Prevention of subglottic stenosis

I. A. LAING., M.R.C.P., D. L. COWAN, F.R.C.S. and R. HUME, Ph.D., F.R.C.P. (Edinburgh)

Introduction

Mechanical ventilation is now widely used in neonatal intensive care. Methods and materials for endotracheal intubation vary between intensive care units. Up to eight per cent of ventilated infants may have subglottic stenosis after discharge from hospital (Jones *et al.*, 1981).

Review

The orotracheal route of intubation is simpler and quicker and may be most appropriate for acute resuscitation of the collapsed infant. With a high turnover of medical staff, a newborn intensive care unit may therefore prefer to train doctors to use the orotracheal route as the sole method of maintaining the airway during mechanical ventilation. One study showed that after cessation of mechanical ventilation, infants chosen at random to be exclusively orotracheally intubated had a lower incidence of post-extubation atelectasis (Spitzer and Fox, 1982) than those who were ventilated by the nasotracheal route. However, fixation of the orotracheal tube has been complicated by cheek and tongue movements causing tube displacement and oral salivation which dampens restraining tapes. Nevertheless a recent randomised study comparing the orotracheal and nasotracheal routes showed no significant differences in occurrence of tube malposition, retaping, local infection, pneumonia, atelectasis and post-extubation stridor (McMillan *et al.*, 1986). The present authors have described a method of orotracheal fixation (figure 1) which overcomes these disadvantages (Laing *et al.*, 1986). The endotracheal tube is fixed both to a sponge platform on the forehead and to a plastic flange taped to the chin. In our study of 500 ventilated infants no evidence of subglottic stenosis was identified in any of the 287 survivors nor in the infants (almost 200) who died and had post-mortem examination.

Long-term stabilization of a nasotracheal tube is simple and may be accomplished by fixing the tube with zinc oxide tape and tincture of benzoin. Tracheal stenosis and clinical stridor were not identified by Stewart, *et al.*, (1978) after nasotracheal intubation of 94 infants. Ratner and Whitfield, (1983) described a three year period of nasotracheal intubations in which no infants had subglottic stenosis, followed by a three-year period in which eight patients, all with birth weight of less than 1500 g, developed subglottic stenosis after orotracheal intubation; seven required tracheostomy and three died. If instability of an orotracheal tube were to cause frictional trauma at the subglottic region then perhaps Ratner's study has a ready explanation. However, intubation of a preterm cadaver both orally and nasally has shown increased tube movement on X-ray during flexion, rotation and especially extension when the nasotracheal tube has been used (Donn and Blane, 1985). Furthermore a study, in addition to our own, records a zero per cent incidence of subglottic stenosis in orotracheally intubated patients (Conner and Maisels 1977). Additional worries regarding the nasotracheal tube have centred round nasal septal necrosis, and ignorance of what happens to cerebral blood flow in the preterm neonate during a variably traumatic (and occasionally delayed) insertion of a tube through the nasopharynx to the trachea. Hypoxaemia, increased

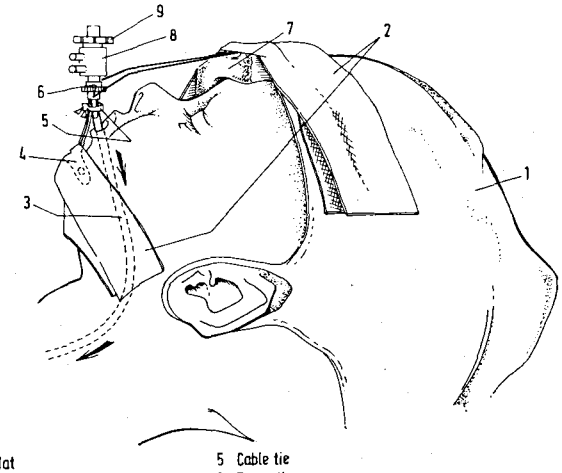

FIG. 1

Stockinette hat (1) with straps tied under the chin, made in the Unit from tubular gauze. Endotracheal tube holder (4) by Portex Ltd., Hythe. Cable tie (5) 32 mm, by R. S. Components Ltd., London, loops round the tongue of the tube-holder (4), the endotracheal tube (3) and the narrow tubular component of the Tunstall (6). Tunstall connection (6) by Penlon Oxford: supplied in a range 2.5-4.0 mm, the appropriate size being 0.5 mm greater than the endotracheal tube size. Jack (8) and plug (9) by 3M Service Centre, Chertsey, fixed directly to Tunstall, ventilator inflow, outflow and pressure monitor lines. Elastoplast (2), sponge (7).

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Department of Child Life and Health, University of Edinburgh, and Department of Otolaryngology, Royal Hospital for Sick Children, Edinburgh.

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TABLE I
GENERAL RECOMMENDATIONS OF ENDOTRACHEAL TUBE SIZE ACCORDING TO INFANT WEIGHT

Weight (kg)	Diameter (mm) Inner	Outer
<1.5	2.0	3.5
1.5–2.5	2.5	4.0
2.5–3.5	3.0	4.5
3.5–4.5	3.5	5.0

arterial pressure and increased intracranial pressure may occur (Raju *et al.*, 1980) and these changes may be harmful to the infant (Volpe, 1981).

Selection of the size of endotracheal tube for an infant is also controversial. There is concern that, with the use of a narrow bore lumen, resistance to flow is high (by Poiseuille's equation), and ventilatory pressure monitored at the airway opening may be very different from the pressure at the alveolus. Furthermore with the increased air leak of a narrow bore tube the system's compliance changes (Perez Fontan *et al.*, 1985). Nevertheless in a prospective study of newborns ventilated for seven days or more, Sherman considered that the increased size of endotracheal tube compared with gestational age was important in the causation of subglottic stenosis (Sherman *et al.*, 1986). He recommended that the ratio of tube size to gestational age should be less than 0.1. In our study (McMillan *et al.*, 1986) endotracheal tube size was determined according to weight of the infant (Table I) but with a narrower tube being used if post-extubation stridor necessitated reintubation. A wider bore tube was also employed if clinical, radiological and blood gas parameters suggested that lung ventilation was inadequate.

The shoulder of some endotracheal tubes was designed to prevent the tube being inserted too far into the trachea, thus cannulating the right main bronchus and causing inadequate ventilation and probable atelectasis of the left lung. Even with the shoulder tube this can still occur, and the wider external diameter for the supraglottic area could cause damage in the subglottic region if inserted too far. Hawkins (1987) considers trauma to be an important predisposing cause of subglottic stenosis, with ulceration leading to circumferential fibrous scarring. The problem with tube position is circumvented by a fibre-optic light source at the tube tip (Heller and Cotton, 1985), or by direct observation of a coloured 1 cm tube tip disappearing partially below the vocal cords. In our own study Laing *et al.*, (1986), a special modified shoulder was made by Portex which proved atraumatic to the neonatal trachea and did not result in identified subglottic stenosis in the 500 ventilated infants born during the six-year period 1978-1983.

The number of endotracheal tubes used has also been quoted as a risk factor for acquired subglottic stenosis (Sherman *et al.*, 1986). Our method of orotracheal fixation resulted in a frequency of accidental extubation once per 256 ventilated days and occurred on only 13 occasions in the six years of the study. Endotracheal tubes were replaced on a further 55 occasions usually for blockage with bronchial secretions. Reducing these interventions to a minimum may contribute to decreasing trauma to the subglottic region.

Length of time of intubation has been considered important. Dankle *et al.*, (1986) in a retrospective analysis of 343 survivors of mechanical ventilation identified five children with subglottic stenosis. They had an average duration of intubation of 56.2 days. Sherman *et al.*, (1986) quotes infants ventilated for greater than 25 days as being an at risk population. In the Edinburgh study (Laing *et al.*, 1986), the range of time of intubation was 1-123 days and no subglottic stenosis was identified. Subsequent to our study however, 326 further infants have been ventilated (1984-1986) and three have presented in early childhood with acute respiratory distress unmasking subglottic stenosis. At first sight the three children were unlikely candidates for developing stenotic lesions. Table II shows that these infants were ventilated for only five, four and three days respectively. It was remarkable that all three had post-extubation stridor immediately the endotracheal tube was removed. Two required to be reintubated with a size 2.0 mm tube and both were successfully re-extubated within four days. One of these infants had had intercostal recession (while on continuous positive airway pressure) even when clinical, radiological and arterial blood gas parameters suggested that lung pathology had resolved. The possibility of individual susceptibility to subglottic stenosis therefore remains. One infant was a black Nigerian and this population is known to be predisposed to keloid formation. Our predominantly Caucasian population in Edinburgh may account in part for the very low incidence of neonatal subglottic stenosis we have achieved in the last nine years.

Summary

Acquired subglottic stenosis has not yet been shown to be entirely preventable. Some infants, especially the black population, may be particularly susceptible to the condition. Both nasotracheal and orotracheal methods of intubation have advantages and disadvantages. A method of fixation of orotracheal tubes has been developed in Edinburgh which has resulted in a low occurrence of subglottic stenosis. Small tube diameters and minimising the numbers of tube changes may also contribute to a reduction in the narrowing of the upper airway.

TABLE II
CHARACTERISTICS OF THE THREE INFANTS WITH SUBGLOTTIC STENOSIS

Infant	Gestation at birth (weeks)	Birth weight (g)	Duration of ventilation (days)	Inner diameter of tube (mm)
1	29	1200	5	2.0
2	31	1690	4	2.5
3	34	2000	3	2.5

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Laing Discussion

Dinwiddie

One of the problems I have seen in prolonged oral endotracheal intubation is marked grooving of the palate and an increased sucking reflex. Have you seen this as a problem and do you think it is important in terms of speech development?

Laing

Yes, it is important. With our method, if it is well put on, the endotracheal tube should go centrally down the mouth. If it is put on badly and the tube is dragged upwards it can cause both a gum and palate problem.

Dinwiddie

Are there also problems with dentition? Studies in animals have shown that with prolonged oral intubation, eruption and development of the central incisors can be inhibited later on.

Pearse

A fallacy of nasotracheal intubation is the idea that it is a rigid method of fixation. In all the techniques I have seen, after it has been there for a while the endotracheal tube will move up and down by a centimetre or so.

Laing

With nasotracheal fixation secretions still remain a problem. After nasal toilet it is quite difficult to hold the tube steady when retaping and know that it is exactly at the right point.

Pearse

The depth of the tip of the tube can be assessed very accurately by palpation. If the tip of the tube can be felt in the sternoclavicular notch, then the tube is correctly sited if the head is in the neutral position. Assessment by X-ray is not as accurate unless the position of the head is standardized for all X-rays. There is a difference in position of at least 1.5 cm in the tip of the tube between full extension and full flexion of the head.

Dinwiddie

As the baby develops a sucking reflex it starts to suck on the tube and the palate moulds around the tube. You know which babies have been in neonatal units and had oral intubation because they have rather a high palate.

Cinnamond

With nasal intubation the tube actually crosses the atlanto-occipital joint, whereas with oral intubation it does not and so head flexion is likely to result in less movement of the tube.

Laing

As the child swallows the larynx actually moves up and down, so even with perfect rigidity of the tube you still get movement there as long as the child is not paralysed. It is impossible to eliminate movement altogether.

Ramsden

Our impression concerning oral tubes is that the really crucial point in using a shoulder tube is whether or not that shoulder is ever pushed through into the glottis. Without exception in the cases at UCH in recent years with subglottic narrowing this has always been so.

Shaw

I suspect that the reduction in incidence at UCH followed the wide promulgation of the ruling that the tip of the tube should not be below the clavicles. It has been implied that the tube can be somewhere between the carina and the cords, but actually the tip of the shoulder tube must never be below the clavicles. The person who intubates must be quite sure that the tube is where he wants it to be by the time it is fixed. Ramming the shoulder into the cricoid very rapidly causes ischaemic necrosis of the cartilage.

Cinnamond

Lack of knowhow and back-up may make it difficult to use some of these techniques and perhaps we, as a body, should be looking more towards something very simple which everyone can emulate to produce a standard result.

Laing

Is it possible that the whole *raison d'être* of the shoulder has been negated by the very simple method of having the last centimetre of the endotracheal tube painted a different colour? As you put the tube through you could actually see, say, a centimetre of black disappearing and if you could just see a millimetre of it at the end of the procedure and fixate at that position, then there would be no need to have a shoulder there at all.

Shaw

If you are careful about how you position the tube it probably does not matter. In inexperienced hands it is quite easy for the shoulder to get pushed through the cords and until that stops we will continue to get subglottic stenosis.

Dinwiddie

It is not the purpose of the shoulder in the first place to position the tube correctly? Why not use a non-shoulder tube and just take an X-ray to ensure it is in the right position?

The shoulder need not necessarily be at the point of the cords. It could be another centimetre higher which would avoid your subglottic trauma, but still give you the reduced airways resistance.

Facer

The resistance in the shouldered tubes has been measured by Hatch (1978) and the resistance is no lower in shouldered tubes than a tube of the diameter of the tip.

Laing

Is that because of turbulence at the point of narrowing?

Facer

It is because of the change in diameter. Where the diameter changes (at the shoulder) you get turbulence and therefore increased resistance, so it is a fallacy to say by using a shouldered tube you are decreasing the resistance.

Gould

I agree with Professor Cinnamond that each unit, perhaps, may have their own particular problem which they have to focus on, and it is when they are actually focussing on the problem and thinking about it that subglottic stenosis is prevented.

Cinnamond

There seems no doubt that there are very many factors involved. As the numbers tend to be fairly small in each individual unit, there seems to be a need for a multicentre approach with very accurate recording of length of time, type of tube used and all the other factors taken into account.

Kearns

An important point is who is responsible for intubation in each centre?

Cinnamond

Another very important factor is the size of the tube used. One of the criteria used in Belfast to judge whether the tube is too big or not is to listen for an air leak around it. The intensive care anaesthetists are quite obsessed by the need to ensure that there is a continual air leak around the tube. What do other people think about this?

Dinwiddie

We check every day for a leak and if the leak disappears we start to get anxious. A survey in the neonatal unit showed that the vast majority of babies ventilated did actually have a leak around their tubes, even though people were not as obsessive about checking it and I suspect this is important in preventing subglottic stenosis.

Pearse

You also notice that on day one you can only get a tube size 2 or 2.5 down but by day three you can get a size 3 down.

Facer

Is that not an indication that the shoulder has gone through into the larynx?

Pearse

No, we never use shoulder tubes.

Graham

The most interesting suggestion to come out of this is that there should be some kind of communication between neonatal units to see how their practices compare.

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