

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), 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.

(Thorax 1999;54:442-443)

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.

Department of
Thoracic Surgery,
Birmingham
Heartlands Hospital,
Birmingham B9 5SS,
UK

D A Waller
J G Edwards
P B Rajesh

Correspondence to:
Mr D A Waller, Glenfield
Hospital, Groby Road,
Leicester LE3 9QP, UK.

Presented at The British
Thoracic Society Winter
Meeting held in London on
15/17 December 1997.

Received 22 December 1997
Returned to author
11 February 1998
Revised manuscript received
4 January 1999
Accepted for publication
7 January 1999

Table 1 Effect of drainage system on mean values of maximum and minimum intrapleural pressures (IPPmax and IPPmin)

	Underwater seal	Flutter valve	Difference of means	95% CI	p value (t test)
IPPmax (mm Hg)	-0.8	-1.6	0.8	0 to 1.6	0.046
IPPmin (mm Hg)	-5.6	-7.4	1.8	0.3 to 3.3	0.023

Table 2 Effect of lung expansion on the intersystem differences in mean minimum and maximum values of intrapleural pressure (IPPmin and IPPmax)

Intersystem difference	Lung expanded	Lung not expanded	Difference of means	95% CI	p value (t test)
IPPmin (mm Hg)	3.2	0.4	2.8	0.1 to 5.5	0.042
IPPmax (mm Hg)	1.2	0.4	0.8	-0.8 to 2.4	0.31

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 H_2O to -3 cm H_2O by the opposing elastic recoil forces of the lung and chest wall.⁵ The ideal postoperative drain-

age system will therefore allow the maintenance of a negative intrapleural pressure, even in the presence of an air leak, and will not unduly disable the patient. The practical disadvantages of the UWS system, in terms of patient immobility and problems in patient transfer, have been documented.¹ This study, while not addressing clinical benefit, shows that the FV system maintains a more negative intrapleural pressure than the conventional UWS system at resting tidal volume and that the difference between the systems is greatest when the underlying lung is expanded. It is important to note that in this study no suction was applied to the underwater seal system for comparison.

The explanation for the difference between the two drainage systems may lie in the relative compliance of the respective valves. The UWS may be more compliant than the FV, thus allowing a shift towards atmospheric pressure in the pleural space. Indeed, it has already been shown that the fluid filled dependent loop, often seen with the UWS, may increase intrapleural pressure to as high as 8 cm H_2O and to diminish drainage to zero.⁶ When the underlying lung is not fully expanded in the presence of an air leak the significant difference between the systems is lost. This is probably because the effect of the air leak outweighs that of the valve on the maintenance of a negative intrapleural pressure.

The recommendation of this study is that, in the presence of an expanded lung and persistent parenchymal air leak, a flutter valve should be considered as an alternative to an underwater seal system. This system may allow for more effective mobilisation and earlier discharge without compromising pleural drainage.

- Graham ANJ, Cosgrove AP, Gibbons JRP, *et al.* Randomised clinical trial of chest drainage systems. *Thorax* 1992;47:461-2.
- Matthews HR, McGuigan JA. Closed chest drainage without an underwater seal (abstract). *Thorax* 1988;43:804.
- McManus KG, Spence GM, McGuigan JA. Outpatient chest tubes (letter). *Ann Thorac Surg* 1998;66:299-310.
- McKenna RJ, Fischel RJ, Brenner M, *et al.* Use of the Heimlich valve to shorten hospital stay after lung volume reduction surgery for emphysema. *Ann Thorac Surg* 1996;61:1115-7.
- Munnell ER. Thoracic drainage. *Ann Thorac Surg* 1997;63:1497-502.
- Gordon PA, Norton JM, Guerra JM, *et al.* Positioning of chest tubes: effects on pressure and drainage. *Am J Crit Care* 1997;6:33-8.