A TECHNIQUE OF PULMONARY VENTILATION WITH A NASOTRACHEAL TUBE

BY
G. JACKSON REES AND J. B. OWEN-THOMAS*

Intensive Therapy Unit, Alder Hey Children's Hospital, Liverpool, England

SUMMARY
A modified naso-endotracheal tube is described which facilitates prolonged intermittent positive pressure ventilation of the lungs in infants and children. A crosspiece allows connection with the inspiratory and expiratory tubes of a circle-type mechanical ventilator. The technique of intubation and of securing the nasal tube to the patient is described in detail. The tube has been used in 126 patients for periods of up to three months. Subglottic stenosis developed in two patients. It is provisionally recommended that the duration of intubation should not exceed three weeks.

The use of polyvinyl chloride material in the manufacture of endotracheal tubes (Brandstater, 1962) has enabled intermittent positive pressure ventilation of infants and children to be maintained during prolonged nasal intubation (Allen, 1965), as an alternative to management by tracheostomy (McDonald and Stocks, 1965).

This communication describes a modified nasotracheal tube, devised to facilitate the management of infants and children undergoing mechanical ventilation.

DESCRIPTION OF NASOTRACHEAL TUBE
The nasal tube is manufactured from polyvinyl chloride and consists of four limbs (fig. 1) meeting with their lumina in communication at the centre of a crosspiece; this connects to the inspiratory and expiratory tubes of the ventilator. Above the crosspiece is a short tube carrying a spigot which is removed before endotracheal suction, after which it is replaced. Below the crosspiece is that part of the tube which passes nasally into the trachea. The crosspiece enables the inspiratory and expiratory tubes of a circle-type ventilator to be attached to the nasal tube without narrowing the patient's airway by an internal connector, thus bringing the deadspace of connecting tubes to the end of the patient's nose. The deadspace, therefore, is little greater than that of a tracheostomy connected to a ventilator in the orthodox fashion.

When in position the nasal tube assumes body temperature and becomes malleable, taking up the configuration of the nasal cavity and larynx.

TECHNIQUE OF INTUBATION
The procedure of nasotracheal intubation and the technique of securing the tube must be carried...
out carefully. Oral intubation is performed under general anaesthesia and an assistant maintains manual pulmonary ventilation (fig. 2). The diameter of oral tube that the larynx will admit indicates the size of nasal tube which will be required. The diameter of the nasal tube should be 0.5 mm less than that of the tube used during oral intubation so as to allow a leak of humidified gases between the external wall of the nasal tube and the mucosal surface of the trachea with the object of limiting damage to mucous membrane. The appropriate length for a nasal tube is based on measurements shown in table I (Bush, personal communication, 1964).

<table>
<thead>
<tr>
<th>Age</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 months</td>
<td>11.8</td>
</tr>
<tr>
<td>4-7</td>
<td>12.6</td>
</tr>
<tr>
<td>8-11</td>
<td>13.6</td>
</tr>
<tr>
<td>1 year</td>
<td>14.5</td>
</tr>
<tr>
<td>2 years</td>
<td>15.2</td>
</tr>
<tr>
<td>3</td>
<td>15.6</td>
</tr>
<tr>
<td>4</td>
<td>16.5</td>
</tr>
<tr>
<td>5</td>
<td>16.8</td>
</tr>
<tr>
<td>6</td>
<td>17.1</td>
</tr>
<tr>
<td>7</td>
<td>17.8</td>
</tr>
<tr>
<td>8</td>
<td>18.3</td>
</tr>
<tr>
<td>9</td>
<td>18.8</td>
</tr>
<tr>
<td>10</td>
<td>19.1</td>
</tr>
<tr>
<td>11</td>
<td>19.1</td>
</tr>
</tbody>
</table>

Having selected the nasal tube, Magill connections are placed in the inspiratory and expiratory limbs of the crosspiece and angulated in the plane of the suction limb (fig. 3) so that upward pressure cannot occur either on the nasal septum or alae nasi. Ulceration of both these structures will occur if this precaution is neglected. Both nostrils are cleansed with sterile swabs and a pernasal suction catheter is used to remove mucus from the post-nasal space. This manoeuvre also serves to assess the patency of the choanae. The nasal tube is lubricated with water-soluble jelly and is passed nasally into the pharynx and visualized by direct laryngoscopy (fig. 4). At the last moment the oral tube is withdrawn and the bevelled tip of the nasal tube is grasped by Magill forceps and gently passed between the vocal cords (fig. 5). The lungs are now ventilated through the nasal tube by connecting the Ayre T-piece to a third Magill connector in the suction orifice of the tube (fig. 6).

**Head harness.**

In order to secure the inspiratory and expiratory limbs of the nasal tube to the infant’s head, a harness is required. This prevents dislodgement of the nasal tube from the larynx and the development of pressure sores on the head from the ventilator tubing.

The harness is constructed by taking two lengths of 2-inch (5-cm) wide elastic adhesive bandage, one being long enough to encircle the head with some overlap of the two ends and the other being rather shorter. The adhesive surfaces of the two strips are applied together in such a way that the shorter piece lies in the middle of the longer piece, leaving two sticky ends exposed. This is now passed round the head below the occiput and the uncovered adhesive parts of longer length are applied to the forehead. In this way a firm fixation of the head harness is created but no adhesive material applied above the hair line (fig. 2).

From a foam plastic sheet 1 inch (2.5 cm) thick a rectangle is cut which is as wide as the elastic adhesive bandage and long enough to place over the bandage on the anterior part of the skull. Two grooves are cut in the foam sheet in the appropriate places to carry the tubes of the ventilator leading to the two ends of the crosspiece (figs. 7 and 8). These grooves must not be too deep. Besides securing the tubing they also protect the head from the pressure of the expiratory and inspiratory limbs carrying warm humidified gases to and from the patient. A further layer of elastic adhesive bandage encircles both foam sheet and tubing (fig. 9).

Rigidity is conferred on the head harness by a “figure of eight” arrangement of bias binding tape taken through the head harness by a cutting needle, and secured to the crosspiece by nylon thread (fig. 10). A nylon stitch encircles the inspiratory and expiratory limbs of the crosspiece, preventing any movement of tubing on the head (fig. 11). A chin strap padded with foam rubber is constructed from two lengths of elastic adhesive bandage and secured as shown (fig. 12). This ensures that the nose is not subjected to upward pressure by the crosspiece. Sufficient room is
Fig. 2
Application of head harness, with no adhesive material in contact with skin. An assistant is maintaining pulmonary ventilation.

Fig. 3
Magill connections in inspiratory and expiratory limbs of crosspiece angulated in the plane of suction limb of nasal tube. Note clamps on ventilator tubing to allow ventilation of lungs, by T-piece via suction limb of nasal tube.

Fig. 4
Nasal tube visualized in the pharynx by direct laryngoscopy. Ventilation of lungs by oral tube.

Fig. 5
Oral tube withdrawn. The nasal tube tip is passed between the vocal cords by Magill forceps.

Fig. 6
Ventilation of the lungs through the suction limb of the nasal tube. Note the cross clamps on the ventilator tubing.

Fig. 7
Parallel lines drawn on the foam plastic sheet indicating the site of grooves to carry ventilator tubing.
FIG. 8
Ventilator tubes lying in grooves cut in foam plastic sheet.

FIG. 9
Layer of elastic adhesive bandage encircling plastic foam and ventilator tubing. Note ½ inch of tube protruding from patient's two nostrils to prevent pressure sores by the crosspiece on the nose.

FIG. 10
"Figure of eight" arrangement of bias binding tapes giving rigidity to nasal tube, Magill connections and head harness.

FIG. 11
Bias binding tape secured to crosspiece by encircling nylon thread. Ventilator tubing secured with encircling nylon thread. Note the spigot in the suction limb. Inspiratory and expiratory limbs are connected to the mechanical ventilator.

FIG. 12
Construction of chin strap from two lengths of elastic adhesive bandage padded at the chin by plastic foam sheet.

FIG. 13
Completed head harness, nasal tube and chin strap in position.
allowed between the upper lip and crospiece of the nasal tube to enable the alae nasae and nasal septum to be cleaned. Cleansing of the patient's ears is carried out by gently lifting the appropriate layer of bandage.

Both inspiratory and expiratory tubes are connected to the ventilator, which is set in motion, and a sterile spigot is placed firmly in the suction limb of the crospiece (fig. 13).

Procedure for suction.

Endotracheal suction is performed only when secretions are thought to be troublesome. A progressive rise beyond 25 cm H₂O in inspiratory pressure on the ventilator dial, in association with poor movements of the chest wall, are signs of partial blockage of the nasal tube lumen. Usually this results from dried secretions at the terminal 2 or 3 cm, and is an indication of failure of humidification. The onset of this obstruction is silent and early detection is dependent on the nurse's awareness that it can occur. The obstruction in the tube can be relieved by instillation of 2-4 ml of sterile saline 0.9 per cent. This solution is trickled down a suction catheter placed in the suction limb of the nasal tube. A negative pressure of 15-20 mm Hg is then applied to the suction catheter. Failure of three attempts to clear the lumen of the nasal tracheal tube in this way calls for extubation and re-intubation with the appropriate size oral endotracheal tube. Ventilation of the lung may then be carried out by hand, using a T-piece circuit, thus relieving the emergency.

Persistent noisy moist sounds in association with prolonged expiration are also indications for endotracheal aspiration. Before endotracheal suction is performed the mechanical ventilation is discontinued and the inspiratory and expiratory tubes are clamped a short distance from the patient's head. Ventilation is then carried out using 100 per cent oxygen by the suction limb circuit (fig. 10), one nurse being responsible for the ventilation of the patient by hand, whilst the other nurse performs endotracheal suction. As a guide to the duration of suction, nurses are asked to exhale and hold their breath at the commencement of suction of the patient. The procedure of suction, and recommencement of intermittent positive pressure ventilation by ventilator should be over well before the nurse feels any discomfort from voluntary breath holding. In patients under the age of 6 months sterile plastic feeding catheters are used for suction, and in older children the appropriate size of angulated catheter with a single terminal hole is used (Bush, 1963).

In order to re-expand areas of lung that might be collapsed as a result of suction, ventilation by hand follows endotracheal suction (Rees, 1958). A sterile spigot is placed in the suction limb of the crospiece, the clamps are removed from the ventilator tubing, and mechanical ventilation is recommenced.

Return to spontaneous ventilation.

Improvement in the patient, indicating that there is no longer a need for passive ventilation, allows the patient to resume spontaneous ventilation. Drugs used to aid the control of ventilation during passive ventilation are withheld before commencing weaning. Diminished quantities of endotracheal secretions, a normal pulse and temperature, together with the ability to maintain satisfactory skin colour during mechanical ventilation with air, are indications that spontaneous ventilation can be resumed. Clinical and radiological resolution of abnormal physical signs in the respiratory system, and a capillary blood carbon dioxide tension below 40 mm Hg during mechanical ventilation are also indications that spontaneous ventilation will be adequate.

Humidified air at a flow rate at least three times the required minute volume is led to the patient through the inspiratory limb. The expiratory limb leading to the ventilator is shortened to 6 inches (15 cm) from the crospiece of the nasal tube, the head harness remaining in position. In this way rebreathing of expired air is minimized and kinking of a long length of tube is prevented. The ventilator remains at the bedside with the settings for ventilation rate and tidal volume previously judged suitable for the patient. Should the need arise, mechanical ventilation can be recommenced without delay. Extubation is performed under general anaesthesia. This also allows an examination of the larynx and subglottic region. The patient is then nursed under close observation in a humidified atmosphere.
Complications.

Minor degrees of subglottic oedema occur immediately following extubation. This is manifest usually by stridor, tracheal tug and intercostal recession, and will respond to humidification and in some instances steroids. Subglottic membranes have been described following prolonged endotracheal intubation (Lu, Tamura and Koob, 1961). Stridor with tracheal tug, intercostal recession, and restlessness with a rising pulse rate, developing 12–24 hours after extubation may indicate the presence of such a membrane. If this is suspected facilities must be immediately available for performing laryngoscopy under general anaesthesia so that secretions or membrane can be removed from the cricoid region by suction or by use of Magill forceps.

Over the past two years prolonged nasal intubation in infants and children has been carried out in this hospital in 126 cases, some requiring mechanical ventilation and some for other reasons. The duration of intubation has varied from two days to three months. In only two cases have serious laryngeal complications occurred. One patient was intubated for eight weeks and the other for three months. Both patients showed a marked subglottic stenosis following extubation. In view of this finding it is considered that a limit should be set on the duration of intubation and that, until further experience is obtained, two to three weeks should be regarded as the maximum safe period for retaining a nasotracheal tube. Changing the nasal tube during this time is unnecessary because it will remain patent providing the inspired gases are adequately humidified.

Nursing staff have found that prolonged nasal intubation has eased the management of children undergoing mechanical ventilation, especially in premature babies and neonates in whom the hazards and difficulties of long-term management by tracheostomy are well known.

ACKNOWLEDGEMENT

The authors wish to thank Mr. Charles T. Fitz-Simon, Department of Child Health, Alder Hey Children's Hospital, Liverpool, for the photography.

REFERENCES


BRITISH JOURNAL OF ANAESTHESIA

TECHNIQUE DE LA VENTILATION PULMONAIRE PAR UNE SONDE NASO-TRACHEALE

SOMMAIRE

On décrit une sonde naso-endotrachéale modifiée qui facilite la ventilation prolongée des poumons en pression positive intermittente chez les nourrissons et les enfants. Une pièce en croix permet une connection avec les sondes inspiratoire et expiratoire d'un ventilateur mécanique d'un type circulaire. On décrit en détail la technique d'intubation et de maintien de la sonde nasale sur le malade. La sonde a été utilisée chez 126 malades pendant des périodes allant jusque 3 mois. Une sténose sous-glottique s'est développée chez 2 malades. On recommande provisoirement que la durée de l'intubation ne dépasse pas trois semaines.

VERFAHREN DER LUNGENVENTILATION MIT EINEM NASOTRACHEAL SCHLAUCH

ZUSAMMENFASSUNG


ACKNOWLEDGEMENT

The authors wish to thank Mr. Charles T. Fitz-Simon, Department of Child Health, Alder Hey Children's Hospital, Liverpool, for the photography.