesser postoperative pneumonia (1.2% *vs.* 9.6%; P<0.001) (*Table 2*).

Additionally, significant factors other than the withdrawal criteria (male, COPD, upper lobectomy or left upper division segmentectomy, and severe pleural adhesion) include the following: age (younger, 69 *vs.* 71 years; P=0.001), smoking history (45.1% *vs.* 63.3%; P<0.001), interstitial pneumonia (11.9% *vs.* 19.2%; P=0.01), steroid and/or immunosuppressant use (2.5% *vs.* 7.4%; P=0.005), anti-thrombogenic agents (3.7% *vs.* 8.6%; P=0.009), primary lung cancer (48.4% *vs.* 60.0%; P=0.002), M-VATS (33.2% *vs.* 52.9%; P<0.001), thoracotomy (0.4% *vs.* 10.5%; P<0.001), lobectomy (21.7% *vs.* 45.4%; P<0.001), systematic LND (42.2% *vs.* 63.9%; P<0.001), more U-VATS (63.9% *vs.* 34.7%; P<0.001), and lung partial resection (40.6% *vs.* 23.6%; P<0.001). No significant differences were observed between groups regarding BMI of <18.5 kg/m^2.

The multivariate analyses revealed thoracotomy [odds ratio (OR): 8.15; 95% confidence interval (CI): 3.55–18.72; P=0.001], COPD (OR: 2.60; 95% CI: 1.68–3.62; P<0.001), and steroid and/or immunosuppressant use (OR: 2.59; 95% CI: 1.35–7.70; P=0.008) to be independently associated with conventional chest removal (Table S1). These factors were observed even when limited to patients undergoing anatomical lung resection (Table S2). Postoperative complications were more frequent with COPD (31.5% *vs.* 16.7%; P<0.001) and thoracotomy (44.6% *vs.* 18.9%; P<0.001). However, steroids and immunosuppressant use did not have significant differences in postoperative complications (*Table 3*).

Discussion

This retrospective study assessed our safety criteria of early chest tube removal, up to 6 hours after thoracic

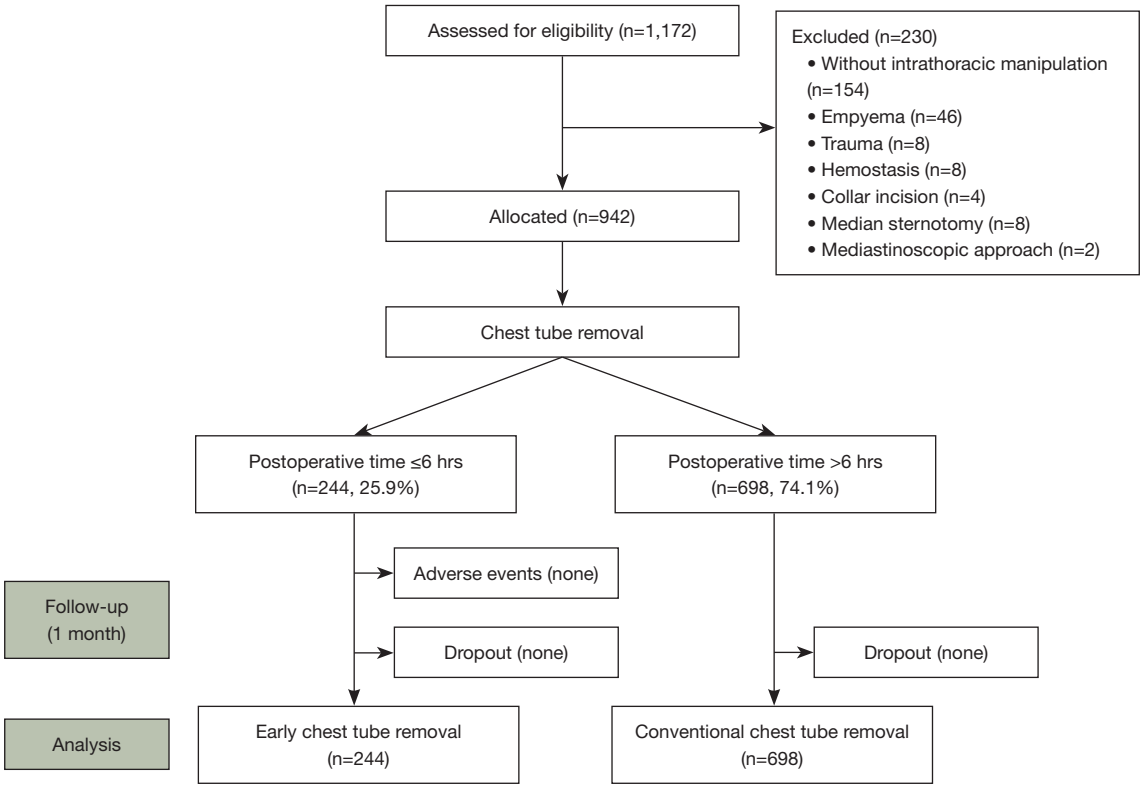

Figure 1 Patient selection flowchart.

surgery. None of the patients with early chest tube removal experienced adverse events, indicating its safety. Additionally, patients with early chest tube removal demonstrated a significant improvement in shorter postoperative hospital stay, and fewer postoperative complications.

This study revealed no obvious problems in patients with early chest tube removal one month after removal. A chest tube could be removed early and the patient could be immediately discharged if they have no preoperative risk, no abnormal intraoperative findings, and a good procedure was performed. Doctrinaire chest tube removal criteria may already be outdated for modern medicine (1,12-19). Postoperative pain was not assessed in this study, but chest tube and pain are highly correlated (18,19,24). Early chest tube removal may affect postoperative complications and shorter hospitalization. Chest tube was removed even during nighttime hours if the criteria were met. This was particularly beneficial in cases where patients experienced intense pain or postoperative delirium, emphasizing the importance of early route management for medical safety concerns (18). Namely, early drain removal might be safer if possible instead of uniformly applying the conventional criteria, considering the patient's preoperative condition and intraoperative findings. The chest tube removal is generally a prerequisite for discharge and significantly influences the duration of postoperative hospitalization. We conducted routine chest X-ray examinations on the day following the chest tube removal in all cases. If there were no evident abnormalities on the X-ray, and no other problematic factors were identified, we allowed discharge. Our early drain removal criteria were considered to be somewhat predictable based on preoperative assessment, and when combined with intraoperative findings, it was believed that the anticipated postoperative hospitalization period could be forecasted.

Factors to consider in chest tube removal criteria

This retrospective study had possibilities that various factors, including the time of surgery completion, the ward condition, and the surgeon's subjectivity, might have had some influence on drain removal. In addition, no significant difference was observed in BMI. More sophisticated criteria might be excluded, such as BMI, and be included, such as

Table 1 Patient baseline characteristic variables according to the chest tube status

Variables	Conventional (n=698)	Early (n=244)	P value
Age (years)	71 [64–76]	69 [54–74]	0.001
Sex (male)	490 (70.2)	125 (51.2)	<0.001
BMI (kg/m^2)	22.9 [20.5–25.4]	22.3 [20.0–25.2]	0.14
BMI of <18.5 kg/m^2	63 (9.0)	19 (7.8)	0.60
Smoking history	442 (63.3)	110 (45.1)	<0.001
eGFR (mL/min)	70.4 [58.7–81.8]	70.4 [62.3–83.2]	0.12
Comorbidity			
Hypertension	325 (46.6)	104 (42.6)	0.30
Hyperlipidemia	264 (37.8)	96 (39.3)	0.70
Hyperuricemia	81 (11.6)	18 (7.4)	0.07
Diabetes	203 (29.1)	59 (24.2)	0.16
Interstitial pneumonia	134 (19.2)	29 (11.9)	0.01
COPD	231 (33.1)	39 (16.0)	<0.001
Asthma	72 (10.3)	34 (13.9)	0.13
Preoperative medication			
Steroid and/or immunosuppressant use	52 (7.4)	6 (2.5)	0.005
Hypnotic medication	185 (26.5)	67 (27.5)	0.80
Anti-thrombogenic agents	60 (8.6)	9 (3.7)	0.009
Disease			
Primary lung cancer	419 (60.0)	118 (48.4)	0.002
Metastatic lung tumor	81 (11.6)	36 (14.8)	0.22
Pneumothorax	70 (10.0)	23 (9.4)	0.90
Mediastinal tumor	80 (11.5)	37 (15.2)	0.14
Others	47 (6.7)	30 (12.3)	0.009
Diseased side			0.82
Right	403 (57.7)	142 (58.2)	
Left	279 (40.0)	95 (38.9)	
Bilateral	16 (2.3)	7 (2.9)	
Surgical approach			
Multiportal VATS	370 (53.0)	82 (33.6)	<0.001
Uniportal VATS	242 (34.7)	156 (63.9)	<0.001
RATS	13 (1.9)	5 (2.1)	0.79
Thoracotomy	73 (10.5)	1 (0.4)	<0.001

Table 1 (*continued*)

Table 1 (*continued*)

Variables	Conventional (n=698)	Early (n=244)	P value
Procedure			
Partial resection	165 (23.6)	99 (40.6)	<0.001
Segmentectomy	129 (18.5)	54 (22.1)	0.22
Lobectomy	317 (45.4)	53 (21.7)	<0.001
Upper lobectomy or left upper division segmentectomy	182 (26.1)	30 (12.3)	<0.001
Mediastinal tumor resection	75 (10.7)	35 (14.3)	0.13
Others	12 (1.7)	3 (1.2)	0.77
Systematic LND	446 (63.9)	103 (42.2)	<0.001

Values are expressed in median [IQR] or n (%). BMI, body mass index; eGFR, estimated glomerular filtration rate; COPD, chronic obstructive pulmonary disease; VATS, video-assisted thoracoscopic surgery; RATS, robot-assisted thoracoscopic surgery; LND, lymph node dissection; IQR, interquartile range.

Table 2 Procedural characteristics and postoperative outcomes according to the chest tube status

Variables	Conventional (n=698)	Early (n=244)	P value
Intraoperative bleeding (mL)	20 [1–90]	1 [1–15]	<0.001
Operative time (min)	159 [113–213]	102 [72–138]	<0.001
Intraoperative findings			
Pleural severe adhesion	150 (21.5)	7 (2.9)	<0.001
Intraoperative air leak	154 (22.1)	15 (6.1)	<0.001
Chest tube duration (day)	1 [1–2]	0 (0.0)	<0.001
PONV	25 (3.6)	7 (2.9)	0.69
Complications	179 (25.6)	18 (7.4)	<0.001
Prolonged air leak	55 (7.9)	0 (0.0)	<0.001
Pneumonia	67 (9.6)	3 (1.2)	<0.001
Arrhythmia	46 (6.6)	9 (3.7)	0.11
Atelectasis	8 (1.1)	1 (0.4)	0.46
Delirium	10 (1.4)	1 (0.4)	0.31
Others	52 (7.4)	5 (2.0)	0.002
Post chest tube removal adverse events	7 (1.0)	0 (0.0)	0.20
Postoperative hospitalization (days)	6 [4–8]	4 [3–5]	<0.001

Values are expressed in median [IQR] or n (%). PONV, postoperative nausea and vomiting; IQR, interquartile range.

thoracotomy, from the perspective of conventional chest tube removal factors and postoperative complications.

Thoracotomy, COPD, and steroid or immunosuppressant use were detected as factors for conventional chest tube removal. It is easier to envision that a larger incision results in a greater amount of drainage. Early chest tube removal, unavoidably, becomes difficult in thoracotomy cases because thoracotomy is often selected in complicated

Table 3 Postoperative complications in patients with conventional removal factors

Variables	Steroid and/or immunosuppressant use			COPD			Thoracotomy		
	Yes (n=58)	No (n=884)	P value	Yes (n=270)	No (n=672)	P value	Yes (n=74)	No (n=868)	P value
Complications, total	14 (24.1)	183 (20.7)	0.51	85 (31.5)	112 (16.7)	<0.001	33 (44.6)	164 (18.9)	<0.001
Prolonged air leak	6 (10.3)	49 (5.5)	0.14	35 (12.9)	20 (2.9)	<0.001	9 (12.2)	46 (5.3)	0.03
Pneumonia	4 (6.9)	66 (7.5)	0.64	32 (11.9)	38 (5.7)	0.002	15 (20.3)	55 (6.3)	<0.001
Arrhythmia	2 (3.5)	53 (6.0)	0.57	21 (7.8)	34 (5.1)	0.12	15 (20.3)	40 (4.6)	<0.001
Atelectasis	0 (0.0)	9 (1.0)	0.56	3 (1.1)	6 (0.9)	0.72	2 (2.7)	7 (0.8)	0.15
Delirium	1 (1.7)	10 (1.1)	0.50	4 (1.5)	7 (1.0)	0.52	2 (2.7)	9 (1.0)	0.21
Others	4 (6.9)	53 (6.0)	0.77	26 (9.6)	31 (4.6)	0.006	10 (13.5)	47 (5.4)	0.01
Postoperative hospitalization (days)	6 [5–9]	5 [4–7]	0.0046	6 [5–9]	5 [3–7]	<0.001	10 [7–13]	5 [4–7]	<0.001

Values are expressed in median [IQR] or n (%). COPD, chronic obstructive pulmonary disease; IQR, interquartile range.

cases. The univariate analysis of this study revealed not only thoracotomy but also M-VATS and RATS, which require multiple ports as significant factors. The conventional criteria for chest tube removal were established primarily during the era when thoracotomy was predominant (1). The size and number of incisions are synonymous with the extent of damage to the parietal pleura and would be considered significant pleural effusion factors (25,26). The significance of minimally invasive approaches suggests not only pain reduction but also pleural effusion decrease (12-19). This would apply not only to lung surgery but also yield similar results in the field of esophageal surgery (27). We believe that the minimal damage to the chest wall in minimally invasive approaches is one of the factors contributing to the achievement of early chest tube removal. Therefore, U-VATS would be a better approach to achieve early chest tube removal among VATS because the number of ports may affect drainage. Additionally, the larger the amount of resection, the more difficult it was to remove the tube early, and not only the surgical approach. Reportedly, lower lobectomy and ≥5 segmental resections result in a large amount of drainage (17).

Prolonged air leak, arrhythmia, and pneumonia are the three major complications after chest surgery (4,28), and COPD and thoracotomy are reported risk factors for all of them (8,29). Early drain removal is challenging for patients with COPD because postoperative air leaks pose a high risk for them. However, the chest tube could be removed in 14.4% of patients with COPD, and this study revealed no re-drainage after removal. In particular, the possibility of delayed air leak is considered to be very low if there is no intraoperative air leak or no lung resection even if a patient has COPD.

Steroids or immunosuppressants generally cause delayed wound healing (20,29). We hypothesized that patients who received steroids or immunosuppressants preoperatively would have more postoperative complications, but they were actuary comparable to those who did not (*Table 3*). Steroids or immunosuppressants may have been a deterrent to early drain removal due to the attending doctor's vague anxiety rather than actual complications. Therefore, steroids or immunosuppressants use may no longer be a failure factor in the future as the number of cases accumulates.

Preoperative antithrombotic drugs did not delay chest tube removal. A report performed surgery while administering antithrombotic drugs (30). However, very few reports performed thoracic surgery (31), so the safety is unclear. Preoperative heparin replacement is not necessary for high-risk bleeding surgeries (32), and heparin administration generally reduces the risk of deep venous thrombophlebitis in patients with a high risk of thrombosis (33). This study immediately started heparin (5,000 units/day) postoperatively in patients who had been taking antithrombotic drugs preoperatively. At least, this study experienced no problems.

While this study included various and not small experiences in different hospitals, involving surgeons, anesthesiologists, and ward nurses, the study is retrospective. This study might indicate that BMI is not a significant criterion to consider but thoracotomy might be included as a

considered factor for early chest tube removal determination. In order to establish more compelling removal criteria, we are currently planning a multi-center prospective study.

Limitations

The limitations of this study include its retrospective design and the involvement of only two institutions. Additionally, the attending physician's subjective judgment may have played a role in the decision on chest tube removal timing. However, this study aimed to assess the safety of early chest tube removal. The skill of the surgical technique and the intraoperative treatment with air leaks may affect the postoperative course but this study does not mandate early chest tube removal according to our criteria. Physicians should have decided according to the facility policy if a patient has some risks and physicians are worried about early removal. Ideal patient profiles for early chest tube removal include elderly patients who are concerned about delirium. Regardless, the advantages and disadvantages of early chest tube removal should be considered before making such a clinical decision.

Conclusions

Early chest tube removal within 6 hours after a thoracic operation has minimal adverse effects and multiple positive clinical benefits. This study would support the potential expansion of our early chest tube removal criteria. Further prospective research is necessary to refine and validate the expanded criteria.

Acknowledgments

We would like to thank Enago (www.enago.jp) for English language editing. This study was presented at the 31st Annual Meeting of the Asian Society for Cardiovascular and Thoracic Surgery hosted in Busan in 2023.
Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1905/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1905/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1905/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1905/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors have no conflicts of interest to declare. 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 Ethics Committee of Kurobe City Hospital (Toyama, Japan; 228-3) with a waiver of the need for informed consent due to its retrospective design.

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Cite this article as: Homma T, Saji H, Shimada Y, Tanabe K, Kojima K, Marushima H, Miyazawa T, Kimura H, Sakai H, Otsubo K, Hatakeyama T, Tsuchiya T. Early chest tube removal within 6 hours after thoracic surgery results in improved postoperative prognosis and no adverse effects. J Thorac Dis 2024;16(5):3096-3106. doi: 10.21037/jtd-23-1905