The impact of chest tube removal on pain and pulmonary function after pulmonary resection†

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Abstract

OBJECTIVE: The aim of this study was to assess the immediate influence of chest tube removal on chest pain and forced expiratory volume in 1 s (FEV1) after pulmonary resection.

METHODS: Prospective longitudinal investigation on 104 consecutive patients (53 wedge/segmentectomies and 51 lobectomies; 69 muscle and nerve-sparing lateral thoracotomy and 35 video-assisted thoracoscopic surgery (VATS)). Post-operative chest pain was controlled in all patients by a standardized combination of oral and intravenous non-opioid analgesics. All patients had one chest tube (24 French). Static and dynamic (after forced expiratory effort) pain and FEV1 were assessed before and 1 h after the chest tube removal by the same operator. No additional analgesics were administered before or after the chest tube removal. The pain level was assessed by the numeric pain scale [range: 0 (no pain)–10 (excruciating pain)]. FEV1 was assessed by a portable spirometer. Bronchodilators were not used in these patients. Pre- and post-removal measurements were compared by the Wilcoxon signed rank test.

RESULTS: The average pre-removal static and dynamic pain scores were 2.6 and 4.1, respectively. The static and dynamic pain scores decreased by 42 and 41%, respectively, after the tube removal (P < 0.0001). The average FEV1 before the chest tube removal was 1.5 l or 53% of the predicted value and increased by 13% after the tube removal (P = 0.0004). In total, 56 and 78% of patients reported static and dynamic pain scores improvement and 67% showed an FEV1 improvement after the chest tube removal. Similar results were observed in patients operated on through VATS or thoracotomy. Compared with patients whose chest tube was removed later, those who had their chest tube removed before post operative day 3 (POD3), showed a greater reduction in the static pain score (41 vs. 31%, P = 0.05) and greater improvement in FEV1 (18 vs. 0.01%, P = 0.02).

CONCLUSIONS: The removal of a chest tube reduces pain and improves ventilatory function, independent of surgical access and particularly in the early post-operative phase. A fast track chest tube removal policy may favour patients’ recovery.

Keywords: Chest tube removal • Static pain • Dynamic pain • FEV1 • Pulmonary resection

INTRODUCTION

Management of chest tubes is pivotal in the post-operative care of patients submitted to pulmonary resection. However, thoracic surgeons have traditionally managed chest tubes based more on their experience and personal preference rather than guided by an evidenced-based approach [1]. Usually, a chest tube is removed when no air leak is detected and the daily pleural effusion has decreased below a certain volume.

The duration of chest tube is known to be one of the most important factor influencing hospital stay and costs [2, 3]. For this reason, many studies have focused on evaluating different protocols of chest tube management, including different application of suction or no-suction, discharge with portable chest drainage systems and outpatient chest tube management in the case of prolonged air leak, and the use of single rather than double chest drainage [4–8]. However, there is scant information about the direct influence of chest tubes on patient symptoms and respiratory function.

We hypothesized that a chest tube may influence the patient’s ventilation and determine chest pain. Although this is a long-standing belief among surgeons, there is no scientific data to prove it.

Thus, the objective of this prospective investigation was to assess the immediate influence of the chest tube removal on chest pain and forced expiratory volume in 1 s (FEV1) in patients submitted to pulmonary resection.

PATIENTS AND METHODS

This is a prospective longitudinal investigation on 104 consecutive patients submitted to pulmonary resections (53 wedge/segmentectomies, 51 lobectomies) for neoplastic (78 patients) or
non-neoplastic (26 patients) diseases in a 12-month period (2010) (Table 1). The study was approved by the local Institutional Review Board, and all patients gave their informed consent for the study protocol. The exclusion criteria included (a) chest wall/diaphragm resection, (b) prolonged air leak >7 days (since patients were discharged with a portable chest drainage device and were therefore not available for the assessment), (c) admission to ICU and (d) double chest drainage.

All patients were operated on by four qualified thoracic surgeons through a muscle sparing and nerve sparing thoracotomy [9] (69 patients) or uniportal video-assisted thoracoscopic surgery (VATS; 35 patients) [10]. As a rule, all patients left the operating theatre with only one chest tube placed at the end of the operation in a mid-chest position up to the apex of the pleural cavity. The site of entrance of the chest tube was one or two intercostal spaces below the thoracotomy (mid-axillary line) or through the uniportal thoracoscopic access in case of VATS.

Perioperative pathways of care were standardized for all patients. Post-operative chest pain was controlled in all patients by a standardized combination of oral and intravenous non-opioid analgesics. We used continuous infusion of intravenous tramadol and non-steroidal anti-inflammatory drug (ketorolac) (400 mg of tramadol and 120 mg of ketorolac at a 2 ml/h velocity of infusion) during the first 2 days POD. From the third POD, we switch to oral paracetamol 1 g (three times/day).

All patients at the time of evaluation (before the chest tube removal) had only one chest tube in place (Redax: radiopaque PVC catheter 24 French). Chest tube removal criteria varied according to the type of operation and the type of chest drainage system connected to the chest tube (analogue or electronic). In general, when the pleural effusion was <400 ml and there was no evidence of air leak, the chest tube was deemed to be removable after chest X-ray confirmation of a satisfactory lung expansion.

Static and dynamic (after forced expiratory effort) pain and FEV1 were assessed in the same patients before and 1 h after the chest tube removal by the same operator and in the same conditions. No analgesics were administered before or after the chest tube removal that could have potentially affect the analysis. No bronchodilators were not used in these patients.

Sample size was calculated to detect a difference of 1 point in static or dynamic VAS, assuming a statistical power of 90% and with a significance level of 0.05.

Pre- and post-removal measurements were compared by the Wilcoxon signed rank test. A P-value of 0.05 was considered statistically significant. The analysis was performed using Stata 9.0 statistical software (Stata Corp., College Station, TX, USA).

RESULTS

The average pre-removal static and dynamic pain scores were 2.6 and 4.1, respectively. The static and dynamic pain scores decreased by 42 and 41% after the tube removal (P < 0.0001), respectively. The average FEV1 before the chest tube removal was 1.5 l or 53% of the predicted value and increased by 13% after the tube removal (P = 0.0004) (Table 2). In total, 56 and 78% of patients reported static and dynamic pain scores improvement and 67% of them reported an FEV1 improvement after the chest tube removal.

Similar results were observed in patients operated on through VATS or thoracotomy (Table 3) Twenty-one of 35 (60%) VATS patients improved their static pain score vs. 35 of 69 (51%) thoracotomy patients (P = 0.4). Twenty-seven of 35 (77%) VATS patients improved their dynamic pain score vs. 51 of 69 (74%) thoracotomy patients (P = 0.7). Thirteen of 35 (37%) VATS patients vs. 22 of 69 (32%) of those submitted to thoracotomy improved their FEV1 (P = 0.4).

Table 2: Comparison of the pre- and post-removal pain and FEV1

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-removal</th>
<th>Post-removal</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static pain</td>
<td>2.6 (2)</td>
<td>1.5 (1.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dynamic pain</td>
<td>4.1 (2.1)</td>
<td>2.4 (1.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>FEV1 (l)</td>
<td>1.5 (0.8)</td>
<td>1.7 (0.9)</td>
<td>0.0004</td>
</tr>
<tr>
<td>FEV1% change</td>
<td>53 (24.7)</td>
<td>60.2 (30.8)</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

Results are expressed as means ± standard deviation unless otherwise indicated. FEV1: forced expiratory volume within the first second.

Table 3: Comparison of the pain change (static and dynamic) and FEV1% change in the two groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>VATS (35 patients)</th>
<th>Thoracotomy (69 patients)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static pain change</td>
<td>1.2 (1.6)</td>
<td>1 (1.4)</td>
<td>0.5</td>
</tr>
<tr>
<td>Dynamic pain change</td>
<td>1.5 (1.7)</td>
<td>1.7 (1.7)</td>
<td>0.6</td>
</tr>
<tr>
<td>FEV1% change</td>
<td>25.3 (59)</td>
<td>13.3 (32)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Results are expressed as means ± standard deviation unless otherwise indicated. FEV1: forced expiratory volume within the first second; VATS: video-assisted thoracoscopic surgery.
Patients who had their chest tube removed before the third postoperative day showed a greater reduction in the static pain score (41 vs. 31%, \( P = 0.05 \)) and a larger improvement in FEV1 (18 vs. 0.01%, \( P = 0.02 \)).

**DISCUSSION**

Chest tube management has become a subject of study for thoracic surgeons to reduce the hospital stay and costs. During the last decade, several prospective randomized controlled trials have tried to evaluate the best strategy for chest tube management after lung resection. These trials have mainly focused on assessing the differences in air leak duration, incidence of prolonged air leak, chest tube duration, and length of stay between the groups of patients managed with different protocols [1].

This interest has been mainly driven by an economic interest on the side of the providers since the chest tube duration is one of the most important factors influencing the hospital stay and hence costs [2, 3]. Little has been studied regarding the functional impact of chest tube on the patient.

Chest tubes cause pain. This notion has been known since decades to surgeons used to observe their patients feeling better and breathing more freely after removal of their chest tubes. However, to our knowledge, there is no scientific data in the literature substantiating this empirical observation with the exception of the indirect demonstration that the use of single tube is superior to double tubes in terms of chest pain [5–8].

For this reason, we tried to apply science to this concept and designed a prospective investigation to measure both pain and ventilatory capacity before and after the chest tube removal following lung resection.

We chose to use the numeric pain scale to assess the degree of pain before and after the chest tube removal. The numeric pain scale is regarded as an effective pain measurement tool in clinical practice [11]. The numeric pain scale is a preferred tool to visual analogue scale in assessing postoperative pain especially in clinical practice [11]. The numeric pain scale is a 10-degree scale. The patients were asked before and after the chest tube removal to quantify the intensity of their static and dynamic pain levels on this scale. However, the numeric pain scale has some limitations because it is subjective and expresses the intensity but not the quality of pain.

We have chosen FEV1% to assess pulmonary function that is by far the most frequently used parameter for assessing respiratory function in our specialty and it is easy to measure at the bedside of the patient by using a portable spirometer.

We found a decrease in the static and dynamic pain scores (42 and 41%, respectively) after the chest tube removal. This means that patients were able to breathe deeply with less pain and be more compliant with chest physiotherapy as demonstrated by a concomitant improvement in their ventilatory function.

As shown in Table 2, patients operated through VATS displayed a higher FEV1% improvement after the chest tube removal compared with the thoracotomy group. This finding may be due by the prevalent role of chest tube in determining pain after VATS procedures. After thoracotomy, the chest tube influence on pain may be blurred by the prevalent thoracotomy chest pain. Thus, early chest tube appears even more important in the context of minimally invasive thoracic surgery.

In a previous multi-centre study, we found that predicted postoperative FEV1 underestimates the real loss of FEV1% in the immediate postoperative period when most of the cardiorespiratory complications occur [14]. In this study, we observed the greatest improvement in FEV1% in those patients in whom the chest tube was removed before the third postoperative day, a phase when the functional loss after lung resection is the highest. An early chest tube removal may help patients to recover their respiratory function particularly in this phase, potentially preventing complications.

Our study may have the following limitations: our results must be verified with different tube types (i.e. silicone tubes) and sizes, and with different regimens of postoperative analgesics.

In conclusion, we were able to objectify that the removal of a chest tube improves ventilatory function and reduce chest pain after pulmonary resection. Removing sooner a chest tube has not only financial benefits but also beneficial functional effects for the patient. Although further investigations are needed to confirm this finding, removing sooner a chest tube may influence quality of life and patient satisfaction and potentially decrease the risk of pulmonary complications.

**Conflict of interest**: none declared.

**REFERENCES**

APPENDIX. CONFERENCE DISCUSSION

Dr H. Hansen (Copenhagen, Denmark): Can you outline your pain regimen? Do you give epidurals, do you give nonsteroidal anti-inflammatory drugs, and what is your pain treatment in those patients?

Dr Refai (Ancona, Italy): We usually give IV non-opioid analgesics on the first postoperative day, and on post-operative day 3 we switch to oral non-steroidal anti-inflammatory drugs.

Dr J. Kuzdzal (Krakow, Poland): Don’t you use any epidural or paravertebral analgesia?

Dr Refai: No, in this group of patients, we didn’t use it.

Dr J. Hutter (Salzburg, Austria): Since you did a lot of work on the intercostal space at your institution, I have one question. Did you always place the tubes in the same position in respect of the anterior part, or the middle part, or the posterior part of the intercostal space?

Dr Refai: When we perform an anterior muscle-sparing and nerve-sparing thoracotomy, we place our drain in the anterior part. When we perform a uniportal VATS, we just insert the tube through the same incision.

Dr Hutter: And also in the thoracotomy group, you placed it through the incision?

Dr Refai: No, it is not through the same incision. It is a different intercostal space.