Postoperative chest tube management: snapshot of German diversity

Albert Lindera, Clemens Ertnera, Volker Stegerb, Antje Messerschmidtc, Johannes Merkd, Inez Cregane, Jürgen Timmf and Thorsten Wallesb,g,*

Abstract

OBJECTIVES: The management of chest tubes is one of the most critical aspects in patient care in thoracic surgery, and no consensus exists regarding the ideal chest tube management strategy.

METHODS: Chest tube management protocols and their effects on chest tube therapy were compared at four German specialist thoracic surgery units. Altogether, 79 patients were stratified for underlying disease and type of surgery. A digital chest drainage system was applied to objectify the presence of air leakages.

RESULTS: In our analysis, the average length of drainage therapy was 4.9 ± 2.8 days. Different chest tube management protocols resulted in a significant degree of scatter between units (P = 0.0348). Higher arbitrary postoperative suction levels (4 kPa) resulted in earlier chest tube removal than lower suction levels (2 kPa) (4.2 ± 2.4 vs 5.4 ± 3.0 days, P = 0.06). Patient discharge following chest tube removal was delayed on average by 3.2 ± 2.9 days. This delay was not correlated with the previous duration of chest tube therapy (Spearman’s ρ = −0.15, P = 0.25) in contrast to the total length of hospital stay (ρ = 0.59, P < 0.001).

Keywords: Chest tube management • Pleural drainage • Lung resection • Outcome

INTRODUCTION

Standardization of medical treatment through broad consensus and diffusion of medical treatment is desirable for several reasons: (i) It sets the basis for a continuous re-evaluation and directed improvement of medical therapy, (ii) it facilitates the training of surgeons, doctors and expert medical staff and (iii) it allows benchmarking and cost analysis on the level of healthcare providers, health insurers and society (Health Service Research, Health Technology Assessment). In oncologic thoracic surgery, generally accepted guidelines exist for diagnostic procedures, indications for surgery and integration of different treatment modalities [1–3]. However, the perioperative treatment of patients lacks published evidence and relies mostly on individual decision making [4]. Here, the duration of postoperative chest tube (ChT) management has been identified as a central step towards postoperative recovery and as a limiting factor for hospital discharge. So far, no generally accepted recommendations exist for postoperative ChT management to streamline the postoperative stay [5–7]. Recent ‘fast-track’ surgery approaches are geared towards the reduction of treatment-related costs by shortening it [7, 8].

Until recently, the decision as to when to remove a ChT depended on the assessment of air bubbles in analogue drainage systems [9]. This approach does not afford quantification of detected air leaks and always includes some degree of subjectivity and uncertainty. The latter results in the application of different ChT management protocols and variable ‘safety corridors’ before a ChT is finally removed.

With the introduction of digital drainage systems by several companies, the presence of an air leak (justifying the continuation of ChT therapy) is now objectively definable and quantifiable [9]. The first studies applying digital chest drainage systems have reported a reduction in inter-observer variability [10] and treatment durations [5, 11, 12]. It can therefore be assumed that the growing experience with digital chest drainage systems will result in a reduction of the unintentionally applied ‘safety corridors’. However, since the applied ChT management protocols differ in various parameters, it is unlikely that this effect will translate directly to patient discharge.

Being interested in the variation in ChT management across centres and its effect on postoperative length of stay, we conducted a prospective clinical analysis at four major thoracic surgery units. To obtain a non-biased assessment of the
presence of an air leak warranting continued ChT therapy, a
digital air leak metre was used.

MATERIALS AND METHODS

Study design

A prospective multicentric case series was performed. The
study was authorized by the responsible ethics committees of
Land Bremen (KBB/mh), Landesarztekammer Baden-Württemberg
(2009-042-f), Landesarztekammer Rheinland-Pfalz and Ärztekam-
mer Berlin and registered at an independent international clinical
trial registry (NCT01467622) [13]. Our primary study objective was
the duration of ChT therapy in postoperative patients and post-
operative hospital stay.

Patient cohort

Between April and August 2009, patients undergoing pulmonary
wedge resection, anatomic segmentectomy or lobectomy were
prospectively enrolled at four German thoracic surgery specialist
units [Klinikum Bremen Ost (KBO), Bremen; Klinik Schillerhoehe
(KSH), Gerlingen; Katholisches Klinikum (KKK), Koblenz;
Evangelische Lungenklinik Berlin (ELK), Berlin] (Fig. 1). Inclusion
criteria were: age 18–85, pulmonary wedge resection, anatomic
segmentectomy or lobectomy with informed consent. Exclusion
criteria were: spontaneous pneumothorax (primary and sec-
dary), pleural empyema, medication with corticoids, immuno-sup-
pressive drugs or platelet aggregation inhibitors other than
Aspirin, previous chemotherapy, previous radiotherapy of the
chest and previous ipsilateral thoracic surgery. The following
data were collected for analysis: demographical patient data, indi-
cation for surgery, surgery performed, presence and extent
of air leak, drained fluid volume, day of ChT removal and length
of hospital stay.

Pulmonary air leak assessment

For application of variable external suction [9], the digital pleural
drainage system Thopaz™ (Medela, Baar, Switzerland) was used
in all patients. The system indicates, in real time, measured air
flow (in the ChT) and effective negative pressure in the pleural
cavity (as measured at the end of the ChT). The presence of an
air leakage was defined by an air flow larger than 10 ml/min.
The detected time of an air leakage was defined as the duration
from the onset of the device until the absence of the air leakage
for at least 4 h.

Chest tube management protocols

Every centre applied its own established treatment protocol for
ChT management. This was defined by: (i) applied minimum and
maximum negative pressure, (ii) cut-off for maximal fluid ef-
flux per day, (iii) duration of the safety interval following detected air
leakage cessation (Table 1). Patients with more than one ChT
were followed until the last tube was removed. No provocative
clamping of the ChT (prior to tube removal) was permitted.

Figure 1: Geographical distribution of the participating thoracic surgery specialist units. The inset indicates the distribution of the different types of surgery.
Table 1: Summary patient demographics, ChT protocols and treatment results

<table>
<thead>
<tr>
<th></th>
<th>KBO</th>
<th>KSH</th>
<th>KKK</th>
<th>ELK</th>
<th>Overall</th>
<th>P</th>
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<tbody>
<tr>
<td>n</td>
<td>11</td>
<td>15</td>
<td>31</td>
<td>22</td>
<td>79</td>
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<tr>
<td>Age (years)</td>
<td>70.9 ± 7.7</td>
<td>63.9 ± 8.4</td>
<td>61.2 ± 10.4</td>
<td>64.7 ± 11.0</td>
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<td>Gender (male/%)</td>
<td>64.0%</td>
<td>60.7%</td>
<td>67.1%</td>
<td>58.8%</td>
<td>67%</td>
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<td>BMI</td>
<td>29.6 ± 6.4</td>
<td>26.6 ± 3.9</td>
<td>26.4 ± 5.3</td>
<td>27.4 ± 6.9</td>
<td>27.0 ± 5.6</td>
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<td>Indication for surgery (other than cancer or metastasis/%)</td>
<td>0.0%</td>
<td>1.7%</td>
<td>3.2%</td>
<td>1.5%</td>
<td>5.5%</td>
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<td>Type of surgery</td>
<td>Wedge resection</td>
<td>4</td>
<td>4</td>
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<td>Segmentectomy</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>14</td>
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<tr>
<td></td>
<td>(bi-) lobectomy</td>
<td>7</td>
<td>6</td>
<td>11</td>
<td>11</td>
<td>35</td>
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<td>Clinical setting and clinical protocol</td>
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<td></td>
<td></td>
<td></td>
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<td>Number of chest tubes</td>
<td>1.0 ± 0</td>
<td>1.4 ± 0.5</td>
<td>1.3 ± 0.5</td>
<td>1.0 ± 0.2</td>
<td></td>
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<tr>
<td>Size of chest tubes (Fr)</td>
<td>24</td>
<td>28-32</td>
<td>28-32</td>
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<td>Standard suction level (kPa)</td>
<td>0.8-4.0</td>
<td>0.8-2.0</td>
<td>0.8-2.0</td>
<td>0.8-4.0</td>
<td></td>
<td></td>
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<tr>
<td>Determined drainage volume for chest tube removal (ml/d)</td>
<td>&lt;250</td>
<td>&lt;200</td>
<td>&lt;200</td>
<td>&lt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absence of an air leak before chest tube removal</td>
<td>&gt;24 h</td>
<td>&gt;12 h</td>
<td>&gt;24 h</td>
<td>&gt;6 h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drainage volume/d at chest tube removal (ml)</td>
<td>136 ± 55</td>
<td>171 ± 158</td>
<td>135 ± 190</td>
<td>187 ± 84</td>
<td>155 ± 143</td>
<td></td>
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<tr>
<td>Detected length of air leak (d)</td>
<td>2.27 ± 2.69</td>
<td>2.00 ± 1.62</td>
<td>1.26 ± 0.68</td>
<td>1.73 ± 1.70</td>
<td>1.67 ± 1.58</td>
<td>0.1464</td>
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<tr>
<td>Lag of chest tube therapy (d)</td>
<td>5.4 ± 2.8</td>
<td>5.3 ± 2.7</td>
<td>5.5 ± 3.2</td>
<td>3.6 ± 1.9</td>
<td>4.9 ± 2.6</td>
<td>0.0348</td>
</tr>
<tr>
<td>Length of hospital stay (d)</td>
<td>7.2 ± 3.1</td>
<td>10.8 ± 3.1</td>
<td>7.3 ± 4.2</td>
<td>7.5 ± 3.2</td>
<td>7.7 ± 3.7</td>
<td>0.3790</td>
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<tr>
<td>Lag of chest tube removal (d)</td>
<td>3.09 ± 2.43</td>
<td>3.07 ± 2.62</td>
<td>4.23 ± 3.00</td>
<td>1.86 ± 1.28</td>
<td>3.19 ± 2.61</td>
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<tr>
<td>Lag of discharge (d)</td>
<td>2.23 ± 2.05</td>
<td>6.33 ± 3.14</td>
<td>2.04 ± 2.18</td>
<td>4.10 ± 3.22</td>
<td>3.16 ± 2.88</td>
<td>0.0057</td>
</tr>
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y: years; BMI: body mass index; Fr: French; kPa: kilo-Pascal; d: days; h: hours.

Data analysis

Statistical analysis was performed using SAS® (version 9.2). Fisher’s exact test for categorical data was applied to test for homogeneity and to compare the relative frequency of events between groups. Groups of continuous data were compared by Wilcoxon’s test with continuity correction and the Kruskal-Wallis test respectively. Analysis of drainage time was conducted using Kaplan-Meier estimates and the log-rank test. Spearman’s rank correlation coefficient (Spearman’s ρ) was used to test for statistical dependence. All P-values were two-sided, and a P-value of <0.05 was considered to indicate statistical significance.

RESULTS

Study population

Overall, 80 patients were enrolled. One patient had to be excluded due to damage of the respective digital Thopaz™ device (Table 1). The majority of patients were male (67%) aged 64.0 ± 10.3 years (range 41-85). Lung resections were performed due to primary lung cancer or secondary metastasis to the lung in 94% of cases. The other indications were pulmonary bulla (n = 1), mediastinal tumour (n = 1), mesenchymal pleural tumour (n = 1) and interstitial lung disease (n = 2). Collectively, 30 wedge resections, 14 segmentectomies and 35 lobectomies were performed (Fig. 1).

Chest tube management protocols

While the definition and the assessment of a pulmonary air leak were identical in all thoracic surgery units, the resulting course of action for removing the ChT varied in several aspects: There were no uniform suction levels, different tolerated drainage volumes (on day of ChT removal), and varied follow-up periods to ensure absence of air leakages (Table 1).

Effects on chest tube therapy

The overall air leak duration (as detected by the Thopaz™ device) was 1.61 ± 1.58 days without significant differences between centres (P = 0.1464) (Table 1). However, the resulting period of ChT therapy was on average 4.9 ± 2.8 days. Analysed according to individual participating centres, there was a significant degree of scatter from 3.59 ± 1.87 to 5.48 ± 3.18 days (P = 0.0348) (Fig. 2). The delay in ChT removal after air leakage closure was more than 3 days and varied significantly between centres from 1.86 to 4.23 days (P = 0.0051). Regarding the type of resection, wedge resections and segmentectomies required shorter ChT durations than lobectomies (4.03 ± 2.68 and 4.07 ± 1.63 days vs 5.97 ± 2.96 days, P = 0.0109) (Fig. 2B). In this study, a higher initial suction level (4.0 kPa) was associated with earlier closure was more than 3 days and varied significantly between centres from 1.86 to 4.23 days (P = 0.0051). Regarding the type of resection, wedge resections and segmentectomies required shorter ChT durations than lobectomies (4.03 ± 2.68 and 4.07 ± 1.63 days vs 5.97 ± 2.96 days, P = 0.0109) (Fig. 2B). In this study, a higher initial suction level (4.0 kPa) was associated with earlier closure (Fig. 2C).

Effects on hospital stay

Following ChT removal, patient discharge from hospital was delayed on average by 3.16 ± 2.88 days, ranging from 2.23 ± 2.05 to 4.09 ± 3.45 days (P = 0.0057) (Table 1). Surprisingly, the finding of different ChT removal rates in the participating centres did not translate into similar differences in the length of hospital stay.
average 7.7 ± 3.7 days; range, 7.2 ± 3.1–10.8 ± 3.1 days; \( P = 0.3790 \) (Fig. 3). The delay in hospital release was not correlated with the previous duration of ChT therapy (Spearman’s \( \rho = -0.1457, P = 0.2544 \)). Similarly, duration of ChT therapy was not influenced by the postoperative suction (negative pressure) level \( (P = 0.5375) \) (Fig. 3B); however, the total hospital stay was significantly correlated with the time to ChT removal (Spearman’s \( \rho = 0.5865, P < 0.001 \)). While the presence of pulmopleural fistulae following surgery did not result in significant intergroup differences (wedge, segment and lobe) in ChT removal, patients following wedge resection were released earlier from hospital \( (P = 0.0247) \) (Fig. 3C).

**DISCUSSION**

We conducted this prospective clinical trial to highlight the variation in ChT management at specialized thoracic surgery units in Germany, and to assess its impact on postoperative length of stay.

The objective time to air leakage closure proved to be independent of the marked interdepartmental procedural differences, but these differences affected the time to tube removal in a significant way. The delay between air leakage closure and removal increased the duration of ChT therapy by a factor of nearly 2. Additionally, even though the length of postoperative
hospital stay is significantly correlated to the duration of ChT therapy, the delay between tube removal and hospital discharge does not correlate with the duration of ChT therapy. This result promises opportunities to shorten the duration of hospital stay through improvements in two ways: (i) shortening the duration of ChT therapy by developing optimal strategies based on digital pump devices and (ii) reducing the delay between ChT removal and hospital discharge following a fast-track approach.

Our study has some limitations: the comparison of 79 patients treated in four independent specialist thoracic surgery units with varying postoperative ChT management protocols on one hand limits the significance of our findings, and on the other hand provides useful comparative-effectiveness evidence. This evidence, however, is specific to the German health care situation, but may be applicable to other European settings that unequivocally differ from the health care system of the USA, where most of the published evidence and recommendations on ChT therapy and fast-track approaches have been made.

The finding that higher suction (negative pressure) levels result in earlier air leakage closure did not reach statistical significance. This is probably due to the small case number in this study and warrants future investigations in larger study cohorts.

The detected delay periods between (i) air leakage closure and ChT removal and (ii) hospital discharge may be motivated by a certain level of uncertainty in the era of ChT assessment through traditional means. Although previous studies have shown that the reporting of digital pleural drainage systems is reliable and may afford earlier ChT removal, the traditional safety corridors still have to be overcome. The use of digital pleural drainage systems, however, will be particularly helpful in overcoming the first delay.

The finding of interest is that despite a relatively narrow duration of air leakage, there was a higher variation in the overall duration of ChT therapy. Therefore, this survey may launch a discussion on strategies to develop broadly accepted and applicable recommendations for postoperative ChT management in patients. Currently, a follow-up trial tests a standardized ChT protocol in a specified subgroup of patients (NCT01177215). Acknowledging the variety of disease patterns covered in thoracic surgery, different guidelines may be needed for diverse patient-subgroups.

AUTHORS’ ROLES

Albert Linder and Thorsten Walles conceived, designed and oversaw all studies and collection of results. Clemens Ertner, Volker Steger, Antje Messerschmidt and Johannes Merk acted as principal investigators of the participating centres. Inez Cregan serviced the project database. Jürgen Timm performed the biometric calculations and statistical analysis along with Albert Linder and Thorsten Walles, Albert Linder, Jürgen Timm and Thorsten Walles drafted the manuscript. Inez Cregan edited the manuscript for language and grammar. All authors had the opportunity to contribute to the interpretation of the results and to the redrafting of the report and all authors approved the final report.

FUNDING

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Conflict of interest Medela AG produces and distributes the digital pleural suction device Thopaz™ that was applied in all patients. Inez Cregan is employee of Medela AG Albert Linder and Volker Steger received compensation (speaker fees, travel) from Medela AG. The remaining authors declare no conflicts of interests.

REFERENCES