External Suction and Fluid Output in Chest Drains After Lobectomy: A Randomized Clinical Trial

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Background. Even when air leakage has ceased completely after lobectomy, chest drains are often not removed because of high fluid output. Accepted thresholds for removal vary between institutions but typically range between 200 and 500 mL/d. There is little knowledge whether external suction influences the amount of fluid.

Methods. We randomly assigned (1:1) 106 patients who underwent lobectomy to either low (–5 cm H_2O) or high (–20 cm H_2O) external suction using an electronic chest drainage system. Only one chest drain was allowed, and we used strict algorithms for chest drain removal, which was delegated to staff nurses: air leakage less than 20 mL/min for 6 hours regardless of fluid output, provided it was serous. The primary end point was fluid output after 24 and 48 hours.

Results. Mean fluid output was significantly higher with high suction after both 24 (338 ± 265 mL versus 523 ± 215 mL) and 48 hours (616 ± 366 mL versus 1067 ± 387 mL ($p < 0.001$). Repeated measure analysis (mixed model) demonstrated that in addition to suction level the surgical approach (video-assisted thoracoscopic surgery/thoracotomy, $p = 0.04$) and affected lobe (upper/lower, $p = 0.001$) were significant predictors of fluid production.

Conclusions. Increased suction levels lead to increased fluid output. Thoracotomy and lower lobectomy are associated with increased fluid output in chest drains, which should be taken into consideration if algorithms for chest drain removal include an upper limit of fluid output.

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In fast-track thoracic surgery early removal of chest drains is an area of interest [1, 2]. Timely removal of the chest drain plays an important role in postoperative care because it improves mobilization of the patient, facilitates pain management, reduces any risk of ascending pleural infections, and shortens the length of hospitalization. With electronic drainage devices available for routine use in many thoracic centers worldwide, it is now possible to investigate basic properties of chest drainage in the clinical setting, which were so far only speculated on from physiologic experimental studies in animals [3]. In a consensus article on the management of the pleural space by Brunelli and colleagues [4], it was mentioned that the negative pressure in passive drainage may increase pleural liquid filtration and that further application of subatmospheric pressure contributes to increased pleural filtration, but this information was not based on clinical data in humans. In addition, lung resections create an alteration in the balance between fluid filtration/lymphatic absorption and the chest/lung recoil pressure, and application of external subatmospheric pressure may increase fluid filtration [5]. Therefore, the assumption is that increased levels of external suction result in a higher fluid volume output, just as it is seen in the use of negative pressure wound therapy in abdominal surgery, when application of suction by vacuum-assisted closure increases fluid output compared with passive drainage of the peritoneal cavity [6].

Most pleural drainage studies investigated air leakage, which is the most common postoperative complication in general thoracic operation. However, even when air leakage has ceased completely many chest drains are not removed routinely if serous fluid production is high. Accepted thresholds of fluid output before chest drain removal vary between institutions and typically range between 200 and 400 mL/d [7–9], but in some studies chest drains have been safely removed after fluid output up to 450 or 500 mL/d [10, 11]. Until recently there were no clinical data about whether the level of external suction had an influence on the volume of fluid production, but a recent randomized trial from Poland found that suction increased fluid output [12]. Parallel with their trial we investigated the same end point but also analyzed the influence of surgical approach and type of lobectomy.

Patients and Methods

The Regional Ethics Committee of Southern Denmark and the Danish Data Protection Agency approved this

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trial. The study was conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all patients.

We did a university-based single-center randomized study designed to evaluate two end points: the influence of external suction on the duration of air leakage after standard lobectomy and the influence of external suction on fluid output in the chest drain. Our sample size was calculated to detect a clinical relevant difference of at least 1 full day of chest drain duration on air leakage, regardless of fluid output. The data on air leakage and chest drain duration will be presented elsewhere.

Eligible for inclusion were all patients admitted for lobectomy (by thoracotomy or video-assisted thoracoscopic surgery [VATS] as decided by the surgeon), age older than 18 years, and the ability to give informed consent. Exclusion from the trial was determined by any of the six surgeons who operated on the patients. The exclusion criteria were previous history of pulmonary or cardiac surgery, expected difficulties with postoperative mobilization, participation in concomitant research studies in our department in which a different chest drainage protocol could influence these results, anticipation of a need for postoperative mechanical ventilation, insertion of more than one chest drain, and finally bilobectomy or middle lobectomy. Patients were informed and enrolled in the study by their surgeon 1 day before operation and allocated as shown in Figure 1.

Operative Management

All patients underwent a standard lobectomy by VATS or thoracotomy at the surgeon's discretion. We used an epidural catheter in all patients, and both groups received the same single dose of antibiotics preoperatively. All vascular structures and bronchi were dissected anatomically and divided by mechanical staplers, and we performed systematic lymph node dissection of the hilar and two mediastinal lymph node stations in every patient. At the end of the surgical procedure only one standard chest drain was allowed (size Charrière 24), and this was placed anteriorly or posteriorly at the surgeon's discretion. Afterward, the chest drain was connected to an electronic drainage system (Thopaz Digital Chest Drainage System; Medela AG, Baar, Switzerland). After a simple test to ensure that the electronic drainage system was patent and airtight and while still on the operating table, all patients were subsequently randomly assigned (1:1) by sequentially numbered, opaque, and sealed envelopes to receive either low external suction (–5 cm H_2O) or high external suction (–20 cm H_2O). Because it was deemed necessary to view the graph on the digital display of the electronic monitor to assure complete cessation of any air leakage before the chest drain was removed, the digital display could not be covered. Consequently blinding was not possible, and, as such, this was an open-labeled randomized study.

Postoperative Management

All patients underwent the same routine postoperative observation regimen and pain management. They were observed 3 hours in our recovery unit before being transferred to the standard thoracic surgical ward, where they were up and walking on the same day of operation. Chest drains were observed for air leakage at least once in every shift by the staff nurses (three shifts of 8 hours each per 24 hours), and the decision for chest drain removal was delegated to the staff nurse in charge of the patient. Chest drain removal followed the same strict algorithm in all patients: when air leakage had decreased to 20 mL/min or less for 6 consecutive hours or 50 mL/min or less for 12 consecutive hours without any visible spikes on the digital display [14, 15], given that the patient was fully mobilized and sufficiently relieved of pain to allow for coughing with a pain score less than 3 on a visual analogue scale of 1 to 10. We allowed chest drains to be removed regardless of fluid output, provided that it was serous. Fluid output was recorded daily at 6 AM, and if the output was bloody without transparency or chylous, the chest drain was left in place until the next day regardless if any air leakage had ceased completely. Fluid output was measured by eyesight directly on the canister scale. Unless the patient experienced hemodynamic or respiratory problems, the first routine chest roentgenogram was not requested until after chest drain removal.

Data collection was done before, during, and after the operation and included age, sex, surgical approach, and which lobe was resected. Complications were recorded, including any need for chest drain reinsertion after removal, any need for pleurocentesis or development of pleural empyema within 30 days, or any need of antibiotic treatment for postoperative pneumonia.

Data are presented with means and SDs when relevant, and statistical analysis was performed using both nonparametric methods (Kruskal-Wallis test and median test) and parametric methods of Student t test and a mixed linear model repeated measures analysis when the dependent variable was "fluid output," "time" (24 and 48 hours) as fixed factor, and level of external suction (–5 cm/–20 cm H_2O), surgical approach (VATS/thoracotomy), and affected lobe (upper/lower) included as covariates. All statistical analyses were performed using SPSS 24.0 statistical software (IBM, Chicago, IL), and statistical significance was determined as p less than 0.05.

Results

In a 13-month period (March 2015 to April 2016) 248 lobectomies were performed in our department, and 106 patients were included in the present trial as illustrated in the CONSORT diagram (Fig 1). Baseline characteristics of the two groups are shown in Table 1. Low suction was applied in 53 patients (n = 34 VATS, n = 19 thoracotomy procedures) and high suction in the remaining 53 patients (n = 25 VATS, n = 28 thoracotomy procedures).

In accordance with the protocol algorithm for chest drain removal six chest drains could be removed on the same day of operation, all in the low-suction group. One of these required reinsertion the same day of removal because of pneumothorax. One patient in the low-suction group experienced chylothorax, and two patients were re-operated on the same day of operation because of bleeding (1 patient in