The Efficiency of Partial Soda-lime Bypass Circuits

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Many anesthesia circle systems are equipped with a soda-lime canister bypass channel which may be used with low gas flows to elevate P_{CO_2}. One simple bypass channel is adjustable to allow increasing degrees and total bypass. This is available on the Ohio model 18 and 19 absorbers. Another bypass apparatus is the rebreathing valve (see fig. 1) on the side of the Ohio model 20 and 21 absorbers. This allows only partial bypass when the screw is in the fully open position. The degree of rebreathing permitted by this circuit is the subject of this study.

METHODS

We evaluated the effectiveness of the Ohio model 20 partial bypass device by measuring the increases in expired P_{CO_2} over a range of inflow rates in anesthetized subjects. These values were compared with the increases in P_{CO_2} during total soda-lime bypass. CO_2 was sampled from the endotracheal tube and analyzed with a Godart capnograph coupled to a Sanborn recorder. Three Ohio model 20 absorbers and one model 19 absorber were studied. All of the absorbers contained approximately the same volume of gas, as determined by a helium dilution method.

Four healthy subjects undergoing surgical operations on extremities were anesthetized with halothane and oxygen. *d*-Tubocurarine was administered, the trachea was intubated, and hyperventilation at 8 l/min (P_{CO_2} 25 mm Hg) was begun, using an Ohio volume respirator as a reservoir connected to a closed-circle system with a volume of 7 l. When a steady state of anesthesia had been attained and end-tidal P_{CO_2} was stable, the rebreathing valve of the Ohio model 20 was opened and CO_2 allowed to rise until it reached a plateau. This was done at three inflow rates (0.5, 2.0, and 6.0 l/min), permitting P_{CO_2} to return to the same initial level before each change in the flow rates. Then an Ohio model 19 absorber was substituted for the Ohio 20 absorber and the procedure was repeated using total bypass. The period of bypass or rebreathing was five minutes in each experiment.

RESULTS

Figure 2 shows the rates of increase of CO_2 in a typical patient, comparing the partial by-

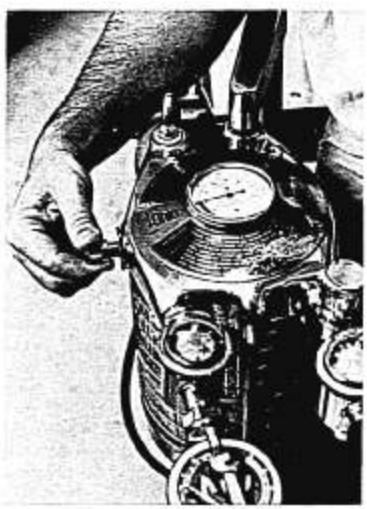

FIG. 1. The Ohio absorber model 20 with attached rebreathing valve in the open, or bypass, position.

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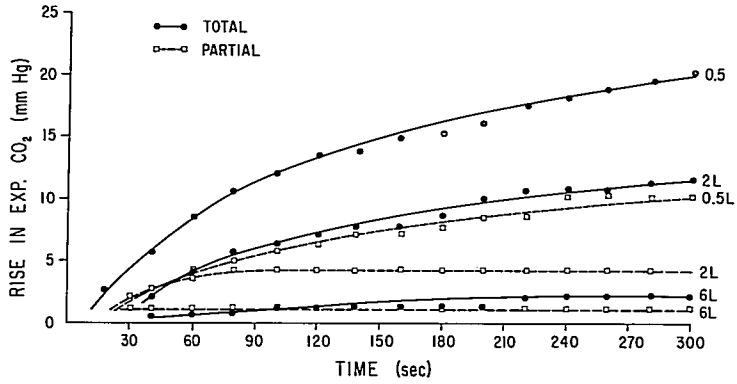

FIG. 2. Plot of the rates of rise of expired P_{CO_2} during total (solid lines) bypass with the Ohio model 19, and partial (interrupted lines) bypass with the Ohio model 20 at various fresh gas flows. The subject was anesthetized and hyperventilated (P_{CO_2} 25 mm Hg).

pass (Ohio model 20) device with a total bypass (Ohio model 19). At high flow rates of fresh gas, there is minimal CO_2 accumulation with either the partial or the total bypass system. At a flow of 2.0 l/min, end-tidal P_{CO_2} increases 3 mm Hg in 60 seconds, then remains constant with partial bypass, but with total bypass P_{CO_2} continues to increase, reaching a 10-mm Hg elevation in five minutes. At low flow rates (0.5 l/min), with partial bypass, P_{CO_2} increases 10 mm Hg in four minutes, then plateaus, whereas with total bypass P_{CO_2} increases approximately 20 mm Hg over five minutes without reaching a plateau.

DISCUSSION

A soda-lime bypass apparatus is used in clinical anesthesia to restore P_{CO_2} and initiate spontaneous respiration following hyperventilation. Ivanov and Nunn [1] studied methods of raising the P_{CO_2} above the apneic threshold in the hyperventilated patient under anesthesia. One method was hypoventilation, low inflow of fresh gas, and soda-lime bypass. In this way, they were able to raise P_{CO_2} approximately 3 mm Hg/min. This was less effective in raising P_{CO_2} than adding 5 per cent CO_2 to the inflow. The results of the present study indicate a slow rate of increase of CO_2 (3–5 mm Hg/min) with total bypass and low fresh gas inflow (0.5 l/min), which is approximately the same as the results of Frumin *et al.*[2] during apneic oxygenation. The Ohio partial bypass rebreathing valve allows a maximal P_{CO_2} increase of 10 mm Hg, which takes five minutes. This apparatus is limited, then, in terms of allowing P_{CO_2} to increase. On the other hand, the small amount of bypass renders this device less of a hazard should it be inadvertently left with the switch in the "open" position.

SUMMARY

The rate and extent of increase in expired P_{CO_2} during partial and total soda-lime bypass at various gas inflow rates were studied in anesthetized patients. At flow rates of 2 l/min or more, P_{CO_2} did not increase more than 10 mm Hg over 5 min with either partial or total bypass.

REFERENCES

1. Ivanov SD, Nunn JF: Methods of elevation of P_{CO_2} for restoration of spontaneous breathing after artificial ventilation of anaesthetized patients. Brit J Anaesth 41:28–37, 1969
2. Frumin MJ, Epstein RM, Cohen GB: Apneic oxygenation in man. ANESTHESIOLOGY 20: 789–798, 1959