A physiological comparison of flutter valve drainage bags and underwater seal systems for postoperative air leaks

D A Waller, J G Edwards, P B Rajesh

Abstract

**Background**—A study was undertaken to compare the relative physiological effects of underwater seal (UWS) versus flutter valve (FV) pleural drainage systems in the treatment of postoperative air leaks.

**Method**—Fourteen patients with air leaks of 1–11 days duration, following lobectomy (n = 5), bullectomy (n = 4), and decortication (n = 4), and pleural biopsy (n = 1) were analysed. Intrapleural pressure (IPP) measurements were made using an in-line external strain gauge connected directly to the intercostal tube. Patients were connected simultaneously to both UWS and FV drainage systems and pressures were measured sequentially, isolating each system in turn. Maximum (IPPmax) and minimum (IPPmin) intrapleural pressures were calculated from graphic traces. The degree of lung expansion was recorded by chest radiography.

**Results**—At resting tidal volume (IPPmax) was significantly higher with the UWS system (mean difference 0.8 mm Hg, 95% CI 0 to 1.6, p = 0.046) and IPPmin was significantly lower with the FV system (1.8 mm Hg, 95% CI 0.3 to 3.3, p = 0.023). The lung was fully expanded in 50% of patients at the time of study. The mean difference in IPPmin between systems was significantly increased when the lung was fully expanded (mean 2.8 mm Hg, 95% CI 0.1 to 5.5, p = 0.042). The mean difference in IPPmax was not affected by the degree of lung expansion (0.79, 95% CI –0.83 to 2.4, p = 0.31).

**Conclusion**—The results of this study suggest that, when postoperative air leak exists without a persistent pleural space, the flutter valve may provide a physiologically more effective alternative to the underwater seal drainage system.

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Keywords: Heimlich valve; pleural drainage; intercostal drain; postoperative air leak

Postoperative air leaks are a major source of bed occupancy in thoracic surgery and the immobility they inflict on the patient is a considerable source of morbidity. The conventional method of treatment by underwater seal drainage is cumbersome and restricts patient mobility. Favourable results with the use of an alternative drainage system, using a Heimlich valve connected to a drainage bag, have led to the development of the Ambulatory Chest Drainage System (Portex Ltd, Hythe, UK). This incorporates a one way flutter valve and a vented outlet into a flexible bag. When compared with underwater seal drains these so-called “flutter bags” were found to be safe, no less effective, and permitted earlier mobility.1 They have also been used successfully for outpatient care.2,3 Concerns regarding blockage of the flutter valves with drained fluid were not realised. Although no significant difference in efficacy between the two systems has been demonstrated, there are anecdotal reports that air leaks treated with the use of a Heimlich valve close faster than expected.4 To investigate the hypothesis that the flutter valve is a better physiological drainage system than the underwater seal, we compared the relative intrapleural pressures generated by each system in patients with postoperative air leaks.

**Methods**

**Patients**

Fourteen patients with a postoperative air leak ranging from 1 to 11 days duration were studied. The operations included lobectomy (5 patients), bullectomy (4 patients), and pleural debridement/decortication (5 patients). Each patient was breathing spontaneously and had a single intercostal tube connected to a correctly primed underwater seal which was not attached to a suction pump.

**Intrapleural Pressure Measurements**

The intercostal tube was simultaneously connected to both an underwater seal system (UWS) and a flutter valve (FV) system via a Y connector. Each limb was alternately occluded to allow concurrent intrapleural pressure measurements with each system. Intrapleural pressures were measured at resting tidal volume using an in-line external strain gauge (Druck Ltd, UK) connected via a needle directly into the proximal intercostal tube. Graphic traces were obtained using a multichannel pen recorder (Lectromed Ltd, UK). From the traces the maximum (IPPmax) and minimum (IPPmin) intrapleural pressures at resting tidal volume were recorded. A chest radiograph was obtained just prior to the pressure measurements to document the degree of lung expansion.

**Statistical Analysis**

Differences in mean IPPmin and IPPmax between groups were assessed using the Student’s t test with statistical significance accepted at p<0.05.
Table 1  Effect of drainage system on mean values of maximum and minimum intrapleural pressures (IPPmax and IPPmin)

<table>
<thead>
<tr>
<th></th>
<th>Underwater seal</th>
<th>Flutter valve</th>
<th>Difference of means</th>
<th>95% CI</th>
<th>p value (t test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPPmax (mm Hg)</td>
<td>−0.8</td>
<td>−1.6</td>
<td>0.8</td>
<td>0 to 1.6</td>
<td>0.046</td>
</tr>
<tr>
<td>IPPmin (mm Hg)</td>
<td>−5.6</td>
<td>−7.4</td>
<td>1.8</td>
<td>0.3 to 3.3</td>
<td>0.023</td>
</tr>
</tbody>
</table>

**Results**

In the 14 patients studied the IPPmin obtained at resting tidal volume was significantly lower (p = 0.023) using the FV system than the UWS system (table 1). Similarly, in these patients the IPPmax obtained during expiration at resting tidal volume was significantly lower (p = 0.046) using the FV system.

**EFFECT OF LUNG EXPANSION**

At the time of pressure measurement seven of the 14 patients had full lung expansion on chest radiography and seven patients had a residual pleural space. The reduction in the IPPmin obtained with the FV system was lost when the underlying lung was not expanded (table 2). The difference in IPPmin between the two systems was therefore significantly affected by the state of lung expansion (p = 0.042) but the difference in IPPmax between the systems was not affected by lung expansion (p = 0.31).

**EFFECT OF CLINICAL CONDITION**

The underlying clinical condition resulting in the air leak had no effect on the differences between the systems in IPPmin or IPPmax. After lobectomy, bullectomy, and empyema surgery, in all but two cases (in whom no change occurred) the use of the FV system resulted in a reduction in IPPmin. Similarly, in all but two cases there was a reduction in IPPmax.

**Discussion**

The normal pleural space is maintained at a negative pressure of −8 cm H2O to −3 cm H2O by the opposing elastic recoil forces of the lung and chest wall. The ideal postoperative drain-

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