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A Method for Supplemental Oxygen Administration during Weaning from Mechanical Ventilation

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Supplemental oxygen is frequently necessary while weaning a patient from prophylactic postoperative mechanical ventilation or following mechanical ventilation for pulmonary insufficiency.[1, 2]

The concentration of oxygen inspired (FI_{O_2}) through an endotracheal tube may be raised above that in ambient air by providing oxygen to a T-piece adapter (see fig. 1). Further increases in FI_{O_2} are proportional to increased oxygen flow and to the length of an expiratory reservoir extension, based on the technique described by Ayre for administration of general anesthesia.[3] Adequate arterial oxygen tensions achieved using the adapter without the reservoir extension allow prediction of satisfactory tensions to be expected using face-mask oxygen following extubation.

The system is valveless and has minimal resistance to gas flow. The T-piece adapter is a modification of one designed by B. A. Briggs, M.D., in 1949. It is made of disposable plastic¶ and fits standard 15-mm anesthesia fittings and standard 20-mm plastic corrugated respirator tubing. The expiratory reservoir extension is made of similar tubing, the length of which determines the volume. Humidification of the oxygen is accomplished by conventional equipment.

The following observations illustrate use of the system:

1) Arterial oxygen tension (Pa_{O_2}) was measured in each of 13 spontaneously breathing patients recovering from cardiac surgery. Oxygen at 10 l/min was delivered to the T-piece adapter connected to the endotracheal tube. Pa_{O_2} values were obtained before and 15 minutes after a reservoir extension (50 ml) was attached. Pa_{O_2} values increased in all cases, the extent being indicated by a mean rise of 44 per cent from 92 ± 26 to 132 ± 53 torr ($P < 0.001$). Pa_{CO_2} did not change significantly, 45.5 ± 5.6 to 45.0 ± 6.4 torr ($P < 0.5$).

2) FI_{O_2} and Pa_{O_2} were measured in one patient at oxygen flow rates of 10 and then 15 l/min with no reservoir extension. Measurements were repeated at 15-minute intervals after extensions representing volumes of 50, 100, and 200 ml were attached. FI_{O_2} was determined by means of a large needle placed in the endotracheal tube, through which inspired

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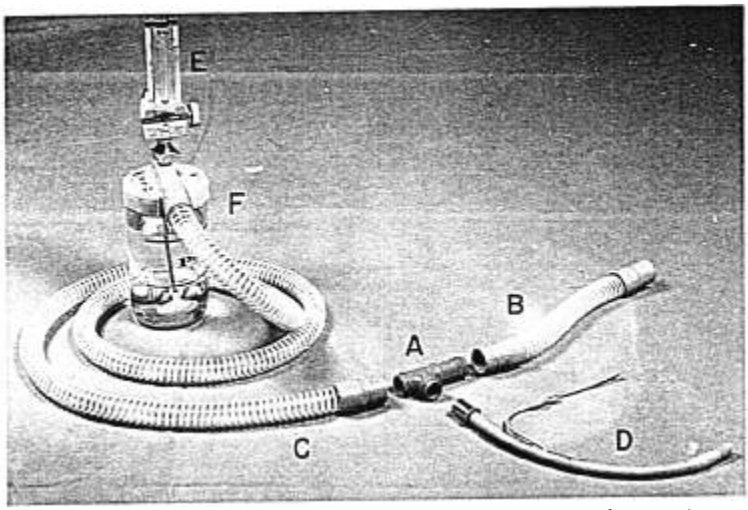

FIG. 1. Photograph illustrating the arrangement of the T-piece adapter used. An expiratory limb may be added to increase the inspired oxygen concentration. *A*, T-piece adapter; *B*, reservoir extension; *C*, oxygen delivery tube; *D*, endotracheal tube; *E*, oxygen flowmeter; *F*, humidifier.

gases were aspirated to a Beckman paramagnetic oxygen analyzer. Increases in $F_{I_{O_2}}$ and Pa_{O_2} were obtained both by increasing the oxygen flow rate and by lengthening the extension (see fig. 2).

3) Pa_{O_2} values in 46 postoperative patients before and 15 minutes after extubation were compared. Before extubation, each patient breathed spontaneously through an endotracheal tube and T-piece adapter without an extension, with oxygen delivered at 10 l/min. After extubation all patients breathed from disposable plastic face masks,** receiving oxygen at the same flow rate.

The mean Pa_{O_2} of the group increased from 204 ± 72 to 233 ± 85 mm Hg after extubation ($P < 0.01$). Eleven of the patients had Pa_{O_2} values below 150 mm Hg before extubation. Eight of these had improved arterial oxygenation following extubation, two had decreases of 4 mm Hg, and one had a decrease from 132 to 97 mm Hg.

DISCUSSION

The T-piece system was initially devised by Ayre in 1937 for the administration of anesthetic agents. The principles to prevent entrainment with air or expired carbon dioxide were elaborated further by Mapleson,[4] Woolmer and Lind,[5] Inkster,[6] and Davies, Verner and Bracken.[7] Rebreathing of expired gases will not occur if the delivered gas flow is more than twice the respiratory minute volume.[3] At the flow rates and with the reservoir volumes described, elevation of Pa_{CO_2} did not occur. However, since minute ventilation was not measured, the possibility of a compensatory increase in ventilation due to rebreathing, although unlikely, is not discounted. The concentration of oxygen inspired is dependent upon the patient's inspiratory flow rate and tidal volume, the oxygen flow rate, and the volume of the reservoir extension. Without a

** Mask 605, Blount Plastics, Inc., Santa Rosa, Calif.

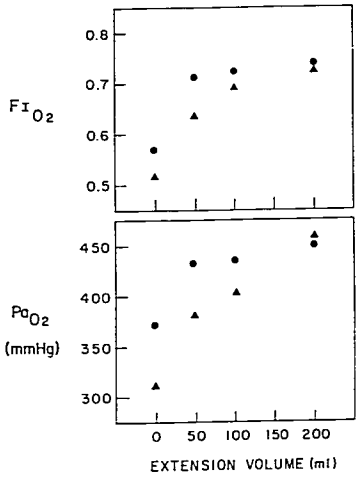

FIG. 2. Inspired oxygen concentration and arterial oxygen tension measured during spontaneous ventilation through an endotracheal tube and T-piece adapter and with reservoir extensions of 50, 100, and 200 ml. Dots = 15 l/min oxygen flow; triangles = 10 l/min oxygen flow.

reservoir extension an increase in inspiratory flow rate or tidal volume decreases $F_{I_{O_2}}$ by air entrainment. Elevation of $F_{I_{O_2}}$ is achieved by the addition of reservoir extensions and by increasing oxygen flow. As a corollary, hypoventilation then increases the inspired oxygen concentration.

This system has also proved useful in the evaluation and weaning of nonsurgical patients who have undergone long-term mechanical ventilation via tracheostomies.

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A New and Simple Method for Ventilating Patients Undergoing Bronchoscopy

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Techniques for assisting or controlling the ventilation of patients under general anesthesia for bronchoscopic examinations have varied widely over the years. Muendrich,[1] in 1953, introduced the ventilating bronchoscope, thereby utilizing various closed-system pressures for ventilation in the bronchoscope itself. Sanders,[2] in 1967, reported his technique, in which a needle was attached at the bronchoscope opening, through which oxygen under pressure was forced intermittently. This jet evoked the venturi effect so that the oxygen plus the entrapped room air provided the necessary pressures and volumes for ventilation. Spoerel,[3] in 1969, added to the Sanders attachment a Bird Mark II ventilator, which provided automatic ventilation. This report

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