Jet Ventilation for Tracheobronchial Suction

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In respirator-dependent patients, suctioning of the tracheobronchial tree induces a period of hypoxia.1-3 It can be minimized by using brief periods of suctioning with intermittent ventilation, but this can make adequate suctioning difficult. The technique of continued ventilation with suctioning through a side opening in the connector to the ventilator partially avoids this problem; however, the ensuing leakage as well as the volume of gas removed by suction will reduce ventilation in volume-controlled respirators. The technique of jet ventilation1-3 has been used to overcome this problem.

METHOD

Blunt steel needles, 16-, 18-, and 20-gauge, were attached to metal sleeves with an internal diameter of 15 mm; these could be readily fitted onto the standard connectors of endotracheal tubes or tracheostomy tubes (fig. 1). A Bird Mark II ventilator, attached to the oxygen pipeline, was used to interrupt the oxygen flow to the jet automatically. The flow control was turned fully open by removing a small arresting screw from the dial. Measurements of the inflation pressures were made on a model lung, using combinations of the three sizes of jets with endotracheal tubes and tracheostomy tubes ranging from 4 to 10 mm in internal diameter.

For tracheobronchial toilet, the patient’s ventilator was disconnected and immediately replaced by the jet as shown in figure 1. The rate and the duration of inflation were set beforehand to approximate the pattern of the patient’s own ventilator.

A comparison of the effects of suctioning over periods of 60 seconds with and without jet ventilation was made in a patient with irreversible brain damage, but with normal lungs, who was ventilated with room air by an Engström ventilator.

RESULTS

From the data obtained with a model lung (fig. 2), it can be seen that with each jet the inflation pressure increases as the diameter of the endotracheal tube or tracheostomy tube is reduced: the larger the jet, the higher the inflation pressure. There was only a negligible difference between the inflation pressures obtained with an endotracheal tube and a tracheostomy tube of the same internal diameter.

In the patient whose tracheobronchial tree was suctioned for 60 seconds without assisted ventilation (fig. 3) a marked reduction in $P_{a_{al}}$ to 45 torr occurred, whereas in the same patient suctioning during jet ventilation (using compressed air) produced no change in $P_{a_{al}}$; a reduction in $P_{a_{al}}$ indicated a greater volume of ventilation than the patient had received on the ventilator.

DISCUSSION

The jet injector is a constant-pressure generator. The positive pressure generated depends on the volume of flow emerging from the jet and the diameter of the tube or diffusor
FIG. 2. Relationship between endotracheal or tracheostomy tube size (mm ID) and the inflation pressure obtained in a model lung using a Bird Mark II ventilator, an oxygen pipeline (60 psi) and 16-, 18-, and 20-gauge cannulas as jets.

into which the jet is blowing. Since the pipeline pressure is constant and the flow control on the Bird Mark II ventilator turned fully open, the inflation pressure will depend on the gauge of the needle used as a jet and the internal diameter of the endotracheal or tracheostomy tube.

From the graphs obtained with the model lung, it can be seen that an 18-gauge needle as a jet will provide adequate inflation pressures for the most commonly used tubes (internal diameters 7 to 10 mm) in patients who have normal lungs. When higher inflation pressures are needed for patients who have low compliance, a 16-gauge needle may be chosen as a jet. A 20-gauge needle would seem suitable for tube sizes in the pediatric range, i.e., with internal diameters of 4 to 6 mm.

Jet ventilation allows continuous, thorough suctioning without any time limits; this is
particularly useful when suctioning is combined with the instillation of small volumes of saline solution to loosen thick secretions. The jet will compensate for the volume of gas removed by suction. With the Bird Mark II ventilator driven by compressed oxygen and with unimpeded air entrainment, the inspired oxygen concentration should be about 70 percent. The introduction of the suction catheter does not interfere with ventilation; in the model it could be demonstrated that the reduction of the lumen of the tube by an inserted catheter usually produced a slight increase in inflation pressure.

We have been routinely using jet ventilation as outlined here in the intensive care unit in all respirator-dependent patients for the past two years and have found it to be very helpful in the management of these patients. Particularly in the presence of widespread pulmonary disease, when high inflation pressures are needed for adequate ventilation and even a very brief interruption of ventilation may induce severe hypoxia, this technique has proved valuable and has allowed adequate tracheobronchial toilet without haste. For safe use of jet ventilation it is important that the tracheostomy or endotracheal tube always remain open; this allows the pressure gradient induced by the jet to establish itself and excess oxygen to escape during inflation.

REFERENCES
1. Taylor PA, Waters HR: Arterial oxygen tensions following endotracheal suction on IPPV. Anaesthesia 26:289–293, 1971