A UNIVERSAL VALVE FOR ANAESTHETIC CIRCUITS

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SUMMARY

During intermittent positive pressure respiration, volume-controlled rather than pressure-controlled ventilation is preferred. To accomplish volume-controlled ventilation, a safe, efficient, universal valve has been designed. This valve has an adequately low opening pressure and an automatic exit closure when desired.

Intermittent positive pressure respiration (IPPR) is best accomplished with a completely closed system during the inspiratory phase, so that all gas squeezed out of the reservoir bag will go to the patient's lungs. Under these conditions ventilation is volume-controlled. A low pressure in the system during the expiratory and resting phases will have least adverse effect on the patient; however, that pressure must be slightly higher than the collapsing pressure of the reservoir bag in order that the latter may remain adequately filled (Mushin and Mapleson, 1954).

When a non-rebreathing valve with automatic exit closure mechanism (Fink, 1954; Ruben, 1955; Lewis, 1956; Frumin et al., 1959; Sykes, 1959) is used for intermittent positive pressure respiration, it is most desirable to have a pressure buffering mechanism in the system to obviate increasing pressure in the bag, thus eliminating the danger of obstruction or occlusion of the exhalation valve with resulting increased resistance to expiration and the risk of rupturing lung tissue.

CONSTRUCTION OF THE VALVE

A small tubular valve (fig. 1) has been designed to solve these problems. It can be used with the semiclosed circle system, or an open system incorporating a non-rebreathing valve. The valve consists of three compartments, a spring-loaded valve, and a safety ball (fig. 2).

The first compartment (I) serves as gas inlet (i) and also as connector to the anaesthetic system. The second compartment (II) houses the piston valve (v). This valve is spring-loaded. The spring may be attached to the face of the valve as in figure 2(a) or may support the valve from below as in figure 2(b). The piston valve itself consists of a flat surface which sits on the long conical tail, as shown in figure 2(c). When the pressure in the bag is low, the valve will rest on valve receiver r₁. As pressure increases, the valve piston will be pressed distally and lie somewhere in the middle of the second compartment. During bag compression when the pressure in the bag is suddenly increased, the valve will lie against the valve receiver r₁ and the system will become completely closed.

Compartment III is composed of the exit portion of the valve and the plastic ball. When the ball is free of the exit, the valve can be brought to rest against the valve receiver r₂. As during bag compression, and the system will become completely closed. When the ball is in position A, the movement of the valve piston is restricted and, while gas may escape through the side vents, the increased bag pressure cannot completely close the valve. When the ball is in position B, the outlet of the valve is completely occluded and a closed system is produced.

FUNCTION OF THE VALVE

Due to its small and tubular shape, this valve is simply connected to the anaesthetic system by inserting it into the tail of the reservoir bag for semiclosed circle technique, as shown in figure 3. For open system using a non-rebreathing valve with automatic exit closure mechanism (such as
Fig. 1
The universal valve (L-V).

Legend: (i) inlet; (s) spring; (r₁) first valve receiver; (v) piston valve; (r₂) second valve receiver; (b) safety ball; (g) groove on the surface of the piston valve; (c) body of the piston valve; (t) guiding tail of the piston valve; (A) safety ball position A; (B) safety ball position B.
TABLE I
Gas-relieving pressure of the automatic universal valve (L–V) at various flow rates.

<table>
<thead>
<tr>
<th>Gas flow (l./min)</th>
<th>0.5</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (cm H₂O)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.7</td>
<td>0.9</td>
<td>1.1</td>
<td>1.7</td>
<td>2.4*</td>
</tr>
</tbody>
</table>

*Valve will close spontaneously.

Table I shows the gas-relieving pressure of the automatic universal valve (L–V) at various flow rates. The valve will close spontaneously if spontaneous pressure built up in the reservoir bag exceeds the opening pressure of the valve, the gas will bleed out just like a conventional expiratory valve in the semiclosed circle system. When an open system with a non-rebreathing valve is used, there will be no undesired exit obstruction or occlusion. However, its outlet can be automatically closed when the reservoir bag is compressed during intermittent positive pressure respiration with semiclosed circle or non-rebreathing techniques. There is only minimal leakage of gas when the valve travels from the inlet to the outlet receiver. Up to 20 l./min of gas can escape without closure of the exit. Sudden closure of the valve during flushing of the system can be prevented by inserting a finger on the safety ball in the outlet. The bag will not become empty or over-distended since the minimal opening pressure of the valve is low enough.

The universal valve is inserted in the tail of the reservoir bag during semiclosed circle systems of anaesthesia. Note that the bag is adequately full, but not over-distended.

Fig. 3
The universal valve is inserted in the tail of the reservoir bag during semiclosed circle systems of anaesthesia. Note that the bag is adequately full, but not over-distended.

Fig. 4
Mid-section of an open system using a non-rebreathing valve with automatic exit closure mechanism. The universal valve (L–V) is inserted into the tail of the reservoir bag to prevent expiratory obstruction or occlusion.
The universal valve (L–V) is connected to an open system using a Frumin non-rebreathing valve by means of a Y-piece.

(0.3 cm H$_3$O) is just slightly higher than the usual collapsing pressure of the thin-walled (0.010–0.015 inch) reservoir bag (0.25 cm H$_2$O). Although Mapleson (1954) found that an expiratory valve opening pressure of 0.5–1 cm H$_3$O is necessary to provide good function of the “one gallon” reservoir bag, this valve, with its comparatively low gas-relieving pressures as indicated in table I, has been found to function well with both small and large gas flows. The anaesthetist has always a good “hand feeling” of the bag. There is no possibility of dilution of the anaesthetic gas with air.

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REFERENCES