A New Pop-Off Valve

SHAOTSU LEE, M.D.*

During controlled ventilation, it is best to work with a completely closed system during the inspiratory phase, so that all gas squeezed out of the reservoir bag by the anesthesiologist will go to the patient's lungs. In the resting state, a low pressure in the system will have least adverse effect on the patient. However, that pressure should be slightly higher than the collapsing pressure of the reservoir bag in order that the latter may remain adequately filled.

To meet the above requirements a valve (L-XIV) has been designed for the purpose of replacing the inefficient conventional pop-off valve on anesthesia machines in current use.

The valve (fig. 1) is cylindrical, and consists of a spring-loaded disc (d) surrounded by vented inner (I) and outer (O) sleeves. A top piece (T), which is also vented, screws onto the inside of the inner sleeve. It contains a screw (S) to permit adjustment of tension on the spring (figs. 2, 3).

During the resting state, the weighted disc makes an air-tight cover over the gas inlet on the bottom of the valve. When the bag pressure is higher than the valve's opening pressure, the disc is raised and gas escapes. This is regulated by the weight of the disc and the flow of gas. The outer sleeve can be rotated freely over the inner, and the vents around the base of each (V_O and V_I, respectively) are spaced so that in one position of the outer sleeve they are completely occluded, making the valve chamber air-tight, and in another they coincide, allowing any excess gas which may have accumulated inside the system (during spontaneous respiration, for example) to escape freely (fig. 2). Around the upper part of the top piece are many vents to allow release of excess gas which might collect when the sleeve vents are closed (fig. 3). The screw fitted into top piece supports a conical spring which holds the disc over the gas inlet. Minor adjustments of spring tension can be made by turning this screw. At the lower end of the top piece there is a receiver to arrest the weighted disc when it is forced to the top of the valve chamber by a sudden increase of pressure under it. The chamber outlet is then closed and the whole system sealed. This occurs during bag compression for intermittent positive pressure breathing. By screwing the top piece up or down to alter the height and size of the chamber, the pressure necessary for automatic closure of the outlet can be adjusted to suit different gas flows and different requirements. The longer the distance which the disc has to travel, the larger will be the amount of gas escaping through the top vents without unwanted outlet closure. When the top piece is screwed down to its limit, the whole valve can be closed completely; this is mandatory for a closed circuit system.

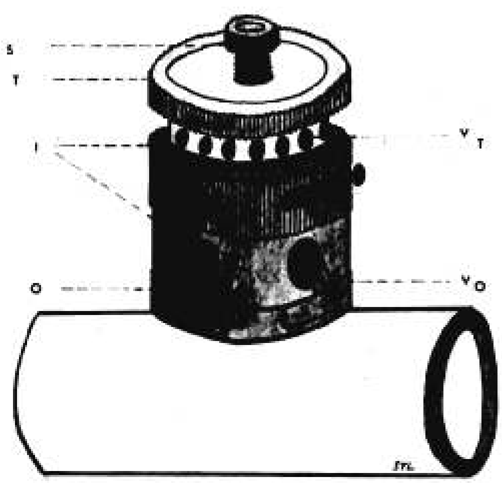

FIG. 1. The perspective view of the valve. The vents on the side wall are closed.

* Division of Anesthesiology, West Virginia University Medical Center, Morgantown, West Virginia.
This work was done at State University of New York Downstate Medical Center, New York City.

The valve may be used with or without a guiding tail. When automatic outlet closure is desired, a disc with an upward guiding tail is better than one without, because it travels more evenly. The guiding tail, surrounded by the conical spring, is inserted loosely into the hollow center of the top piece.

The valve disc may be round or square. If a simple square disc is used, the largest square (d^2, fig. 4) which the chamber can accommodate should be selected. The corresponding valve inlet should be the largest which the square can cover; the appropriate diameter will be just slightly less than the length of the side of the square. If a round disc is chosen, its perimeter should be halfway between the edge of the valve base and the rim of the inlet. If R_1 is the radius of the inlet, R_2 the radius of the disc, and R_3 the radius of the base, R_2 must be equal to, or slightly larger than $R_1 + (R_3 - R_1)/2$. With these proportions, the inlet will always be covered even if a disc without guiding tail is not exactly centered.

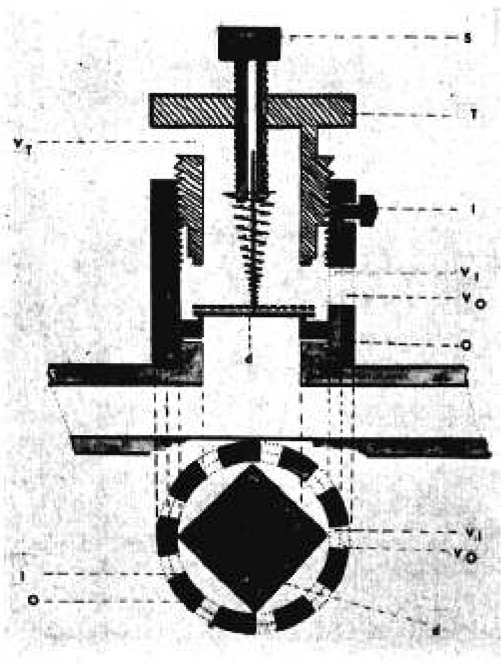

FIG. 2. Midsection and top view of the valve. The vents on the inner and outer sleeves coincide with each other. The valve is open and its function is similar to the conventional pop-off valve but with a lower opening pressure.

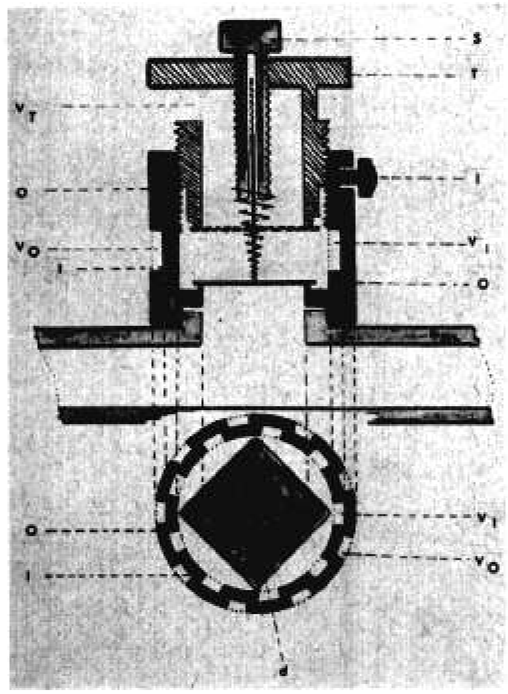

FIG. 3. Midsection and top view of the valve. The vents on the inner sleeve are covered by the outer sleeve and the side wall of the main chamber is closed. The valve is functioning as a conventional pop-off valve and automatic outlet occlusion can be produced by sudden bag compression.

A square disc travels more evenly than a round one, which has a larger surface area for the same size of valve inlet. The remaining area between round disc and wall of chamber ($\pi R_3^2 - \pi R_2^2$) is therefore smaller than that between square disc and chamber wall ($\pi R_3^2 - d^2$); thus there is relatively less space for flow of gas past a round disc.

There are seven main functions of the valve described. (1) It provides automatic outlet closure when this is desired during compression of the reservoir bag in a semiclosed circuit or nonrebreathing system.[1] (2) It can be regulated for different inflation volumes and pressures. Bag compression can be adjusted with different gas flows and lung compliance to obtain the most efficient ventilation. The valve functions efficiently with either small gas flows for infants or larger flows for adults. (3) It can be closed completely, for use with

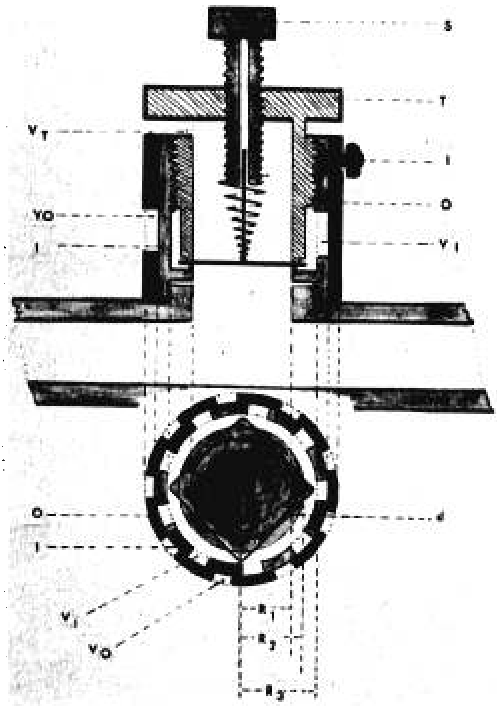

FIG. 4. Midsection and top view of the valve. The side wall vents are closed as in figure 3. The top piece is screwed all the way down and holds the disc valve tightly on its inlet rest. The valve is completely closed. T—Top piece; I—Inner sleeve; O—Outer sleeve; D—Valve disc; S—Adjustable screw on top piece; V_I, V_O, V_T—Vents on inner and outer sleeve and top piece; d—side of square disc valve; R_1—Radius of gas inlet; R_2—Radius of round disc valve (if used); R_3—Radius of base of main valve chamber.

a closed circuit system. (4) As a pop-off valve it allows escape of excess gas and relief of increased bag pressure. A maximal flow of 50 liters/minute or more can pass through the valve, although safety vents are provided to allow free escape of gas when higher flows are used. (5) It has a low opening pressure (0.3–1.0 cm. H_2O at 1–25 liters/minute) which is adjustable. When "hand feeling" of the bag is practiced, the opening pressure can be made slightly higher than the usual collapsing pressure of the reservoir bag, and therefore the latter will not become too distended but will still remain full enough to act as a reservoir.* (6) The valve is sealed in its resting state. There is, therefore, no possibility of dilution of anesthetic gases with air. (7) Although the valve functions best in the upright position, this is not absolutely necessary.

REFERENCES

1. Lee, S.: A modified nonrebreathing system, ANESTHESIOLOGY **25**: 238, 1964.
2. Mapleson, W. W.: Volume-pressure characteristic of the "one-gallon" reservoir bag, Brit. J. Anaesth. **26**: 11, 1954.
3. Lee, S.: An universal valve (L-V) for anesthetic circuits, Brit. J. Anaesth., in press.

* Mapleson [2] has suggested an opening pressure for an expiratory valve of not less than 0.5–1.0 cm. H_2O, so that the "one-gallon" bag can function properly. I have, however, found that a valve with an opening pressure of 0.3 cm. H_2O provides adequate volume and good "hand feeling" of the thin-walled 5-liter bag.[3]

A New Needle for Controlled Spinal Drainage

JOSEPH A. EPSTEIN, M.D., BERNARD S. EPSTEIN, M.D.,* SYLVAN SURKS, M.D.

The evacuation of cerebrospinal fluid from the basal cisterns by means of spinal drainage is an important technical contribution facilitating neurosurgical operative exposures. This is vital when approaching aneurysms of the circle of Willis and in the surgical management of pituitary tumors and other lesions involving the base of the brain, including hypophysectomy and pituitary stalk section. Aids such as urea and mannitol can overload the circulation and introduce complicating problems of a toxic or metabolic nature. The use of hyperventilation and hypotension may be minimized or avoided if an effectively functioning spinal draining system is instituted.

* The Long Island Jewish Hospital, New Hyde Park, Long Island, New York.