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Early Water Seal of Chest Tubes Following Video-Assisted Thoracic Surgery Pleurodesis



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ABSTRACT

Introduction: Early water seal following minimally invasive pulmonary lobectomy has been shown to reduce chest tube duration and postoperative length of stay (LOS). We evaluated chest tube duration and postoperative LOS following a standardized chest tube management protocol change (water seal on postoperative day 1) after video-assisted thoracic surgery (VATS) pleurodesis.

Methods: We identified adult patients undergoing VATS pleurodesis from August 2013 to December 2021. The chest tube protocol was changed in January 2017 such that patients were placed to water seal on the morning of postoperative day 1. Patients were divided into two groups, before the change (Group 1: August 2013–December 2016) and after (Group 2: January 2017–December 2021). We compared demographics, clinical characteristics, operative details, postoperative chest tube duration and output, and postoperative LOS between the groups. Descriptive statistics and log-transformed multivariable linear regression models were used to identify differences in patient outcomes that were associated with the protocol change.

Results: A total of 488 patients underwent VATS pleurodesis during the study period (Group 1: 329 patients; Group 2: 159 patients). The median age was 61 y (interquartile range [IQR] 49–68), 51% were females, 69% were White, and 29% were Black. For postoperative LOS, Group 1 had an IQR of 3–7 d, while Group 2 had an IQR of 2–6 d ($P < 0.001$). The multivariable log-transformed linear regression models demonstrated that the practice change was associated with reduced chest tube duration (0.77 times the chest tube duration before the change; $P < 0.001$) and reduced LOS (0.81 times the LOS before the change; $P = 0.006$). There was an associated reduction in patients needing to return to the operating room ($P = 0.048$) and needing postoperative extended ventilatory support ($P = 0.035$).

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Conclusions: Development of a standardized protocol to water seal chest tubes on postoperative day 1 following VATS pleurodesis is associated with reduced chest tube duration and LOS without an increase in postoperative complication rates.

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Introduction

Chest tubes are an essential component of postoperative care for patients undergoing thoracic surgeries. After surgery, the goal is to regain full expansion of the lungs via drainage of any excess air or fluid that has accumulated as a result of the procedure.¹ A chest tube accomplishes this goal and the volume of drainage serves as an indicator of the condition of the thoracic cavity postoperatively.² The postoperative management of chest tubes for various thoracic procedures has been heavily debated in terms of low-risk strategies that will provide the optimal duration of chest tube insertion and postoperative length of stay (LOS). Chest tubes are painful and immobilizing to patients, and longer placement can increase the risk of infection and hospital stay.^{3,4} The early removal of chest tubes has been shown to reduce pain and increase ventilatory function.⁵

At our institution, chest tubes are initially placed on traditional wall suction, followed by a conversion to water seal once the lung has become fully inflated. Early conversion to water seal has already been shown to reduce chest tube duration and postoperative LOS following a minimally invasive pulmonary lobectomy.⁶ The goal of this study is to evaluate if this same principle holds true for video-assisted thoracic surgery (VATS) pleurodesis, given that the main determining factor for length of hospital stay following this procedure is the chest-drain duration.⁷

Pleurodesis is a procedure in which an irritant is introduced into the pleural space to prevent subsequent fluid or air accumulation. The irritant can be introduced by either chemical or mechanical means during the procedure. This causes the two linings of the pleural space, the parietal and visceral pleura, to become inflamed and fibrotic. This inflammation and further fibrosis results in adhesions between the two membranes, thus obliterating the pleural space and the opportunity for future fluid accumulation.^{8–10} In this study, we will evaluate if an early conversion to water seal is associated with favorable clinical outcomes for patients undergoing VATS pleurodesis.

Methods

Patient population and setting

In this study, a single-institution retrospective review was conducted of all adult patients who underwent a VATS pleurodesis procedure during the period of August 2013 to December 2021 at the University of Alabama at Birmingham, a tertiary referral hospital and academic medical center. With approval by the UAB Institutional Review Board, we used the Society of Thoracic Surgeons General Thoracic Surgery Database at the University of Alabama at Birmingham to conduct

our search. A total of 545 patients who received a VATS pleurodesis procedure within the given time frame were identified. This list was refined to exclude any pediatric patients, defined as being aged less than 19 y and any patients who received a VATS procedure for decortication. These criteria excluded a total of 57 patients, yielding a final population of 488 patients. Of the 488 patients included in this study, there were 396 who received a chemical pleurodesis, 33 who received mechanical pleurodesis, and 59 who received a combined mechanical and chemical pleurodesis. A summary of our study cohort is depicted in [Figure](#).

Protocol change

Postoperative chest tube management for patients undergoing VATS pleurodesis involved the patient initially being placed on traditional wall suction, followed by a transition to water seal on postoperative day 2 or when the lungs became fully expanded on imaging. Beginning January 2017, this protocol was changed such that any patient who underwent a VATS pleurodesis was transitioned from suction to water seal on postoperative day 1 rather than day 2. An institutional review board–approved waiver of informed consent was obtained for patient participation in the study (IRB-300001975). We divided our initial patient population into two groups based on the practice change date. Group 1 included patients from August 2013 to December 2016 who were placed on the original chest tube protocol ($n = 329$). Group 2 included patients from January 2017 to December 2021 who were placed on the new protocol ($n = 159$).

Variables assessed and statistical analysis

All patient records were thoroughly reviewed and data were collected on each patient's demographics, clinical and operative characteristics, and postoperative outcomes. Specifically, the primary outcomes assessed were the duration of postoperative chest tube use, LOS after surgery, and cumulative chest tube output per day. Secondary outcomes were recorded as the presence of any postoperative complications, including pulmonary embolus, pneumothorax, pneumonia, acute renal failure, respiratory failure, tracheostomy, prolonged air leaks, acute respiratory distress syndrome, atelectasis, and pleural effusion. Other secondary outcomes assessed included rates of reoperation, readmission within 30 d, and death before hospital discharge or within 30 d of discharge. Finally, the primary indication for pleurodesis was recorded for each patient and the rate of simultaneous wedge resection or blebectomy. Patient outcomes were compared between those placed on water seal postoperative day 2 (Group 1) and those placed on water seal postoperative day 1 (Group 2).

Descriptive statistics and log-transformed multivariable linear regression models were used to identify differences in patient outcomes that were associated with the protocol change. Normality was tested using the Kolmogorov–Smirnov test. If a continuous variable was normally distributed, its mean and standard deviation were listed with *P* values generated via Student's *t*-test. For continuous variables that were not normally distributed, median and interquartile ranges (IQRs) were listed with *P* values generated via Wilcoxon Scores (Rank Sums) one-sided comparison. Categorical variables were analyzed using Chi-squared tests. For categorical variables in which the sample size was limited, a Fisher's exact test was used. For the multivariable generalized linear regression model, an array of common clinical and operative characteristics was selected. The final variables included in the model were age, sex, smoking history, insurance status, Zubrod score, American Society of Anesthesiologists score, body mass index, comorbid conditions, preoperative thoracic radiation therapy, history of cardiothoracic surgery, concomitant lung resection, robotic technology, operation duration, type of pleurodesis, agent used for chemical pleurodesis, and year of surgery being after 2017 (protocol change). SAS 9.4 was used for statistical analysis.

Results

Patient demographic and clinical characteristics

Of the 488 patients identified for this study, 69% were Caucasian and 51% were female. The median patient age was 61 y (IQR 49–68). The majority of patients received a chemical-only pleurodesis procedure (81%) with Talc being the most common chemical agent used representing 59% of all cases. Between the two groups, there was no difference in gender, race, or type of pleurodesis procedure performed. There was a difference in patient age between the two groups. The median age of Group 1 was 61 y (IQR 50–69) and of Group 2 was 58 y (IQR 42–67, *P* = 0.021). In terms of relevant risk factors from the past medical history, there were two statistically significant differences between the groups. Of the patients in group 1, 10.2% had a history of preoperative thoracic radiation therapy compared to 2.9% in group 2 (*P* = 0.024). Group 2 had a higher rate of cerebrovascular accident history (9.6%) in comparison to group 1 (3.0%, *P* = 0.002). There were no other significant differences in the relevant past medical history between the two groups. The primary indication for pleurodesis differed significantly between the two groups. In Group 1, 75% of patients received pleurodesis for a pleural effusion *versus* 60% in Group 2 (*P* < 0.001). In Group 2, 40% of patients received pleurodesis for a pneumothorax *versus* 25% in Group 1 (*P* < 0.001). The rate of simultaneous wedge resection or blebectomy was not found to be significantly different between the groups, occurring in 16% of patients in Group 1 and 21% of patients in Group 2 (*P* = 0.108).

Primary and secondary outcomes

For Group 1 and Group 2, the median LOS after surgery was 4 d; however, the distribution of days differed significantly

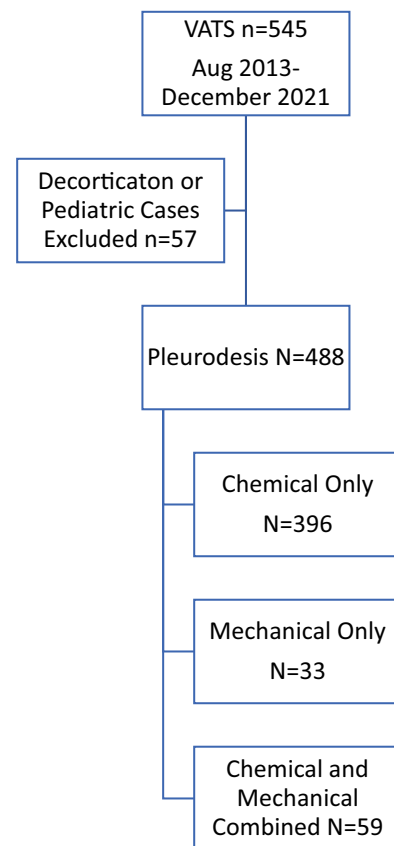


Fig. — Patient selection, inclusion, and exclusion criteria.

between the groups. Group 1 had an IQR of 3–7 d, while Group 2 had an IQR of 2–6 d (*P* < 0.001). The distributions of days of postoperative chest tube use also differed significantly between the two groups. Each group had a median of 3 d for postoperative chest tube use; however, Group 1 had an IQR of 3–5 d, while Group 2 had an IQR of 2–4 d (*P* < 0.001). Cumulative chest tube output per day decreased significantly from 688 mL in Group 1 to 600 mL in Group 2 (*P* = 0.024). Multivariable log-transformed linear regression models demonstrated that the protocol change was associated with both reduced chest tube (CT) duration and a reduced LOS. After adjustment for other baseline and operative characteristics, the CT duration was 0.77 times the CT duration before the change (*P* < 0.001) and the LOS was 0.81 times the LOS before the change (*P* = 0.006). Between the two groups, there was no significant difference in the rate of patients requiring readmission to the hospital within 30 d of discharge. There was also no significant difference in the rate of patient deaths before hospital discharge or 30 d following discharge. There was an associated reduction in the number of patients returning to the operating room for a second procedure following the protocol change (11.2% in Group 1 to 5.7% in Group 2, *P* = 0.048). In addition, there were no patients who required postoperative extended ventilation support in Group 2 (*versus* nine patients [2.7%] in Group 1, *P* = 0.035). Finally, there was not a significant increase in the rates of any of the measured postoperative complications between the groups. A comparison of postoperative outcomes and complications can be seen in [Table](#).

Table – Postoperative outcomes following VATS pleurodesis before and after instituting postoperative day 1 water seal chest tube protocol.

Outcome	Before n = 329	After n = 159	P value
LOS after surgery: median (IQR)	4.0 (3.0–7.0)	4.0 (2.0–6.0)	<0.001*
Postoperative chest tube use in days: median (IQR)	3.0 (3.0–5.0)	3.0 (2.0–4.0)	<0.001*
Cumulative chest tube output in mL: median (IQR)	687.5 (388.0, 1360.0)	600.0 (355.0, 1034.0)	0.023*
Reoperation	37 (11.2%)	9 (5.7%)	0.048*
Readmission within 30 d	25 (13.4%)	8 (9.9%)	0.424
Death within 30 d or before hospital discharge	35 (10.6%)	15 (9.4%)	0.680
Postoperative complications			
Pulmonary embolus	5 (1.5%)	3 (1.9%)	0.764
Pneumothorax requiring chest tube reinsertion	8 (2.4%)	8 (5.0%)	0.130
Other postoperative pulmonary complications	12 (4.8%)	9 (8.5%)	0.176
Pneumonia	22 (6.7%)	7 (4.4%)	0.317
Acute renal failure	67 (20.4%)	21 (13.3%)	0.057
Respiratory failure	20 (6.1%)	10 (6.3%)	0.927
Tracheostomy	3 (0.9%)	1 (0.6%)	0.745
Postop air leak > 5 d	17 (5.2%)	9 (5.7%)	0.826
Acute respiratory distress syndrome	7 (2.1%)	5 (3.1%)	0.496
Atelectasis requiring bronchoscopy	6 (1.8%)	1 (0.6%)	0.298
Pleural effusion requiring drainage	19 (5.8%)	6 (3.8%)	0.343

LOS = length of stay; IQR = interquartile range.

*P values generated by Wilcoxon Scores (Rank Sums) one-sided comparison.

Discussion

The results of this study indicate that fast-tracking the recovery of patients undergoing VATS pleurodesis, via early conversion to water seal on postoperative day 1, is associated with a reduction in postoperative LOS and postoperative chest tube use by about 1 d each. Our results also show that an early conversion to water seal is associated with reduced rates of returning to the operating room and an associated reduction in postoperative extended vent support. Most notably, we did not find a significant increase in the rates of any postoperative complications after implementing the protocol change.

There have been numerous studies over the past 3 decades focusing on the postoperative management of chest tubes, as there is no official protocol, and the decision is largely institutional or up to the discretion of the thoracic surgeon.² First, several studies have evaluated the role of traditional suction versus water seal of chest tubes following thoracic procedures. One such study concluded that water seal was superior to traditional suction for stopping air leaks following pulmonary resection.¹¹ Other studies have also displayed the benefits of a water seal, specifically by implementing a short period of traditional wall suction followed by a conversion to water seal.^{12,13} In the aforementioned studies, the benefits of a water seal are the reduction in the duration of air leaks, thus reducing chest tube duration and overall LOS in the hospital. In fact, persistent air leaks were one of the leading causes of an extended stay in the hospital for thoracic surgery patients.¹⁴ Suction followed by water seal is a protocol that is implemented at our institution because of these benefits.

However, this still begs the question of when the optimal time is to convert to a water seal. One study evaluated early

conversion to water seal following minimally invasive pulmonary lobectomy and this was found to reduce chest tube duration and postoperative LOS.⁶ To our knowledge, there has been no literature applying this concept to the management of chest tubes following VATS pleurodesis. Therefore, it was warranted that we explored this fast-track method by developing a new chest tube protocol in hopes of improving outcomes for these patients. The findings of this study add to the current literature by supporting the notion that water seal management of chest tubes is superior to suction and that an earlier conversion to water seal has associated benefits for the patient.

In reviewing our findings, the limitations of this study should be considered. This study was conducted at a single institution and is therefore subject to institution-specific biases. As this is also a retrospective chart-review analysis, it is subject to inherent biases in data collection. However, our chosen cohort is a representative sample of the patient population in question and we strongly believe that these findings will be applicable to those at other institutions. The goal of postoperative chest tube management is to improve the quality of care for the patient while minimizing complications and decreasing unnecessary time in the hospital. Future studies should consider applying this protocol to other thoracic procedures so that early conversion to water seal could potentially become standard of care.

Conclusions

In this study, we found that implementing a new chest tube protocol, involving early conversion to water seal on postoperative day 1, is associated with a reduced chest tube duration and LOS following VATS pleurodesis. We also found

that early conversion to water seal is associated with decreased rates of reoperation and postoperative extended vent support without significantly increasing the rates of any other postoperative complications. Fast-tracking thoracic surgery patients should be considered as it has the potential to improve patient outcomes and increase hospital efficiency.

Author Contributions

Grant Wagner: Analysis and interpretation of results and manuscript preparation; Ammar Asban: Analysis and interpretation of results and manuscript preparation; Rongbing Xie: Data collection, analysis, and interpretation of results; Leah Schoel: Data collection; Zachary Burns: Data collection; James Donahue: Study conception and design and manuscript review; Benjamin Wei: Study conception and design, analysis and interpretation of results, and manuscript review.

Disclosure

None declared.

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REFERENCES

1. Venuta F, Diso D, Anile M, Rendina EA, Onorati I. Chest tubes: generalities. *Thorac Surg Clin*. 2017;27:1–5.
2. Shintani Y, Funaki S, Ose N, et al. Chest tube management in patients undergoing lobectomy. *J Thorac Dis*. 2018;10:6432–6435.
3. Dokhan A, Abd EM. Influence of timing of chest tube removal on early outcome of patients underwent lung resection. *J Egypt Soc Cardiothorac Surg*. 2016;24:86–93.
4. Jiang H, Wang J, Yuan DF, Fang JW, Li Z. Feasibility and safety of early chest tube removal after complete video-assisted thoracic lobectomy. *Indian J Cancer*. 2014;51 Suppl 2:60–62.
5. Refai M, Brunelli A, Salati M, Xiumè F, Pompili C, Sabbatini A. The impact of chest tube removal on pain and pulmonary function after pulmonary resection. *Eur J Cardiothorac Surg*. 2012;41:820–822.
6. Bertholet JW, Joosten JJ, Keemers-Gels ME, van den Wildenberg FJ, Barendregt WB. Chest tube management following pulmonary lobectomy: change of protocol results in fewer air leaks. *Interact Cardiovasc Thorac Surg*. 2011;12:28–31.
7. Dearden AS, Sammon PM, Matthew EF. In patients undergoing video-assisted thoracic surgery for pleurodesis in primary spontaneous pneumothorax, how long should chest drains remain in place prior to safe removal and subsequent discharge from hospital? *Interact Cardiovasc Thorac Surg*. 2013;16:686–691.
8. Ali M, Surani S. Pleurodesis. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2021.
9. Banini BA, Alwatari Y, Stovall M, et al. Multidisciplinary management of hepatic hydrothorax in 2020: an evidence-based review and guidance. *Hepatology*. 2020;72:1851–1863.
10. Mercer RM, Hassan M, Rahman NM. The role of pleurodesis in respiratory diseases. *Expert Rev Respir Med*. 2018;12:323–334.
11. Cerfolio RJ, Bass C, Katholi CR. Prospective randomized trial compares suction versus water seal for air leaks. *Ann Thorac Surg*. 2001;71:1613–1617.
12. Marshall MB, Deeb ME, Bleier JL, et al. Suction vs water seal after pulmonary resection: a randomized prospective study. *Chest*. 2002;121:831–835.
13. Ayed AK. Suction versus water seal after thoracoscopy for primary spontaneous pneumothorax: prospective randomized study. *Ann Thorac Surg*. 2003;75:1593–1596.
14. Irshad K, Feldman LS, Chu VF, Dorval JF, Baslaim G, Morin JE. Causes of increased length of hospitalization on a general thoracic surgery service: a prospective observational study. *Can J Surg*. 2002;45:264–268.