A NONREBREATHING VALVE OF NEW DESIGN *

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NONREBREATHING circuits are as old as general anesthesia itself. The inhaler with which Morton made his first demonstration of ether anesthesia at the Massachusetts General Hospital in 1846 included inspiratory and expiratory valves placed to form a physiologically sound nonrebreathing circuit, an arrangement which was echoed in many later pieces of apparatus (1).

For the application of the nonrebreathing principle to pediatric anesthesia, credit is due to Leigh (2) and to Stephen and Slater (3, 4). The work of these authors has drawn attention to the many advantages of this system. These include: small resistance to gas flow, minimal dead space, no rebreathing from reservoir bag, and the possibility of aiding respiration. There are accompanying disadvantages: loss of water vapor and of heat and wastage of anesthetic gases, but in practice these are far outweighed by the benefits.

Presently available nonrebreathing valves readily lend themselves to the performance of assisted respiration but have the serious limitation that this entails using both hands, one to occlude the expiratory orifice while the other squeezes the bag. Accordingly, an attempt has been made to produce a valve in which the expiratory exit will be occluded automatically and leave one of the anesthesiologist's hands free for other tasks.

PRINCIPLE AND MODE OF OPERATION

The assembly consists essentially of a conventional nonrebreathing valve surmounted by a slack diaphragm (fig. 1). Increased pressure in the breathing bag is transmitted through a duct (A) and causes distention of the diaphragm (B). This forces a disk (C) against the expiratory valve leaf. Thus, the expiratory orifice is sealed and gas can no longer escape through it. Gas squeezed from the bag must, therefore, enter the patient.

When pressure on the bag is released at the commencement of expiration, diaphragm (B) immediately becomes slack. Pressure on the disk (C) is relaxed, the expiratory leaf opens, and exhaled gas escapes through the orifices (labeled E).

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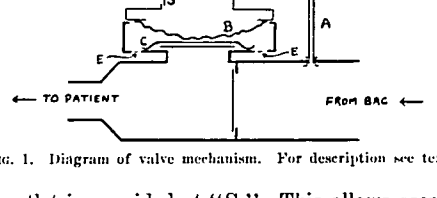

FIG. 1. Diagram of valve mechanism. For description see text.

A safety outlet is provided at "S." This allows escape of excess gas and is adjustable to function as an outlet of any desired extent. By this means overdistention of the bag and of the patient's lungs is prevented.

With the safety outlet wide open the automatic closing device ceases to operate, since pressure cannot build up over the diaphragm. In these circumstances the apparatus becomes in effect a nonrebreathing valve of conventional design and continues to operate as such.

ADVANTAGES

The essential feature of the valve is that during assisted respiration the expiratory orifice is occluded automatically at the appropriate

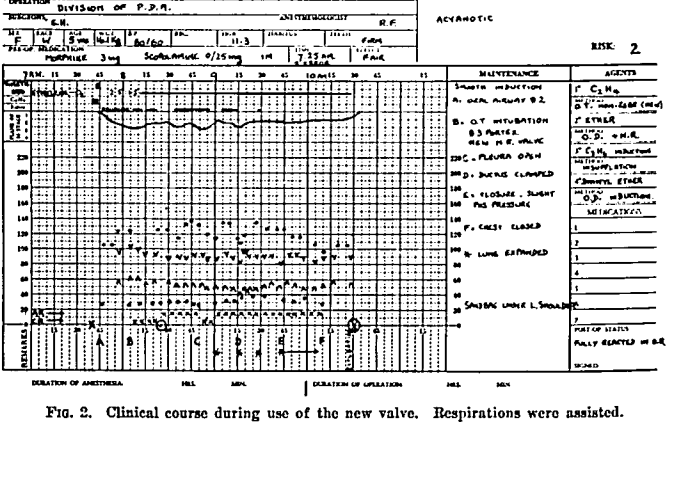

FIG. 2. Clinical course during use of the new valve. Respirations were assisted.

phase of the respiratory cycle. The anesthesiologist is no longer required to seal the exit with a finger, a maneuver which is both fatiguing and difficult to time accurately. It also becomes much easier to graduate the amount of pressure applied to the bag. All degrees of assistance to the gentlest aid are readily performed, a feature of obvious value in the handling of infants.

The apparatus is compact and operates efficiently in any position, whether on the side, end up, or upside down. The dead space (11.5 cc.) and resistance (2 to 3 mm. of water) are minimal.

CLINICAL TRIAL

The valve has been tested over a period of five months to date in a total of 47 cases, including 6 cardiac operations. The youngest patient was an infant one day old who underwent a successful procedure for

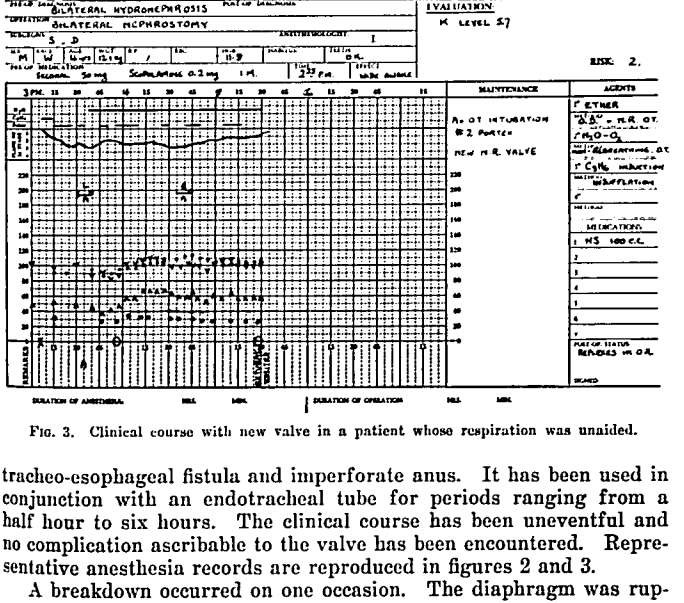

FIG. 3. Clinical course with new valve in a patient whose respiration was unaided.

tracheo-esophageal fistula and imperforate anus. It has been used in conjunction with an endotracheal tube for periods ranging from a half hour to six hours. The clinical course has been uneventful and no complication ascribable to the valve has been encountered. Representative anesthesia records are reproduced in figures 2 and 3.

A breakdown occurred on one occasion. The diaphragm was rup-

tured owing to a defect in the rubber and the automatic closing device was thereby rendered inoperative. In this instance the patient was transferred to a to-and-fro system. However, it may be pointed out that this failure did not endanger the patient since the apparatus continued to function as a conventional nonrebreathing valve. Removal of the diaphragm head, which requires only a few seconds, would permit digital control of the expiratory exit in the same way as on existing models.

SUMMARY

A new nonrebreathing valve is described. The design provides for automatic closure of the expiratory orifice whenever the breathing bag is compressed. Respiration can be assisted or controlled with remarkable ease and delicacy, and only one hand is required for this purpose.

The valve has been used clinically in 47 cases with satisfactory results and has proved a notable convenience in pediatric anesthesia.

ACKNOWLEDGMENT

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