Clinical Workshop

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Reduction of Tracheal Damage by the Prestretching of Inflatable Cuffs

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With the accumulation of experience and improved facilities, artificial ventilation is being administered safely and effectively for progressively longer periods. When support is required for more than just a few days, tracheostomy is usually performed. Clinical evidence of tracheal obstruction develops in a small but significant proportion of the growing number of survivors.1,2

Following tracheostomy, obstruction can occur from either tracheomalacia or fibrotic stenosis. The stomal area occasionally is affected, but in patients who have received ventilatory assistance, the lesions typically develop 1.5 to 3 cm below the stoma opposite the inflatable cuff.2 Of the patients seen with tracheal obstruction at the Massachusetts General Hospital since 1962, 85 per cent were primarily affected in this region. Some degree of damage at this level is common when standard inflatable cuffs are used.3,4 The development of tracheomalacia or stenosis, however, represents a consequence of tissue repair when this damage has been severe. In a study by Cooper and Grillo of postmortem human trachea, macroscopic evidence of tissue trauma was noted consistently where a cuffed tube had been used for more than 48 hours. The extent of the lesion could be correlated with the duration of exposure, severe destruction of the cartilaginous rings being a prominent feature when the period of intubation exceeded three weeks.4 An identical spectrum of lesions was experimentally reproduced in dogs.5

Inflatable cuffs in common usage have low compliance. Inflation produces a tense, more or less spherical, balloon. When employed to provide an almost completely airtight seal, the intracuff pressure commonly exceeds 160 mm Hg. Distortion of the trachea by the rigidly inflated cuff is inevitable, and when exposure is prolonged, local tissue necrosis frequently develops. By using low-pressure pliable cuffs, serious damage to the trachea can be avoided. Because these cuffs are soft, they do not distort the trachea, but conform to its shape.6 Pressure necrosis is, therefore, absent or minimal.7 Latex rubber cuffs with these properties are being tested clinically, but are not yet commercially available. It is, however, possible to achieve similar pressure-volume characteristics with the currently available plastic (polyvinyl chloride) cuffs by stretching them prior to use (figure 1). Following prestretching, large volumes of air are accepted with comparatively minor increases in balloon tension, and airtight seals can be achieved at low intracuff pressures.

In figure 2, the pressure-volume characteristics of standard and prestretched cuffs in four patients are compared. At an airway pressure of 30 cm H2O, the standard cuffs provided airtight seals at intracuff pressures of 270, mm Hg, 280 mm Hg, 358 mm Hg...
and 310 mm Hg. Using prestretched cuffs, the same endpoint was reached at intracuff pressures of 30 mm Hg, 32 mm Hg, 32 mm Hg, and 82 mm Hg, respectively. That this is not the ideal solution is illustrated by the results in the last patient: stretching was inadequate and the final intracuff pressure remained relatively high. In all four patients, however, balloon tensions were reduced considerably.

Prestretching has been practiced in the Respiratory Unit of the Massachusetts General Hospital since 1967. Minor difficulty with insertion of the tube has been encountered occasionally, but can be avoided if care is taken to first deflate the cuff. Following insertion enough air to just provide air-tight seal is injected; in more than 200 patients, there has been no case of respiratory obstruction from cuff herniation, nor any other untoward effects. Since the introduction of this maneuver no patient admitted to the Respiratory Unit has developed respiratory obstruction following decannulation.

METHOD

Prior to insertion and under sterile conditions, the plastic tracheostomy tube is placed in water at 90 to 95° C. The cuff is then gently inflated with 20 to 30 ml of air, the volume depending on tube size. After ten minutes, the tube is removed and allowed to cool with the cuff still inflated. A permanently stretched cuff, which can often accept

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**Fig. 1.** Two plastic tracheostomy tubes. The cuff on the left has been prestretched.

**Fig. 2.** Pressure-volume characteristics of standard and prestretched plastic cuffs in situ in four patients. The bracketed figures represent the volume of air (corrected for pressure) required to provide an air-tight seal.

up to 5 ml of air before any rise in intracuff pressure occurs, is produced.

REFERENCES


