A new venturi attachment for the Cape ventilator, to facilitate control of $F\mathrm{I}_{\mathrm{O}_2}$

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http://www.nickalls.org/dick/papers/anes/venturi1984.pdf

The Cape ventilator (Penlon Ltd) still remains one of the most widely used ventilators in intensive therapy units (ITU). However, when low fractional inspired oxygen concentrations ($F\mathrm{I}_{\mathrm{O}_2}$) are prescribed, particularly when associated with low minute volumes ($\dot{V}$), the required supplemental oxygen flow is small. Flows less than 2 litres/min are not uncommon. For example; an $F\mathrm{I}_{\mathrm{O}_2}$ of 0·35 and a $\dot{V}$ of 8 litres/min requires an oxygen flow of only 1·4 litres/min. Such low flows cannot be delivered accurately with the commonly available Medishield wall flowmeters, which incidentally, are calibrated at only 350 kPa, and under-read when used at the normal hospital pipeline pressure of 400 kPa (BOC personal communication). Furthermore, when calculating the $F\mathrm{I}_{\mathrm{O}_2}$ from estimates of the tidal volume (VT), frequency (f), and oxygen flow, the errors are such that only a very rough estimate can be made. $F\mathrm{I}_{\mathrm{O}_2}$ should always be measured directly (and preferably be monitored continuously) but oxygen analysers are still not available everywhere.

We have devised a simple venturi attachment, easily made from components available in ITU, which facilitates prescription of the $F\mathrm{I}_{\mathrm{O}_2}$. The attachment (Fig. 1) is made from an empty 1 litre Polyfusor infusion bottle (The Boots Company, PLC), the T-piece connector from a Magill rebreathing system, and the variable venturi supplied with the Hudson 'multivent' oxygen mask (Henleys Medical Supplies Ltd). The 'giving-set' end of the infusion bottle is cut off, leaving a hole the same diameter as the infusion bottle. A hole is also made in the other end to fit the T-piece connector. The venturi is fitted to the remaining female arm of the T-piece; the air entrainment apertures must be well clear of the infusion bottle. The attachment replaces the oxygen reservoir bag in the front port of the ventilator.

The performances of five randomly selected venturis (each paired with a different Medishield flowmeter to maximise errors) were tested using a Cape ventilator set to deliver a minute volume much greater than would normally be used (VT 1500 ml, oxygen dilution; f 12·7 breaths/min). $F\mathrm{I}_{\mathrm{O}_2}$ was determined to the nearest 0·5% with a Servomex oxygen analyser for each venturi setting, both at the manufacturer's recommended oxygen flow, and 2 litres/min less than this. The results are shown in Fig. 2.

The slightly high $F\mathrm{I}_{\mathrm{O}_2}$ readings obtained using the 'recommended' oxygen flows are due to the added resistance offered to the venturi outflow at these higher flows by the T-piece connector and open ended reservoir, resulting in a decreased entrainment ratio at the venturi. We recommend therefore, that this attachment is used with an oxygen

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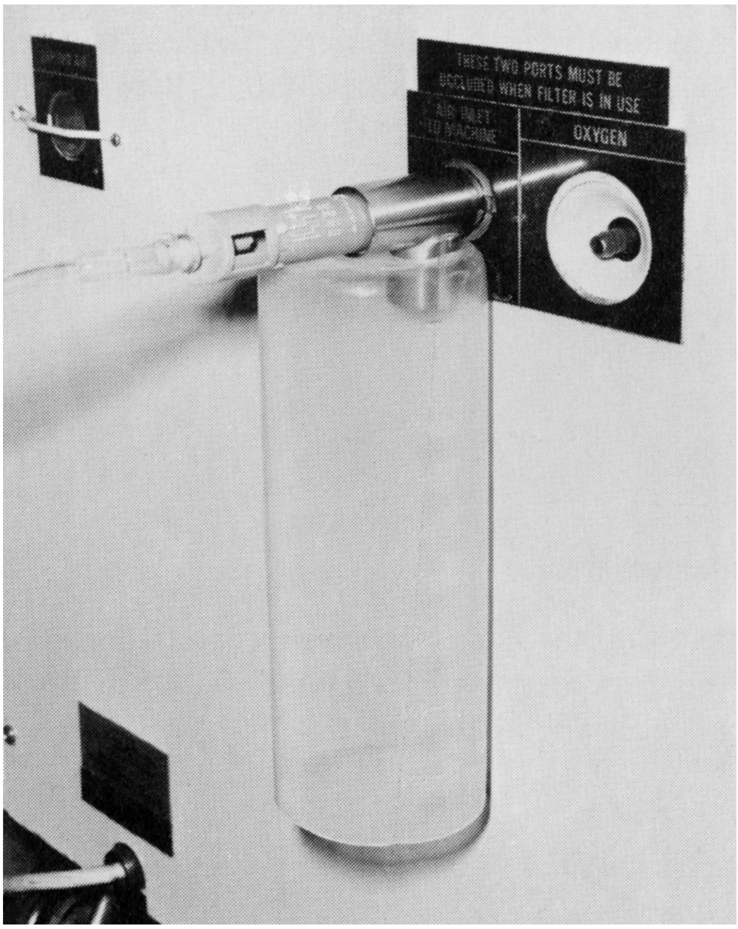

Figure 1:
The venturi attachment in the front port of the Cape ventilator

flow of 1 litre/min less than those specified on the venturi. The oxygen flow need then only be set to within 1 litre/min on the flowmeter.

This attachment facilitates changing the $F\mathrm{I}_{\mathrm{O}_2}$, as well as making the $F\mathrm{I}_{\mathrm{O}_2}$ relatively independent of the oxygen flow, tidal volume, and frequency, within the constraints indicated above. The attachment is particularly useful for patients requiring long-term ventilation with a relatively low $F\mathrm{I}_{\mathrm{O}_2}$ (e.g., Guillain-Barré syndrome), because it completely eliminates inadvertent and potentially harmful increases in the $F\mathrm{I}_{\mathrm{O}_2}$.

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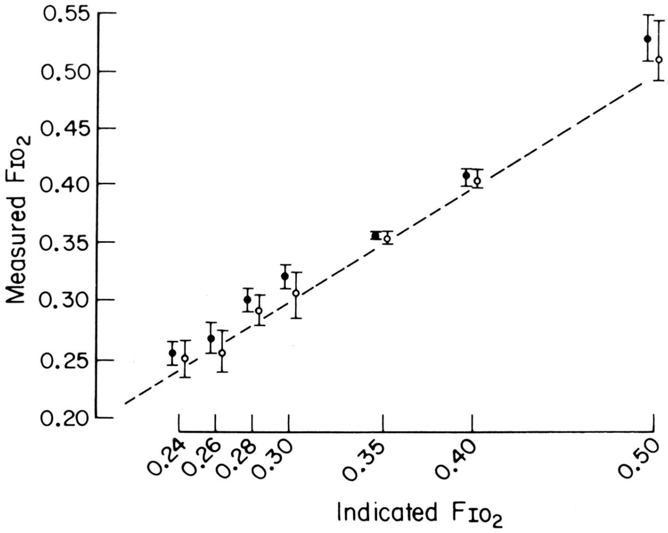

Figure 2:
Fractional oxygen concentrations measured in the inspiratory limb of the Cape ventilator, showing the mean (n=5) and range for each oxygen setting between 0·24 and 0·5. —•— $F\text{I}_{\text{O}_2}$ using the manufacturer's recommended oxygen flow for mask use; —○— 2 litre/min less than the recommended oxygen flow; line of equality.
