Quantification of aspirated air volume reduces treatment time in pneumothorax

O. Engdahl, J. Boe

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ABSTRACT: In 62 consecutive cases of pneumothorax, suction treatment was applied by a new method using a recently-developed vacuum pump (Pleupump) allowing the quantification of the volume of air through the chest drain. The previous 62 cases of pneumothorax treated with standard suction equipment were used as a control group. The new technique resulted in a statistically significant reduction in the mean suction treatment time from 8.1 to 4.8 days in patients with spontaneous pneumothorax. The mean total number of days in hospital was reduced from 10.0 to 6.5. This was accomplished without an increase in the number of complications or recurrences of the pneumothorax.


Pneumothorax is frequently treated by drainage, using an intercostal tube connected to a continuous vacuum allowing air aspiration and re-expansion of the lung [1-4]. Lung expansion is demonstrated by chest radiograms and the air evacuation is assessed by observing air bubbles in a bottle of water.

Neither the traditional device for the vacuum treatment of pneumothorax nor its more modern single-use version make it possible to quantify the air passing from the patient. A new device, the Pleupump (fig. 1), makes this quantification possible. The pump is battery-operated and allows the patient to be ambulatory. The maximum capacity of the pump motor is 4 L/min, which has proved sufficient in most cases of pneumothorax [5].

The aim of this investigation was to determine whether the systematic use of the Pleupump in the treatment of every kind of pneumothorax could reduce the treatment time, and to establish whether this could be achieved without an increase in the number of complications or recurrences.

Material and methods

Sixty two consecutive cases of pneumothorax, in which treatment using an intercostal drainage tube with continuous aspiration was instituted, were studied. The standard technique involved the introduction of a plastic tube in the medioclavicular or the mid-axillary line. A 20 Ch Argyle plastic chest tube with a built-in trocar (Medishield, USA) was used in all patients. The tip of the tube was positioned as close to the apex of the lung as possible. After the initial evacuation of air from the pleural cavity, the tube was connected to the Pleupump with a vacuum of 15 cmH₂O. The re-expansion of the lung and the correct position of the tube was confirmed by radiograms.

The evacuated air was quantified on a daily basis. The apparatus incorporates a volume meter capable of detecting volumes as small as 0.01 l. The accumulated air volume can be read on a display and is normally noted as l-day⁻¹. When there had been no air flow through the pump for 24 h and the radiograms showed a fully expanded lung, the chest tube was clamped for 4 h and then removed if no recurrence appeared.

The previous 62 cases of pneumothorax treated in the same department using the same technique, apart from the vacuum pump, were used as a historical control group. A standard 3-bottle arrangement had been used instead of the Pleupump, and continuing air leakage had been assessed by observing air bubbling in the bottle. In eight cases in the control group a Heimlich valve [6] was used during the last days of treatment before the clamping of the tube.

Fig. 1. - The Pleupump.
Table 1. - Number of patients, sex, age, COPD distribution and size of the initial pneumothorax

<table>
<thead>
<tr>
<th>Case of pneumothorax</th>
<th>PleuPump</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>42</td>
<td>45</td>
</tr>
<tr>
<td>Male/female</td>
<td>26/9</td>
<td>31/7</td>
</tr>
<tr>
<td>Age (mean±sd) yrs</td>
<td>41±20</td>
<td>42±19</td>
</tr>
<tr>
<td>COPD</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Size of the initial pneumothorax</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>&lt;4 cm</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>4-6 cm</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>&gt;6 cm</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
| COPD: chronic obstructive pulmonary disease.

Table 2. - Results

<table>
<thead>
<tr>
<th>Spontaneous pneumothorax</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage tube time</td>
<td>4.8±3.1</td>
</tr>
<tr>
<td>(n=35)</td>
<td>(7.2±4.4)*</td>
</tr>
<tr>
<td>Total time in hospital</td>
<td>6.5±3.7</td>
</tr>
<tr>
<td>(n=38)</td>
<td>(9.0±4.4)*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All pneumothoraces</th>
<th>PleuPump</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment time days</td>
<td>4.8±3.0</td>
<td>7.1±5.2**</td>
</tr>
<tr>
<td>(n=60)</td>
<td>(6.2±3.9)*</td>
<td></td>
</tr>
</tbody>
</table>

*: p<0.05; **: p<0.01. Treatment time in parentheses is calculated without patients treated with a Heimlich valve. (mean±sd)

The PleuPump group and the control group were studied in terms of treatment time. Both the number of days of air aspiration and the total number of days in hospital were noted. Complications as well as recurrences within the three year observation period were studied. Recurrences were divided into early, within the same hospital stay as the initial pneumothorax, and late, after discharge from hospital to the end of the observation period. The number of "failed clamping attempts", resulting in a recollapse of the lung, were also observed. The size of the initial pneumothorax prior to the start of treatment was assessed from the chest radiograms. The largest distance from the lung to the parietal pleura in a frontal projection was measured. A distance of <4 cm was considered to represent a small pneumothorax, 4-6 cm a medium-sized pneumothorax and >6 cm a large pneumothorax.

Comparison between the two treatments with respect to treatment time was performed by Mantel's test and Fishers permutation test. Fishers exact test was applied for comparison of proportions. Two-sided tests were used.

The main characteristics of the population studied are presented in table 1. The age distribution and size of the initial pneumothorax are similar in the two groups. There is no significant difference between the number of patients with chronic obstructive pulmonary disease (COPD) in the two groups. Because of incomplete case notes the number of smokers was impossible to determine.

The treatment time is reduced significantly when the PleuPump is used in patients with spontaneous pneumothorax (table 2). This reduction is significant both for the time of active drainage and for the total time spent in hospital. When the total time in hospital was calculated, five patients in the PleuPump group and four in the control group were excluded. They all suffered from COPD and their time in hospital was not only determined by the pneumothorax. In eight cases in the control group a Heimlich valve was used during the last days of treatment. As this may have prolonged the treatment time
with the drainage tube for these patients, the distribution of treatment times is presented without these eight patients (fig. 2). The difference in distribution of treatment times is still significant. When patients with traumatic and iatrogenic pneumothorax are included, the time difference with a drainage tube decreases slightly but remains significant. The total time spent in hospital has not been compared for these patients as the length of the hospital stay for them is usually determined by factors other than the pneumothorax.

Six cases in the Pleupump group and no patients in the control group had treatment times less than three days. A total of eight cases with clamping failure in the control group (13%) should be compared with no cases in the Pleupump group. Two patients in the Pleupump group and three in the control group required surgery for their pneumothorax. These patients are not included in table 2. The number of complications resulting from the suction treatment was very small in both groups. In the Pleupump group one patient developed a pneumonia and another an intrapleural haemorrhage. One patient in the control group developed a wound infection. The number of recurrences, early as well as late, was the same in the Pleupump group and the control group.

Discussion

A physician confronted by a case of pneumothorax can choose between several alternative modes of treatment. If the pneumothorax is small, he can simply wait for the air to resolve [7]. This is a fairly slow process, since only 1.25% of the air is absorbed every day, but the process can be speeded up using nasal oxygen [8, 9]. A simple exsufflation of the pneumothorax might be contemplated and is favoured by some authors [10, 11], although this procedure entails a high risk of early recurrence [2, 7, 12]. In some centres, especially in the USA, early surgical intervention, using thoracotomy, is advocated [3, 13, 14].

In spite of the above-mentioned alternatives, most authors seem to agree on the importance of an intercostal drainage tube and the application of a continuous vacuum as the standard treatment for a pneumothorax larger than 20%. In order to prevent the lung from recollapsing when the drainage tube is clamped, it is important that the suction treatment is continued until the leakage of air has ceased [1, 15–17]. This makes the detection of a continuing air leakage important in order to minimize the "over-treatment" of the patient and to prevent premature clamping attempts.

We present the outcome of treatment involving continuous suction using a new apparatus, the Pleupump, which quantifies the air passing from the patient. This is compared with a standard suction equipment in which the air leakage is detected by observing air bubbles.

For methodological reasons it was not possible to conduct a prospective, randomized study. Since the indications for chest tube treatment, and the overall procedure are standardized in our hospital, we decided instead to use a historical control group comprising the same number of cases treated immediately prior to the use of the Pleupump. The traditional equipment allows only an assessment of the air leakage, normally conducted by the physicians once or twice daily during rounds. This should be regarded as an intermittent test rather than a continuous supervision of air flow.

Daily chest radiograms ensured full lung expansion. Test clamping of the drainage tube was performed as soon as the air leakage seemed to have stopped for 24 h. If no recollapse of the lung was noted during 4 h, the drain was removed. This protocol has been the same in this hospital for many years and resembles that used with the Pleupump. The only major difference between the protocols is the more accurate detection of air leakage with the Pleupump.

The mean treatment time in the control group is similar to previous observations [1, 2, 12, 17] and represents the average result of suction treatment using
equipment without quantification of aspirated air volume. The use of the Pleupump reduced the treatment time by 40% in patients with spontaneous pneumothorax. Failed clamping attempts were completely eliminated and this probably helped reduce the treatment time, as a recollapse of the lung can be suspected to delay healing of the initial lesion. The most important advantage of the reduced treatment time is probably that no patients were "over-treated" when the Pleupump was used.

As we have previously shown [5], in a number of cases the initial lesion is healed within only a few days. We think that the physician who is forced to rely on pure observation of air bubbles, tends to prolong treatment time fearing recollapse on clamping of the drainage tube. This, probably, increases treatment time in cases with air leakage of short duration. In fact, there were no spontaneous pneumothorax patients with treatment times shorter than three days in the control group compared to six patients in the Pleupump group.

Another factor that has to be taken into account is how the patient is treated after the failure of a clamping attempt. We suspect that the fear of repeating the same mistake tends to increase treatment time. Although there could be other explanations, the six patients with spontaneous pneumothorax and failed clamping in the control group had a longer than average treatment time (9–20 days).

One possible objection to a reduction in treatment time could be the suspicion that the thoracic drainage tube promotes the formation of adhesions to prevent recurrences and that consequently a prolonged treatment time reduces the incidence of such recurrences [15, 16]. We failed to find any support for this theory in the present study. Although the treatment time was significantly reduced, the incidence of recurrence was the same in both groups (20%), which is similar to or lower than that reported by others [1, 7, 12, 18].

A powerful incentive for the reduction of aspiration time is the increased risk of infectious complications associated with prolonged treatment times [12]. The overall complication rate in this study was, however, too low to enable any comparisons. Economic factors also strongly favour the shortening of the hospitalization period. In Sweden alone, more than 3,000 days in hospital could be saved every year with a 40% reduction in the treatment time for spontaneous pneumothorax.

In conclusion, treatment using our new method, which enables the aspirated air volume through the drainage tube to be quantified, reduces the treatment time without an increase in the rate of complications or recurrences of pneumothorax.

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References