



Reasons for extended length of stay following chest tube removal in general thoracic surgical patients

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Background: Many patients undergoing general thoracic surgery can be discharged on the same day as chest tube removal, but some are not, leading to increased resource utilization. This study assesses the frequency and duration of extended length of stay (ELOS) after tube removal and identifies risk factors for ELOS.

Methods: We retrospectively reviewed all adult patients undergoing general thoracic surgery at a tertiary referral medical center captured in the Society of Thoracic Surgeons General Thoracic Surgery Database and obtained detailed clinical data on chest tube management from August 2013 to April 2017. Pre-operative demographics, procedures, diagnoses, comorbidities, hospital service category, and lab values were examined to identify risk factors associated with ELOS after chest tube removal using multivariable generalized linear regression models.

Results: One thousand and four hundred seventy patients had ≥ 1 chest tubes placed at the time of operation and discharged after chest tube removal: anatomic lung resection (34%), wedge resection (29%), decortication (16%), and other (21%). Fifty-one percent of these patients were male, 81% were white, and the mean age was 59 years (SD: 15 years). One-third of the patients had prior cardiothoracic operations. Twenty-three percent of these patients had ELOS, defined as discharge ≥ 1 calendar day after chest tube removal with a median additional hospital stay of 3 days (interquartile range, 2–7 days). A multivariable regression model demonstrated that risk factors for ELOS included being admitted to an oncology or transplant service, undergoing decortication procedure, active smoking, and increased disability.

Conclusions: Patients with obesity, more severe disability, or actively smoking, undergoing, decortication, admitted to transplant and oncology services were more likely to experience ELOS. These factors should be considered when identifying appropriate patient groups for fast-track algorithms.

Keywords: Length of stay; chest tube; thoracic surgical surgery

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Introduction

Similar to enhanced recovery pathways seen in other surgical specialties (1,2). Fast-track pathways have been utilized in thoracic surgery to speed up recovery and reduce postoperative stay (3-7). Chest tube management

following thoracic surgical procedures plays a pivotal role in this process. Many patients are able to be discharged the same day as postoperative chest tube removal, while others require an extended length of stay (ELOS).

Many aspects of postoperative chest tube management

have previously been studied, including the utility of intraoperative chest tube placement, the timing of chest tube removal, and the optimal output threshold for chest tube removal. Some studies show that foregoing postoperative chest tube drainage is not associated with major adverse events in specific patient populations (8). Although these results sound promising, they are not applicable to many patient populations and should not be taken to mean that chest tube drainage should be omitted entirely (9). The optimal timing of chest tube removal has long been debated, with many centers relying on volume output threshold as the benchmark by which to decide the appropriate time for chest tube removal (4,10,11). Some centers have turned to digital devices for chest tube output volume calculations and air leak assessments, but the use of analog devices still remains popular in many institutions across the US (12-15). Appropriate thresholds for output volumes have also been studied, as some surgeons have argued for higher daily volume outputs (450–500 cc) to be used as acceptable thresholds for chest tube removal (10). Together, these studies highlight some of the various details that should be considered when undergoing postoperative chest tube drainage.

However, despite the extensive research on postoperative chest tube management, there remains a paucity of literature surrounding the factors that influence discharge following chest tube removal. Some studies have mentioned same-day discharge following chest tube removal, but none have analyzed the barriers or facilitators to making this a reality (16,17). This retrospective study at a tertiary referral center aims to provide further insight into those reasons for ELOS following chest tube removal. The goal of this study is to assess the frequency and duration of hospital stay after chest tube removal and identify specific risk factors associated with ELOS. We present the following article in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting checklist (available at <http://dx.doi.org/10.21037/jtd-20-1210>).

Methods

Data source and patient selection

This was a retrospective study using the Society of Thoracic Surgeons General Thoracic Surgery Database at the University of Alabama at Birmingham, a tertiary referral medical center, all adult patients who underwent a general thoracic surgery procedure between August 1,

2013 and April 1, 2017 were identified. Cases that involved intraoperative placement of a chest tube were deemed eligible and included. Esophagectomies were excluded. A total of 1,470 patients were included and followed up until their discharge. Informed consents are covered by general preoperative consent forms.

Demographic characteristics including age, race, gender, body mass index (BMI), smoking status (current, former, never), and activity status (ECOG score) were collected. Preoperative clinical characteristics such as comorbidities congestive heart failure (CHJTD-20-1210-R1F), coronary artery disease (CAD), peripheral vascular disease (PVD), transient ischemic attack (TIA), cerebrovascular accident (CVA), pulmonary hypertension, interstitial fibrosis, diabetes), preoperative diagnosis, steroid use, prior cardiothoracic surgery, current dialysis status, and history of chemotherapy or radiation were also collected. Postoperative variables recorded include procedure type, last Creatinine (Cr, mg/dL), last Hemoglobin (Hgb, g/dL), air leak >5 days, location of discharge (home, hospice, nursing home, other), postoperative pneumonia, readmission within 30 days, initial ventilator support requirement >48 h, postoperative urinary tract infection (UTI), postoperative catheterization or urinary retention, and discharge with urinary catheter. In this manuscript, our primary outcome, ELOS, was defined as staying in the hospital for 1 or more calendar day(s) after the last chest tube is removed. The length of time between chest tube removal and discharge was recorded after review of the electronic medical record and the associated ICD-9 and ICD-10 codes. Demographic and clinical data were then analyzed to identify any predictors for delayed discharge after chest tube removal. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). IRB approval (protocol #170516005) was obtained for the performance of this study.

Statistical analysis

Descriptive statistics were conducted, and continuous variables were expressed as median and interquartile range. Dichotomous variables/ordinal variables were expressed as number and proportion. Continuous variables were compared using *t*-test; dichotomous variables were compared using the chi-square test. To eliminate any rule of confounding factors or bias, univariate and then multivariable linear regression analysis were conducted to identify predictors associated with LOS after chest tube

Table 1 Postoperative characteristics of patients experiencing ELOS after chest tube removal compared to patients with no ELOS

Postoperative characteristics	ELOS after CT removal (n=338)	No ELOS after CT removal (n=1,132)	P value
Hospital days (median, IQR)	7.0 (4.0–14.0)	2.0 (1.0–4.0)	<0.0001
Air leak >5 days duration (n, %)	9 (2.7)	114 (10.1)	<0.0001
Duration of chest tube use (median, IQR)	3.0 (1.0–5.0)	2.0 (1.0–3.1)	<0.0001
Additional hospital days after chest tube removal (median, IQR)	3.0 (2.0–7.0)	0.0 (0.0–1.0)	<0.0001
Urinary tract infection (n, %)	14 (4.1)	6 (0.5)	<0.0001
Urinary retention req. Catheterization (n, %)	39 (11.5)	161 (14.2)	0.2046
Discharged with Foley catheter (n, %)	4 (1.2)	24 (2.1)	0.2682
Pneumonia (n, %)	28 (8.3)	18 (1.6)	<0.0001
Initial vent support >48 h (n, %)	10 (3.0)	3 (0.3)	<0.0001
Sepsis (n, %)	8 (2.4)	3 (0.3)	<0.0001
Surgical site infection (n, %)	4 (2.8)	6 (1.8)	0.4531
Discharge to extended care/transitional care unit (n, %)	50 (14.8)	10 (0.9)	<0.0001
Discharge facility (n, %)			
Discharge to home	271 (80.2)	1,115 (98.6)	<0.0001
Discharge to nursing home	6 (1.8)	0 (0.0)	<0.0001
Discharge to hospice	4 (1.2)	1 (0.1)	0.0024
Discharge to other facility	4 (1.2)	3 (0.3)	0.0315
Readmission within 30 days after discharge (n, %)	48 (14.3)	78 (6.9)	<0.0001

This table demonstrates the result of univariate analysis that includes postoperative factors and the difference between those with and without ELOS. ELOS, extend length of stay; IQR, interquartile range.

removal. Since we are comparing two cohorts in order to determine how their characteristics differed, we did not conduct any subgroup analysis or sensitivity analysis. SAS 9.4 was used for statistical analysis.

Results

Patient demographic and clinical characteristics

Of the 1,470 patients who were eligible and included in the study, 51% of patients were male, 81% were white, and the mean age was 59 years (SD: 15 years). All patients were followed up to discharge. Of the total cohort, 338 (23.0%) patients had ELOS following chest tube removal with a median additional stay after chest tube removal of 3 days (interquartile range, 2–7 days) (*Table 1*). Surgical procedures were distributed between anatomic lung resection (34%), wedge resection (29%), decortication (16%), and 21% had

another general thoracic surgical procedure (*Table 2*). By univariate analysis, ELOS patients were younger than non-ELOS patients, with a mean age difference of 2.6 years between the two groups. Black patients were more likely to have ELOS compared to white patients [79/263 (30%) *vs.* 255/1,187 (21%); $P=0.0027$ (*Table 3*)].

Compared to patients without ELOS, those with ELOS were more likely to have heart failure, CAD, stroke, diabetes, renal failure, pulmonary hypertension, and severe chronic illness (*Table 3*). Patients with ELOS were more likely to have an urgent operation and have their service of origin be oncology, transplant, or pulmonary (*Table 2*). Among surgical procedures, decortication operations were particularly prone to ELOS (*Table 2*). Following surgery, ELOS patients were more likely to develop pneumonia, require longer mechanical ventilation, and develop urinary infections and sepsis (*Table 1*). In addition, ELOS patients were more likely to be discharged to a transitional care

Table 2 Pre-operative and intraoperative characteristics of patients experiencing ELOS after chest tube removal compared to patients with no ELOS

Perioperative characteristics	All patients (n=1,470)	ELOS after CT removal (n=338)	No ELOS after CT removal (n=1,132)	P value
Cohort service				
Thoracic	1,207 (82.0)	152 (45.0)	1,055 (93.2)	<0.0001
Oncology	24 (1.6)	20 (5.9)	4 (0.4)	<0.0001
Transplant	35 (2.3)	30 (8.9)	5 (0.4)	<0.0001
Pulmonology	55 (3.7)	40 (11.8)	15 (1.3)	<0.0001
Other service	149 (10.1)	96 (28.4)	53 (4.7)	<0.0001
Operation type				
Emergent	3 (0.2)	1 (0.3)	2 (0.2)	0.6701
Urgent	36 (2.5)	20 (5.9)	16 (1.4)	<0.0001
Elective	1,427 (97.0)	316 (93.5)	1,111 (98.1)	<0.0001
Palliative	4 (0.3)	1 (0.3)	3 (0.3)	0.9239
Procedure categories				
Lung procedure	506 (34.4)	59 (17.5)	447 (39.5)	<0.0001
Wedge procedure	430 (29.3)	72 (21.3)	358 (31.6)	0.0003
Decortication procedure	235 (16.0)	136 (40.2)	99 (8.7)	<0.0001
Cyst procedure	79 (5.4)	16 (4.7)	63 (5.6)	0.5519
Thymus procedure	69 (4.7)	7 (2.1)	62 (5.5)	0.0094
Diaphragm procedure	26 (1.8)	8 (2.4)	18 (1.6)	0.3417
Chest wall procedure	24 (1.6)	9 (2.7)	15 (1.3)	0.0886
Other procedure	58 (3.9)	18 (5.3)	40 (3.5)	0.1376
Operation duration (min)		105.5±115.9	106.7±128.4	0.8745
Unexpected return to the OR	32 (2.1)	14 (4.1)	18 (1.6)	0.0049

This table showed the result of univariate analysis that includes operative type, procedure type and service patients of those with and without ELOS. ELOS, extended length of stay.

facility or nursing home, and require readmission within 30 days (*Table 1*).

Of the 338 with ELOS, the majority of them (195 patients) stayed for one more day after chest tube removal (57.6%). *Figure 1* demonstrates the distribution of patient length of stay after chest tube removal.

Multivariable analysis

To examine the many factors associated with ELOS, a multivariable linear regression analysis examined

predictors of duration of stay following chest tube removal was conducted. The three highest impact predictors of longer stay post chest tube removal include admission to a transplant service, admission to an oncology service, and greater generalized disability (*Table 4*). In terms of procedures, addition, patients undergoing decortication were at highest risk for ELOS after chest tube removal. As for comorbidities, obesity, anemia, and current smoking were the strongest predictors of ELOS after chest tube removal (*Table 4*). Use of robotic surgery, race, gender, and insurance status were not risk factors for ELOS.

Table 3 Comparisons of ELOS after chest tube removal among thoracic surgery patients based on demographics and clinical characteristics

Demographics	All patients (n=1,470)	ELOS after CT removal (n=338)	No ELOS after CT removal (n=1,132)	P value
Age in years (mean ± SD)	59.0±15.1	57.0±15.3	59.6±15.0	0.0051
Sex				
Male	746 (50.7)	184 (54.4)	562 (49.6)	0.1221
Race				
White	1,187 (80.7)	255 (75.4)	932 (82.3)	0.0048
Black	263 (17.9)	79 (23.4)	184 (16.3)	0.0027
BMI	28.0±6.6	28.6±7.1	27.9±6.4	0.0990
Smoking				
Current	307 (20.9)	82 (24.3)	225 (19.9)	0.0832
Former	616 (41.9)	123 (36.4)	493 (43.6)	0.0186
Never	544 (37.0)	132 (39.1)	412 (36.4)	0.3805
Comorbidities				
Hypertension	842 (57.3)	200 (59.2)	642 (56.8)	0.4323
Congestive heart failure	84 (5.7)	42 (12.4)	42 (3.7)	<0.0001
Coronary artery disease	249 (16.9)	63 (18.6)	186 (16.4)	0.3456
Peripheral vascular disease	83 (5.6)	21 (6.2)	62 (5.5)	0.6095
Transient ischemic attack (TIA)	33 (2.2)	6 (1.8)	27 (2.4)	0.5052
Cerebrovascular accident (CVA)	45 (3.1)	17 (5.0)	28 (2.5)	0.0168
Pulmonary hypertension	29 (2.0)	14 (4.1)	15 (1.3)	0.0011
Interstitial fibrosis	49 (3.3)	14 (4.1)	35 (3.1)	0.3467
COPD	378 (25.7)	79 (23.4)	299 (26.4)	0.2582
Currently on dialysis	31 (2.1)	18 (5.3)	13 (1.1)	<0.0001
Diabetes	280 (19.0)	85 (25.1)	195 (17.2)	0.0012
Steroid use	150 (10.2)	50 (14.8)	100 (8.8)	0.0015
Prior cardiothoracic surgery	526 (35.8)	128 (37.9)	398 (35.2)	0.3672
Preoperative chemo – current malignancy	163 (11.1)	25 (7.4)	138 (12.2)	0.0136
Preoperative thoracic radiation therapy	143 (9.7)	24 (7.1)	119 (10.5)	0.0626
ECOG status				
Normal activity, no symptoms	251 (17.1)	15 (4.4)	236 (20.9)	<0.0001

Table 3 (continued)

Table 3 (continued)

Demographics	All patients (n=1,470)	ELOS after CT removal (n=338)	No ELOS after CT removal (n=1,132)	P value
Symptoms, fully ambulatory	787 (53.5)	120 (35.5)	667 (59.0)	<0.0001
Symptoms, in bed ≤50% of time	304 (20.7)	125 (37.0)	179 (15.8)	<0.0001
Symptoms, in bed >50% but less than 100% of time	98 (6.7)	52 (15.4)	46 (4.1)	<0.0001
Bedridden	25 (1.7)	22 (6.5)	3 (0.3)	<0.0001
Moribund	4 (0.3)	4 (1.2)	0 (0.0)	0.0002
Greater disability Zubrod ≥2	431 (29.3)	203 (60.1)	228 (20.2)	<0.0001
Laboratory				
Last creatinine level (mg/dL)	±1.2	±1.6	±1.0	<0.0001
Last hemoglobin level (g/dL)	12.7±2.3	11.2±2.7	13.2±1.9	<0.0001

This table demonstrates the result of univariate analysis that includes demographics and clinical characteristics of patients with ELOS and those without ELOS. ELOS, extended length of stay.

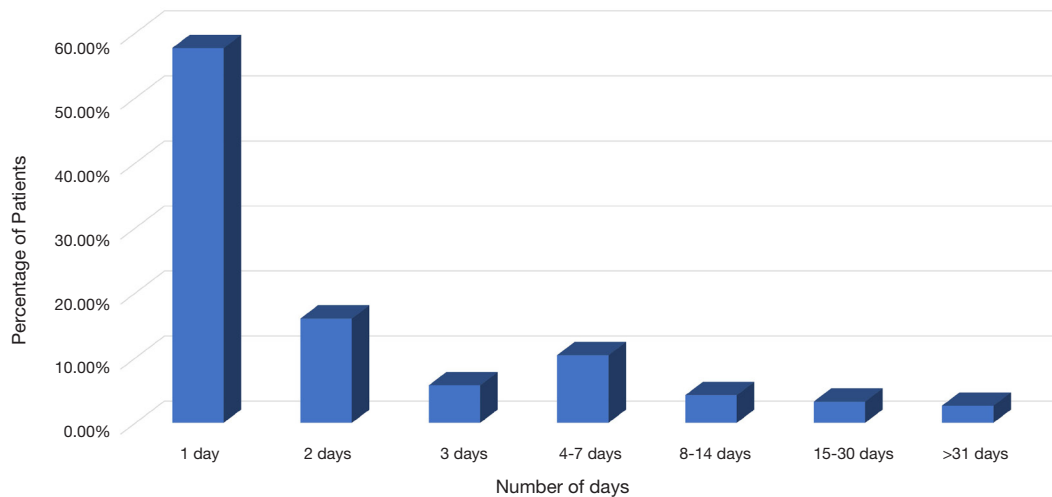


Figure 1 Distribution of extended stay in days among patients with ELOS (n=338). ELOS, extended length of stay.

Discussion

The results of this study show that the service into which a patient is admitted may serve as a predictor for ELOS. In our institution, patients admitted to transplant, pulmonary, and oncology services were more likely to experience

ELOS after chest tube removal than patients admitted to general thoracic surgery services. In addition, certain patient characteristics such as obesity, severe disability, or active smoking were associated with increased length of stay following chest tube removal and should be considered when determining postoperative pathways to discharge. Our

Table 4 Predictors (by multivariable linear regression) of ELOS after chest tube removal among fast-track thoracic surgery patients

Risk factor	Coefficient ^a	P value
Service transplantation	7.88	<0.0001
Service oncology	2.10	0.015
Greater disability (Zubrod \geq 2)	1.42	<0.0001
Decortication procedure	1.31	0.0004
Current smoker	1.05	0.0001
Lower hemoglobin (per 1 g/dL)	0.41	<0.0001
Higher BMI (per 5 kg/m ²)	0.31	0.001

This table illustrates risk factors that are associated with extended length of stay based on multivariable linear regression analysis. ^a, Number of additional days of extended length of stay associated with presence of risk factor. ELOS, extend length of stay.

finding that decortication procedures were associated with ELOS indicates that the type of thoracic surgery procedure should also be considered when constructing fast-track pathways.

Our study adds to current literature surrounding postoperative chest tube management by exploring what factors affect the timeline of a patient's discharge following chest tube removal. We were unsurprised to find that non-thoracic surgical services had higher rates of ELOS, as chest tube management is protocolized and familiar to our thoracic surgery team. Discharge planning often centers on the date of anticipated removal of the chest tube, a parameter that is best understood by the surgical team. Similarly, the comorbidities that correlated with higher ELOS—current smoking, obesity, severe disability—were also unsurprising as these conditions have been shown to lead to longer lengths of stay and increased complications for patients undergoing thoracic procedures (18–22).

Finding differences in ELOS among procedure type was interesting as it suggests there may be utility in creating fast-track pathways that are procedure-specific and not broadly applied to all general thoracic surgical procedures. The increased length of stay for decortication procedures may be explained by the pathology of disease, as decortication procedures may be undertaken after long bouts of illness or chronic disease as opposed to wedge resections or other anatomic lung resections which may be done on an elective basis. Some patients require prolonged administration of intravenous antibiotics following decortication for

empyema, which requires additional planning and could partially explain ELOS in this population.

The main limitation of this study is that it was performed at a single institution and thus may be subject to institution-specific biases. For example, the difference seen in ELOS between the thoracic service and other services may not be seen at other institutions depending on their chest tube protocol and education practices. However, our cohort is a representative sample and therefore, we believe that the findings of this study would be applicable to other institutions.

Conclusions

We found that there are certain risk factors that are associated with the ELOS following chest tube removal. These include obesity, severe disability, active smoking, admission to non-thoracic surgical services, and undergoing decortication procedures. These factors should be considered when establishing fast-track algorithms, as pathways may need to be adjusted to accommodate for patients possessing these risk factors. Utilizing expedited pathways to minimize ELOS following chest tube removal could help optimize resource utilization in the care of general thoracic surgical patients.

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