Valtteri Vilkki

Complications related to tube thoracostomy in Southwest Finland hospital district between 2004-2014

Syventävien opintojen kirjallinen työ

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Vastuuhenkilö: Jarmo Gunn

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Faculty of Medicine

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The purpose of this study was to describe the frequency and types of complications after tube thoracostomy (TT) among all patients treated with TT for both traumatic and non-traumatic indications.

This was a retrospective register-based study of patients treated with TT between the years 2004-2014 in Southwest Finland hospital district.

1808 patients who had undergone TT were identified, complete data on TT treatment was available for 1169 patients. 233 (19.9%) patients had 289 complications, 284 (98.3%) were positional resulting in tube malfunction. In 84 (7.2%) patients malposition of the tube resulted in need for non-urgent operative treatment. There were 103 in-hospital deaths, but none due to TT complications. Empyema as a treatment indication was more frequent in patients with complications (15,9% vs 6,8%, $p<0.001$) as was diabetes (21,9% vs 13,2%, $p=0.001$). The likelihood of complications was lower with CH16 tubes (OR 0.22, $p<0.001$) and higher in diabetics (OR 1.86, $p=0.001$).

Tube thoracostomy is a common procedure and complications occur in 19.9% of patients. Serious complications caused by the chest tube placement, however, are extremely rare. Complications were most common in patients treated for empyema and diabetics. Small CH16 tubes were associated with a lower incidence of complications.

Keywords: chest tube, thoracostomy, complications, pneumothorax, hemothorax, pleural effusion, pleural empyema

Complications related to tube thoracostomy in Southwest Finland hospital district between 2004-2014

Short title: Chest tube complications

VA Vilkki, BM[1]; JM Gunn, MD, PhD[1,2].

[1] Department of surgery, University of Turku, PO Box 7245, 20014, Turku, Finland (vaivil@utu.fi)

[2]Heart Centre, Turku University Hospital, PO Box 52, 20521, Turku, Finland (jarmo.gunn@tyks.fi).

Corresponding author:

Jarmo Gunn

Heart Centre, Turku University Hospital

PO Box 52, 20521 Turku

Tel. +35823130548

Email Jarmo.gunn@tyks.fi

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Abstract

Background and Aims: The purpose of this study was to describe the frequency and types of complications after tube thoracostomy (TT) among all patients treated with TT for both traumatic and non-traumatic indications.

Material and Methods: Retrospective register-based study of patients treated with TT between the years 2004-2014 in a university hospital.

Results: 1808 patients who had undergone TT were identified, complete data on TT treatment was available for 1169 patients. 233 (19.9%) patients had 289 complications, 284 (98.3%) were positional resulting in tube malfunction. In 84 (7.2%) patients malposition of the tube resulted in need for non-urgent operative treatment. There were 103 in-hospital deaths, but none due to TT complications. Empyema as a treatment indication was more frequent in patients with complications (15,9% vs 6,8%, $p<0.001$) as was diabetes (21,9% vs 13,2%, $p=0.001$). The likelihood of complications was lower with CH16 tubes (OR 0.22, $p<0.001$) and higher in diabetics (OR 1.86, $p=0.001$).

Conclusions: Tube thoracostomy is a common procedure and complications occur in 19.9% of patients. Serious complications caused by the chest tube placement, however, are extremely rare. Complications were most common in patients treated for empyema and diabetics. Small CH16 tubes were associated with a lower incidence of complications.

Keywords: chest tube, thoracostomy, complications, pneumothorax, hemothorax, pleural effusion, pleural empyema

Introduction

Tube thoracostomy (TT) as a treatment to remove excessive material from the pleural cavity has been known already for thousands of years. The oldest known documents of TT are from the fifth century BCE. Hippocrates is attributed as the first person to treat a patient with TT and successfully managed to treat inflammation with this procedure.(1) TT is at present an ubiquitous treatment for example for pneumothorax, hemothorax, hemopneumothorax, pleural empyema and pleural effusions. Although thoracostomy has been known for a long time, it was generally accepted as a treatment for the above-mentioned conditions as late as in the late 1950s.(1) Currently TT is one of the most commonly performed invasive therapeutic procedures.(2)

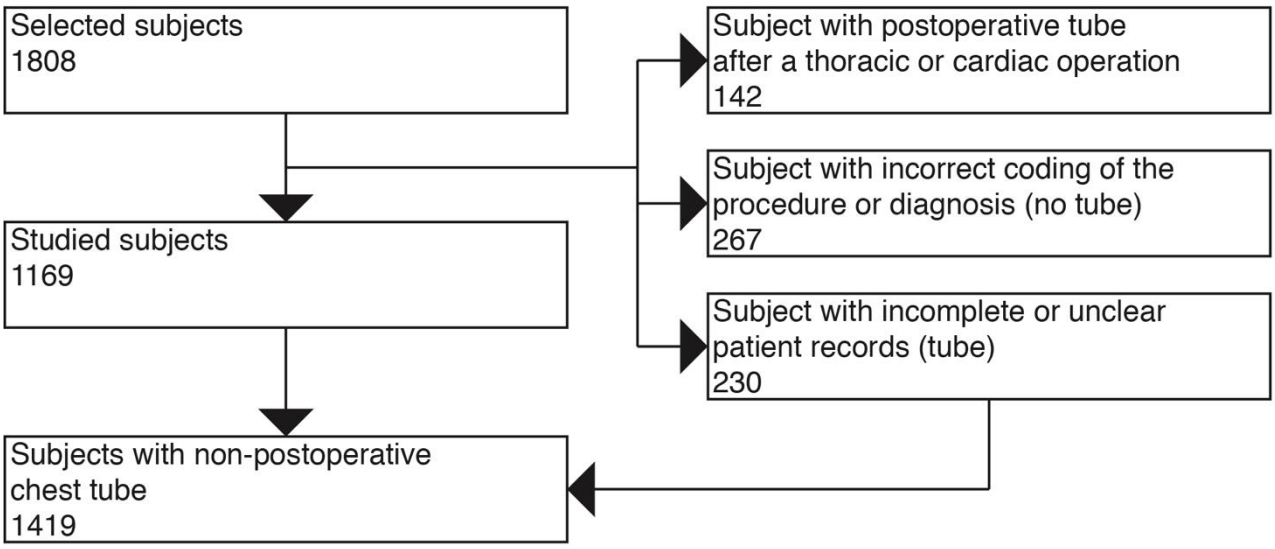
Despite its relative safety and ease as a procedure it can lead to potentially severe complications. In previous studies the complication rates have been reported as high as 40%, ranging from 1-40%.(3) (4) (5) (6) Most of the existing literature focuses on outcomes in trauma patients.(4) (6) The purpose of this study was to describe the frequency and types of complications of TT among all patients treated with TT for both traumatic and non-traumatic indications.

Material and Methods

The study was a retrospective register-based study. Consecutive patients treated with TT between the years 2004-2014 in a hospital Southwestern Finland Hospital District were identified from patient records and operative logs. Patients receiving TT were identified by the procedural codes (NOMESCO code GAA10). Patients receiving a postoperative chest tube after a thoracic or cardiac operation were excluded and data on thoracostomy patients dying outside the hospital (for example

emergency treatment in the field or patients treated at primary health care facilities) could not be retrieved for this study. Also bedside TT:s in the ICU and other intensive care units are not necessarily assigned procedure codes in the patient records and could thus not be identified. Based on the criteria 1808 patients were identified. The study flow chart is presented in Figure 1. Of the 1808 patients 497 were excluded due to incomplete or unclear patient records or incorrect coding of the procedure or diagnosis. 230 of these 497 patients had received a tube and the total number of 1419 tubes was used to estimate the yearly incidence of tube thoracostomies. 142 of the selected subjects had a postoperative tube after a thoracic or cardiac operation due to inaccurate coding. The final patient population used for outcome analyses was 1169 patients.

Figure 1. Study flow chart



Patient records were reviewed for baseline characteristics and perioperative data (table 1-2.). Indications for placement were grouped into malignancies, traumas, iatrogenic complications (e.g. central venous line placement complication), spontaneous pneumothoraxes, empyema or parapneumonic effusions, pleural effusions and other. Urgency was classified as elective or urgent. Cases where the procedure was planned and postponed for the following or any later date were

classified as elective and all other cases as urgent. Physician specialties were cardiothoracic, other surgical, anesthesia, emergency medicine, radiology, pulmonology, other, resident physician and unknown. The category "other" included other specialties, physicians with no specialty and medical students. Chest tube size was registered as French (Fr). Placement site was classified as anterior axillary, mid axillary, posterior axillary, anterior mid clavicular and unknown.

Bleeding disorder, smoking, diabetes, COPD, asthma and antithrombotic medication were registered as pertinent history relating to TT complications. Recorded antithrombotic/anticoagulant drugs were warfarin, heparin or low molecular weight heparin (LMWH), clopidogrel, ASA and other antithrombotics. If there was no clear mention of smoking cessation, the patient was defined as a smoker. COPD was defined as a diagnosis of chronic lung disease in the patient records. Diabetes (type 1 and 2) was based on a diagnosis in patient records.

Aho et al generated a standardized format for reporting TT complications. They grouped complications into five clearly defined categories: insertional, positional, infective/immunologic, removal and instructional/educational/equipment related.(7) The same grouping was used in this study. Insertional complications were complications occurring within 24 hours and were further divided into malposition, perforation of organ, bleeding requiring transfusion, intractable pain and need for operative intervention. Positional complications were complications occurring after 24 hours and were classified as need for operative intervention, need for new tube (obstruction, inadequate drainage of liquid or blood) and prolonged air leak. Prolonged air leak was defined as air leak >7 days post-insertion. Operative intervention included any procedure performed under general anesthesia.

Categorical variables were presented as numbers and proportions and continuous variables as mean and standard deviation. Between groups differences were evaluated with Chi-square-test for categorical variables and independent samples T-test for continuous variables. Independent

predictors of complications were evaluated with binary multivariable logistic regression analysis. Variables with a p-value <0.10 on univariable analysis were entered in the multivariable model. P-values under 0,05 were considered statistically significant. SPSS for mac version 24 (IBM Armonk, NY, USA) was used for analyses.

Results

Baseline characteristics

Baseline characteristics are shown in Table 1. The patient population used for analyses was 1169. Mean age of the population was 60.5 years and the age distribution were 1-98 years. 31.8% of the subjects were smokers. Diabetes was present in 15.0%, COPD 11.2% and asthma in 7.2%. There were no patients with known bleeding disorders. 21.0% patients had one or more ongoing anticoagulant or antithrombotic medication*).* Diabetes was more prevalent in patients with complications compared to patients without complications (21.9% vs 13.2%, p<0.001).

Table 1. Baseline characteristics

				All	Complication	No Complication	p-value
Total [n (%)]				1169 (100.0)	233 (100.0)	936 (100.0)	0.148
Age [mean (± sd)]. years				60.5 (19.2)	60.2 (19.1)	60.6 (19.2)	0.967
Gender [n (%)]							
	Male			699 (59.8)	149 (63.9)	550 (58.8)	0.148
	Female			470 (40.2)	84 (36.1)	386 (41.2)	0.148
Comorbidities and medications [n (%)]							
	Smoking			372 (31.8)	72 (30.9)	300 (32.1)	0.736
	Diabetes			175 (15.0)	51 (21.9)	124 (13.2)	0.001

	COPD (med)			131 (11.2)	22 (9.4)	109 (11.6)	0.340
	Asthma (med)			84 (7.2)	16 (6.9)	68 (7.3)	0.833
	Warfarin			45 (3.8)	9 (3.9)	36 (3.8)	0.991
	Heparin/LMWH			95 (8.1)	16 (6.9)	79 (8.3)	0.432
	Clopidogrel			7 (0.6)	2 (0.9)	5 (0.5)	-
	ASA			132 (11.3)	24 (10.3)	108 (11.5)	0.593
	Other anticoagulant/antithrombotic			5 (0.4)	1 (0.4)	4 (0.4)	-
	Some anticoagulant/antithrombotic			245 (21.0)	45 (19.4)	200 (21.5)	0.490
	Bleeding disorder			0	0	0	-

Operative and baseline data

Operative and baseline data is shown in Table 2. Most of the TT:s were performed by pulmonologists in 40.5% of subjects. Resident physicians performed 26.2% and cardiothoracic surgeons 14.4% of procedures. Anesthesiologists, emergency physicians, radiologists, and other physicians were a minority of performing physicians. Specialty of the treating physician was unknown in 6.4% of patients.

Tube size varied between 8 and 32 Fr. 16 Fr tubes were the most common size (40.5% of subjects). In 34.1% of the cases tube size was not recorded.

33.4% of the tubes were placed in the posterior axillary and 22.9% in the midaxillary position. Anterior axillary placements were done in 2.6% cases and anterior midclavicular only in 0.5% patients. 40.5% of the placements were not clearly specified in the records.

Malignant effusions were the most common indication for tube thoracostomy with 37.6% subjects. Other indications in descending order of frequency were trauma, benign effusion, pneumothorax, empyema, pneumonia, iatrogenic and infection. There was a statistically significant difference in indications for tube placement between groups. Patients who experienced a complications were more likely to have empyema or parapneumonic effusion as an indication for the procedure (p=0).

Most of the TT placements were urgent, 87.1%. 2.7% subjects received bilateral tubes and 2.2% of the tubes were inserted under ultrasound guidance.

Data on treatment duration was retrieved for 67.3% and data on length of stay for 89.6% patients. The mean tube treatment duration was 6 days and hospital stay was 10 days. The longest treatment duration was 43 days.

Table 2. Operative and baseline data

				All	Complication	No Complication	p-value
Total [n (%)]				**1169 (100.0)**	**233 (100.0)**	**936 (100.0)**	**0.148**
Physician specialty [n (%)]							
	Cardiothoracic			168 (14.4)	40 (17.2)	128 (13.7)	0.174
	Other surgical			100 (8.6)	29 (12.4)	71 (7.6)	0.018
	Anesthesia			5 (0.4)	1 (0.4)	4 (0.4)	-
	Emergency medicine			10 (0.9)	3 (1.3)	7 (0.7)	0.423
	Radiology			24 (2.1)	3 (1.3)	21 (2.2)	0.357
	Pulmonology			473 (40.5)	76 (32.6)	397 (42.4)	0.006
	Other			8 (0.7)	1 (0.4)	7 (0.7)	-
	Resident physician			306 (26.2)	67 (28.8)	239 (25.5)	0.317
	Unknown			75 (6.4)	13 (5.6)	62 (6.6)	-
Tube size [n (%)]							
	8			25 (2.1)	4 (1.7)	21 (2.2)	0.557
	12			8 (0.7)	2 (0.9)	6 (0.6)	-
	16			473 (40.5)	69 (29.6)	404 (43.2)	0.000
	18			7 (0.6)	2 (0.9)	5 (0.5)	-
	20			113 (9.7)	25 (10.7)	88 (9.4)	0.539
	22			6 (0.5)	2 (0.9)	4 (0.4)	-
	24			68 (5.8)	15 (6.4)	53 (5.7)	0.651
	26			2 (0.2)	0 (00.0)	2 (0.2)	-
	28			57 (4.9)	15 (6.4)	42 (4.5)	0.216
	30			2 (0.2)	0 (00.0)	2 (0.2)	-
	32			9 (0.8)	1 (0.4)	8 (0.9)	-
	Unknown			399 (34.1)	98 (42.1)	301 (32.1)	-
Placement site [n (%)]							
	Midaxillary			268 (22.9)	48 (20.6)	220 (23.5)	0.345
	Anterior midclavicular			6 (0.5)	2 (0.9)	4 (0.4)	-

	Anterior axillary			30 (2.6)	5 (2.1)	25 (2.7)	0.650
	Posterior axillary			391 (33.4)	63 (27.0)	328 (35.0)	0.020
	Unknown			474 (40.5)	115 (49.4)	359 (38.4)	-
Indication [n (%)]							
	Malignancy			440 (37.6)	68 (29.2)	372 (39.7)	0.003
	Trauma			195 (16.7)	39 (16.7)	156 (16.7)	0.979
	Iatrogenic			19 (1.6)	3 (1.3)	16 (1.7)	0.649
	Pneumothorax			158 (13.5)	33 (14.2)	125 (13.4)	0.747
	Empyema or parapneumonic effusion			101 (8.6)	37 (15.9)	64 (6.8)	0.000
	Effusion			166 (14.2)	32 (13.7)	134 (14.3)	0.820
	Other			90 (7.7)	21 (9.0)	69 (7.4)	0.400
Urgency [n (%)]							
	Elective			151 (12.9)	25 (10.7)	126 (13.5)	0.266
	Urgent/emergency			1018 (87.1)	208 (89.3)	810 (86.5)	0.266
One tube [n (%)]				1138 (97.3)	223 (95.7)	915 (97.8)	0.082
Bilateral tube [n (%)]				31 (2.7)	10 (4.3)	21 (2.2)	0.082
Ultrasound guided placement [n (%)]				26 (2.2)	4 (1.7)	22 (2.4)	0.557
Tube time [mean (range)] days				6 (1-43)	11.1 (2-43)	5.0 (1-33)	0.000
Hospital time [mean (range)] days				10 (1-111)	16.4 (2-111)	8.4 (1-70)	0.000

Complications

In this study, there were 289 complications in 233 patients (19.9%) after chest tube placement. The most common type of complication was positional in 96.5% of patients, meaning that the tube did not perform adequately during the treatment period. Only 1.7% of the complications were insertional complications and 1.7% of the complications were infective. Removal and instructional/educational/equipment related complications didn't occur. In the present study, there was no perforation of an organ, bleeding requiring transfusion or intractable pain.

In 66,8% of cases the positional complications were a need for a new tube and in 29.1% of cases operative intervention was needed to treat the underlying cause for which the tube was placed. A combination of need for operative treatment and a new tube occurred in 49 cases. There were

altogether 103 deaths, none of which were attributable to the chest tube placement itself and all of them occurred later than 24 hours after tube insertion.

Among the diabetic patients, complication types were distributed similarly to the whole population. 51 diabetics had altogether 60 complications; 1 (1.7%) malposition, 17 (28.3%) need for operative intervention and 42 (70.0%) need for a new tube.

Table 3. Complications

Total complications [n]				289
Total insertional complications [n]				5
Insertional complications separately [n (% of total complications)]				
	Malposition			5 (1.7)
	Perforation of an organ			0
	Bleeding requiring transfusion			0
	Intractable pain			0
	Need for immediate operative intervention			0
Total positional complications [n]				284
Positional complications separately [n (% of total complications)]				
	Need for operative intervention			84 (29.1)
	Need for new tube			193 (66.8)
	Prolonged air leak			2 (0.7)
Infective complications [n (% of total complications)]				5 (1.7)
Removal complications [n (% of total complications)]				0
Instructional/educational/equipment related complications [n (% of total complications)]				0

On multivariable binary logistic regression, chest tube size CH16 was associated with a lower risk of complications (OR 0.22, 95%CI 0.10-0.52, p<0.001) **and diabetes was associated with an elevated risk of complications** (OR 1.86, 95%CI 1.28-2.70, p=0.001).

Discussion

The main finding of this study is that although complications occur in 1 out of 5 patients receiving a tube thoracostomy, severe complications are infrequent.

Tube thoracostomy is a frequent procedure; based on the present study the yearly incidence in Southwestern Finland is at least 28/100 000 inhabitants not including postoperative chest tubes and bedside tubes at intensive units (population of the catchment area approx. 460 000 inhabitants).(8) In spite of it being a staple procedure of acute medicine its complications have not been extensively studied. Most of the previous studies on the epidemiology of chest tube complications have described outcomes in trauma patients only.(4) (6) There exists few studies including patients treated with TT for non-traumatic indications.(9) The complication rates have been reported between 1-40% in previous studies depending on the definition of complications. Hernandez et al. found in their systematic review and meta-analysis that the TT complication rate for traumatic indications has been approximately 19% during the past three decades identical to our study.(6) In another study including patients treated with TT for any indication the complication rate has also been approximately 19%.(9) Based on the current study and existing literature the frequency of complications related to TT is quite high. The complication rate is similar to that seen in trauma patients although the patient population is quite different. The most common indication for the procedure was a primary or metastatic thoracic malignancy in 37.6% of patients and most of these were treated by a pulmonologist, with pulmonologist consequently being responsible for 40.5% of the chest tube placements. Malignancies as an indication have not been as frequent in other studies or it has not been defined as an indication itself.(9)

Serious complications in the present study were, however, infrequent and no death was attributable to the chest tube placement. Nevertheless, 29.1% needed operative intervention, but operations were performed to treat the pre-existing condition for which the chest tube was placed, and no

patient required surgery because of a complication related to the chest tube per se. There were 103 deaths after tube placement, which were almost exclusively due to malignancy in the nearly half of patients who received a TT for malignant pleural effusion.

98.3% of the complications occurred after 24 hours and only 5 patients had early complications, all of which were malpositions. In earlier studies the early complication rates have been higher. This is unlikely due to major differences in definitions as the classification of complications used in this study is quite similar to other studies.(2) (7)

The most frequent complication was need for a new tube due to malfunction (for example occlusion) and the second most frequent complication was need for operative treatment. These two complications represented 95.9% of all complications and occurred in 19.5% of TT treated patients. This is clinically relevant and implies that some form of reintervention is to be anticipated during the hospitalization. Whether some tube malfunctions could be avoided by primary placement of large bore tubes is possible, but previous literature on the importance of tube diameter is conflicting; many studies show similar treatment failure rates for both small and large tubes and based on the existing literature for example the British Thoracic society advocates small size chest tubes as first line treatment for noninfectious indications. Most of the studies on size, however, are also retrospective and do furthermore do not fully adjust for the viscosity of the treated effusion and other patient specific factors.(10) (11) (12) The prospective randomized TIME study showed no difference in efficacy or complications between small and large tubes, although notably the study was no designed to assess complication rates.(13) Several studies, including one prospective randomized, specifically on malignant effusion have demonstrated similar results and complication rates irrespective of tube diameter.(14)(15)(16) In this study, small CH16 tubes were independently associated with fewer complications. These tubes were mostly inserted by pulmonologists (95.8%) and almost exclusively for malignant effusion. Consequently extrapolating the results to other indications should be made with caution.

Diabetics were also more likely to experience a complication. The reason for this is unclear as the higher incidence of complications was not explained by a higher infection rate. Also, the indications were similar to the whole population in diabetics and the frequency of infective indications was even slightly lower (13,7% vs 15,9%). The most likely explanation is a type I error, but it could also be explained by a higher comorbidity burden in diabetics. This is possible especially as most of the diabetics had type II diabetes, alluding to obesity and other lifestyle –related factors that typically increase the frequency of postprocedural complications. Aside from diabetes, empyema or parapneumonic effusion as an indication for treatment was associated with complications. This is intuitive, as infective collections of the pleura are often viscous and adhesions are frequent, which entail a propensity for tube occlusion. Notably most studies advocating preference of small tube sizes for other indications still recommend large sizes for empyema and hemothorax.

Infection was the only potentially serious complication directly caused by the tube in this study. Infections accounted for only 1.7% (5 cases) of the complications. Other serious complications primarily caused by the drain were nonexistent in the present study while the literature describes a large spectrum of possible complications.(9) (17)

Limitations

The study has all the limitations inherent in a retrospective registry-based study; incompleteness of data and lack of prospective data collection leading to possible missing data on preprocedural characteristics. Some minor complications might be missing, but complications requiring in-hospital treatment are identifiable from procedural codes, medication charts and blood product reporting. Also, the information gained from this study cannot be directly applied to describe

complication frequencies in patients receiving bedside or imaging guided chest tubes, which were not included in the present patient population.

Conclusions

Tube thoracostomy is a common procedure and complications occur in 19.9% of patients. Serious complications caused by the chest tube placement, however, are extremely rare. Complications were more common in diabetics and patients receiving a chest tube for empyema or parapneumonic effusion. Small CH16 tubes were associated with a lower incidence of complications but were also most frequently used for palliative care in cancer patients. Cases where tube thoracostomy is insufficient or malfunctioning the need for a new tube (16.5%) or operative intervention (7.2%) are, however, quite common and should be anticipated.

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