Chest drainage suction decreases differential pleural pressure after upper lobectomy and has no effect after lower lobectomy

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Abstract

Background and objective: To our knowledge, no reports have been published describing the effect of suction on pleural pressures after different types of lobectomy. Improving knowledge of pleural physiology in the postoperative period could lead to better postoperative care. The aim of this investigation is to evaluate the effect of postoperative suction on inspiratory, expiratory and differential pleural pressures after upper or lower lobectomy. Methods: Records of intrapleural pressures from 24 lobectomy patients (operated on in two different institutions) were selected for study. All patients had normal preoperative pulmonary function tests (forced expiratory volume in 1 s (FEV1) >80% and forced vital capacity (FVC)/FEV1 >70%), and neither postoperative air leak nor any other postoperative complication. We selected six cases of each type of lobectomy (right upper lobectomy (RUL), right lower lobectomy (RLL), left upper lobectomy (LUL) and left lower lobectomy (LLL)). In three cases of each group, no suction was indicated, while in the other three cases, chest tubes were placed under 15 cmH2O suction, according to the standard local perioperative care protocol in each participating centre. Inspiratory and expiratory pleural pressures were measured at 2-min intervals by an electronic device using a DigiVent™ (Millicore A.B., Sweden) suction chamber. Recording started 5—10 h after closing the chest, and included 5 consecutive hours during the first postoperative night, with the patients at rest in 30—45° sitting position. There was no evidence of pneumothorax during the recording time. The influence of lobectomy site (upper or lower) and suction on inspiratory, expiratory and differential pressures were evaluated by Student’s t-tests. Results: In the group of cases under no suction, upper lobectomy patients had larger differential pressures (22.6 in upper vs 11.5 cmH2O in lower lobectomy cases, p < 0.001), differential pressure decreased in patients under suction (9.1 in upper vs 11.1 cmH2O in lower lobectomy cases, p < 0.001) and the effect was mainly due to a less negative inspiratory pressure. Conclusion: Pleural suction leads to a large decrease of differential pleural pressure after upper pulmonary lobectomy. The influence of this finding on postoperative work of breathing in the early postoperative period remains to be investigated.

Keywords: Pulmonary lobectomy; Pleural suction; Pleural physiology

1. Introduction

Pleural suction is frequently indicated after pulmonary lobectomy. Most published papers on postoperative pleural suction are only addressing the issue of the correlation of chest suction and air leaks. A review of published evidence concluded that pleural suction does not decrease the incidence of prolonged air leak; however, to our knowledge, no investigations have been published in which the authors have measured postoperative pleural pressures and evaluated how suction can influence their values. We hypothesise that suction could play a role in decreasing the work of breathing after lung resection by its effect on the inspiratory pleural pressure. This report aims to describe the values of the inspiratory, expiratory and differential pleural pressures after pulmonary lobectomy and to investigate if applying suction to chest tubes may influence the values of these parameters most directly related to the action of the inspiratory muscles (inspiratory and differential pleural pressures).

2. Methods

Records of intrapleural pressures from 24 lobectomy patients (operated on in two different institutions) were selected for the study, among consecutive lobectomy cases performed in 2008. To be included in the study, patients should have had normal preoperative pulmonary function.
Upper lobectomy (suction) 900
Upper lobectomy (no suction) 900

In three cases of each group, no suction was indicated, while in the other three cases, chest tubes were placed under 15 cmH2O suction. The decision to apply suction or not was made according to the standard local perioperative care protocols in each participating centre. In one of the hospitals, suction was not used in standard cases, while in the other, patients were placed on suction until the morning of the first postoperative day and during night time thereafter [2].

After completion of the procedure, one single chest tube (24 French) was left in the pleural space, in a lateral position up to the apex, trying to avoid the tube to be trapped in one of the fissures or between the lower lobe and the dome of the diaphragm. We selected six cases of each type of lobectomy (right upper lobectomy (RUL), right lower lobectomy (RLL), left upper lobectomy (LUL) and left lower lobectomy (LLL)). In three cases of each group, no suction was indicated, while in the other three cases, chest tubes were placed under 15 cmH2O suction. The decision to apply suction or not was done according to the standard local perioperative care protocols in each participating centre. In one of the hospitals, suction was not used in standard cases, while, in the other, patients were placed on suction until the morning of the first postoperative day and during night time thereafter [2].

Inspiratory and expiratory pleural pressures were measured at 2-min intervals by an electronic device using a DigiVent® (Millicore A.B., Sweden) pleural drainage chamber. A thorough explanation of the pleural drainage system can be found elsewhere [3]. Basically, this device incorporates two battery-powered electronic sensors, one for measuring flow and the other for measuring pressure. Sensors are integrated in a micro-electro-mechanical-system (MEMS), integrating mechanical elements, sensors, actuators and electronics on a common silicon substrate through microfabrication technology [4]. Device electronics provides sensor signal conditioning and compensation, data storage and data display. Records are stored in a memory chipset and downloaded later on to a computer. A continuous display of airflow (from 0 to 9 l min⁻¹) and pressure readings (from +5 to −99 cmH2O) is available at a small LCD display.

Before connecting to the patient’s chest tube, the system was calibrated to the room pressure, which was considered as zero. After chest tube withdrawal, data were downloaded in MS Excel format and reviewed. For analysis, we selected all pressure readings corresponding to the first night after surgery (5—10 h after closing the chest) and included 5 consecutive hours. During the selected period of time, no physiotherapy manoeuvres were performed and the patients rested in bed. No radiological evidence of pneumothorax existed in a chest radiography taken at admission in the postoperative care unit. Pressure readings simultaneous to any digital recording of air leak were excluded from the analysis.

Tests (forced expiratory volume in 1 s (FEV1) >80% and forced vital capacity (FVC)/FEV1 >70%) and neither postoperative air leak nor any other intra- or postoperative complication.

As a rule, all operations were performed through a lateral or posterior muscle-sparing thoracotomy or video-assisted mini-thoracotomy by qualified thoracic surgeons.

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Records were grouped in four depending on the site of lobectomy and the use of postoperative pleural suction. For each group, descriptive analysis of inspiratory, expiratory and differential (calculated subtracting expiratory from inspiratory) pressures and normality tests of the continuous variables was performed. The influence of suction on inspiratory and differential pressures was evaluated by Student’s t-test.

Patients signed informed consent after fully understanding the procedures.

Statistical analysis was performed by Stata 10.0 software (Stata Corporation, College Station, TX, USA).

### 3. Results

A total of 3600 records of inspiratory and expiratory pressures were available for analysis. Half of the records came from cases with postoperative suction.

Table 1 depicts the descriptive statistics of inspiratory, expiratory and differential pleural pressures, grouped by site of surgery and suction. All variables had a normal distribution.

In the group of cases under no suction, upper lobectomy patients had larger differential pressures (22.6 in upper vs 11.5 cmH2O in lower lobectomy cases, $p < 0.001$), differential pressure decreased in patients under suction (9.1 in upper vs 11.1 cmH2O in lower lobectomy cases, $p < 0.001$), and the effect was mainly due to a less negative inspiratory pressure.

In lower lobectomies, mean inspiratory, expiratory and differential pleural pressures were not different between the

![Fig. 1. Influence of suction on postoperative differential pleural pressure, according to lobectomy site.](Image 309x87 to 547x260)
suction and non-suction groups. On the contrary, all types of pleural pressures were lower in cases of upper lobectomy when suction was applied to the pleural space ($p < 0.001$).

A graphic demonstration of the above findings is shown in Fig. 1.

4. Discussion

To our knowledge, pleural manometry has never been used as a clinical parameter in patients after lung resection. In patients with pleural effusion, electronic methods for measuring pleural pressures have been found to be reliable [5] and pleural manometry has been claimed to enhance the understanding of pleural diseases with undeniable clinical benefits [6].

Applying suction to the pleural space after lobectomy has been used for years, based on an unwritten consensus that suction promotes compensatory postoperative volume increase of the remaining lung and avoids pneumothorax in cases of postoperative air leakage. Nevertheless, a review of published evidences [1] has pointed out that suction does not decrease duration of postoperative air leak and is not useful, except in cases of large residual pneumothorax or massive air leak. Instead of focussing on postoperative air leakage, we have tried to measure post-lobectomy pleural pressures for a better understanding of the influence of suction on the postoperative pleural physiology in a clinical setting.

The mechanics of the pleural space in the patient after lobectomy have not been extensively studied in the medical literature. Variations of the pleural pressure result from complex forces transmitted between the chest wall and the visceral pleura surface through a thin layer of pleural fluid [7]. Classically, pleural pressures have been evaluated using oesophageal and gastric balloon-tipped catheters [8]. This technique allows the evaluation of several parameters such as lung and chest wall compliance, work of breathing and muscle function. Although oesophageal manometry is considered the only suitable method for measuring pleural pressure in humans [9], this cannot be applied to patients after lobectomy since oesophageal pressure recording is an indirect estimation of pleural pressures in both intact pleural cavities. In experimental settings, direct measurement of pleural pressures has been judged very difficult due to the pleural space width, and different available methods have been reviewed and discussed [9]. The postoperative chest is quite a different model for studying pleural physiology, since contact between both pleural layers is initially lost and, unless chest tubes are clotted or obstructed by lung tissue, measuring the pressure transmitted through them seems to be a good estimate of the true postoperative pleural pressure. As a limitation of any clinical study on pleural pressures, location of the chest tubes inside the pleural cavity could have an influence on the recordings of the postoperative pleural pressures since it could be hypothesised that recordings depend on the location of the tip of the tube (and its lateral orifices) and the type of lobectomy (superior or inferior). This limitation is more feasible after postoperative development of pleural clotting or adhesions. In our study, all recordings were obtained during the initial hours after surgery in cases without immediate postoperative complications, such as haemothorax or respiratory insufficiency; we can assume that at that time there was no intrapleural clotting or adherences. Nevertheless, we cannot be certain that chest tubes remained fully patent along all the recording period and, depending on the position changes of the patient, variations in pressures could have occurred. To decrease variability of the data, due to transitory changes, we selected several hundreds of records per patient.

Vertical gradients in pleural pressure have been demonstrated in experimental [9] and clinical settings [8] and could have influenced our results since the position of the pleural tubes inside the chest could have varied from patient to patient. To decrease the influence of this fact, we have focussed our investigation on differential pressures speculating that tube placement gradients (if any) could have influenced similarly both inspiratory and expiratory pressures, but not differential ones.

Basically, the work of breathing can be defined as the force required to overcome the elasticity of the lungs and chest wall [10]. Since expiration is mostly a passive process, except in patients with severe COPD – who have not been included in our study – the work of breathing is associated with the inspiratory effort. Then, the most relevant parameter in our study should be the inspiratory pressure. Due to the above-mentioned bias in measuring pressures in a clinical situation, we have considered differential pressure to be the most interesting parameter to be discussed.

As we have shown, differential pressure remained unchanged in patients after lower lobectomy in spite of the use of suction. On the other hand, a large decrease was found in differential pressures after upper lobectomy if pleural suction was instituted. We cannot state that using suction decreases the work of breathing after upper lobectomy since we have measured only one of the multiple parameters implicated in the inspiratory effort [10]. A scientific evaluation of the postoperative work of breathing should have taken into consideration all peripheric factors modifying the compliance of the operated lung and chest wall. On the other hand, our results have to be considered as a preliminary approximation to the study of the postoperative pleural space; thus, clinical standards concerning postoperative management of the pleural space should not be modified on the basis of the current results. At this moment, we can only conclude that pleural suction leads to a large decrease of differential pleural pressure after upper pulmonary lobectomy.

References

Appendix A. Conference discussion

**Dr S. Cassivi** *(Rochester, MN)*: That is another excellent contribution to the science of the pleural space, and I think that is one of the advantages of the digital device is that it is going to teach us a lot about what is going on in the pleural space. The question is, what is the clinical implication of this? Does this mean that for upper lobectomies you should use some suction to decrease that pleural pressure gap and on lower lobectomies you don’t need it? What does this mean to you?

**Dr Varela**: The question is very relevant, indeed. What we tried to investigate the influence of suction on the postoperative period. The idea we are working on is that suction probably decreases the effort of breathing in patients without COPD or bronchial obstruction. In this investigation we have shown that differential pressure is lower if you use suction after upper lobectomy but it is too early to conclude something on the work of breathing.

We are just starting.

**Dr L. Lampl** *(Augsburg, Germany)*: I am a little bit surprised that right-sided and left-sided upper lobectomies show the same pressure difference if you consider that on the right side there are remaining 7 of 10 and on the left side only 4 of 9 segments. Could you explain that, please?

**Dr Varela**: We analysed previously the differences between right upper lobectomy and left upper lobectomy, and, as you say, pressures are not the same. To avoid losing power in the current analysis we have joined together both types of lobectomy. Probably in a future paper we will analyse separately right and left lobectomies.

**Dr H. Eid** *(Dubai, UAE)*: I would like to ask you, was the difference related to phrenic palsy? Do you do phrenic palsy for upper or lower? You do it maybe for lower and don’t do it for upper? What is your technique for upper lobectomy? Do you do anything for the phrenic? Does that make the difference?

**Dr Varela**: We tried to keep it alive in all cases, because I don’t think that provoking a temporary palsy of the phrenic nerve makes sense. We dissect it carefully if it is needed, and that is all.