Part II: Respiratory Failure

Chapter 21: Endotracheal Intubation and Tracheostomy

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The provision of an artificial airway by tracheal intubation is frequently required in Intensive Care, especially in patients with impaired laryngeal reflexes or who are in acute respiratory failure. Intubation of the trachea is possible with an orotracheal, nasotracheal or tracheostomy tube.

Endotracheal Intubation

The major indications for intubation in the Intensive Care Unit are:

1. To secure or maintain a clear airway.

2. To prevent aspiration of gastrointestinal tract contents.

3. To enable adequate tracheal suction.

4. To apply mechanical ventilatory support.

5. As a means for delivering high concentrations of oxygen.

Tracheal intubation is performed through either the oral or nasal route. There is division of opinion as to which is the better method. The main advantages of nasal intubation are:

1. A nasal tube is usually better tolerated by patients.

2. It is easier to intubate via the nasal route in the awake patient.

3. A nasal tube is easier to fix and secure to the patient.

4. Nasal intubation avoids tube occlusion or damage by the patient's teeth.

Unfortunately, nasal intubation has the disadvantage that smaller diameter tubes are required. Tracheal suctioning is thus more difficult, and there is an increased likelihood of tube occlusion. Airway resistance is also considerably greater in spontaneous breathing, and weaning off mechanical ventilatory support may be delayed. There is a further risk of causing damage to nasal passages and nose bleeds can be precipitated. Bacteraemia has also been shown to occur more frequently with nasal than with oral intubation.

The intensivist should be familiar with the various techniques of tracheal intubation. The procedure may be performed in the awake patient (with or without local analgesia and sedation) or after intravenous administration of an induction agent (ie, diazepam or thiopentone) and a muscle relaxant (usually suxamethonium). If respiratory obstruction is

present, muscle relaxants should be avoided. Preoxygenation with 100% oxygen for several minutes must be carried out prior to the procedure.

The Difficult Intubation

Difficulties with endotracheal intubation can be anticipated in patients with:

1. a short muscular neck with a full set of teeth;

2. a receding lower jaw;

3. a long, high curved palate;

4. limited neck and jaw movements (ie, as a result of osteoarthritis and trismus) and;

5. space occupying lesions in the pharynx and larynx.

When a difficult intubation is anticipated, awake intubation can be performed using a fibreoptic bronchoscope or a fibreopetic laryngoscope. Other methods such as "blind" intubation or retrograde catheter insertion should not longer be necessary. It must be stressed, however, that the intensivist must be familiar with the technique before attempting to use fibreoptic instruments for difficult intubations.

Endotracheal and Tracheostomy Tubes

Orotracheal, nasotracheal and tracheostomy tubes should be regarded as foreign bodies within the airway. Since they always cause microscopic lesions of the mucosa (and sometimes significant gross lesions), careful consideration should be given to the types of tubes used in Intensive Care.

Tube Material

Early red rubber tubes have no place in an Intensive Care Unit. Only tubes made of non-irritant, implant-tested materials should be used. Disposable, plastic polyvinyl chloride or silastic tubes are satisfactory. They are relatively kink resistant and offer better long-term tolerance.

Tube Shape

A conventionally shaped (curved) endotracheal tube will be deformed according to the airway anatomy and exert forces at the base of the tongue, posterior larynx, and anterior trachea. The deformation forces are less with new flexible tubes and those tubes which conform more anatomically to the airway.

Tube Size

With translaryngeal intubation, a tube with an outside diameter considerably less than the diameter of the cricoid ring should be used, in order to diminish the risk of laryngeal

damage (ie, subglottic stenosis). The tube sizes recommended for men should have external diameters less than 13 mm, with internal diameters of 8-9 mm; and for women, 11 mm and 7-8 mm respectively. The diameter of a tracheostomy tube should also be much less than the internal diameter of the trachea. Tube sizes for children are discussed in Chapter 10, Equipment for Paediatric Intensive Care.

Tube Cuff

The stiff cuffs of red rubber tubes and older plastic tubes require fairly high pressures to overcome their stretch pressures. Hence, when such a cuff is inflated to obtan an adequate seal, excessively high intracuff and cuff-to-tracheal wall pressure result. Tracheal damage from endotracheal tube cuffs (such as ulceration, dilation, and stenosis) is a well recognized problem. Theoretically, the cuff-to-tracheal wall pressure should be considerably less than the capillary perfusion pressure of 32 mmHg (4.3 kPa), so that mucosal microcirculation is not arrested (although an even distribution of cuff pressure against the tracheal wall is also important).

Various cuff designs have been introduced to reduce cuff-to-tracheal wall pressure, including intermittently inflating cuffs, double cuffs, foam (Kamen-Wilkinson) cuffs, and cuffs consisting of sets of annular walls. The thin-walled, high-volume, low-pressure ("floppy") cuff is by far the most successful and widely used, and is recommended for Intensive Care patients. With this cuff, intracuff pressure equals cuff-to-tracheal wall pressure, and when the former is kept below 30 cm water (3.0 kPa), mucosal circularion is not seriously affected. The McGuiniss pressure-limiting pilot balloon (Lanz, USA) is a safety device to prevent overinflation of a large-volume cuff. Nitrous oxide will diffuse into an air-filled cuff and increase intracuff pressure and volume, and this should be rememberewd when Intensive Care patients undergo prolonged surgery with gaseous anaesthesia.

Endotracheal Tube Adaptors

Standardization of respiratory therapy equipment is important so that all connectors are compatible. Adaptors must allow manual disconnection to enable tracheal suctioning to be carried out. The use of 15 and 22 mm coaxial connectors reduces compatibility problems.

Long-Term Intubation

In general, endotracheal intubation is limited to a period of about 2 weeks. A tracheostomy should be avoided unless the need for the artificial airway exceeds this length of time, although there is still some controversy regarding this period.

Although intubation itself has a number of complications, many of which are avoidable, prolonged intubation avoids the complications of tracheostomy. However, the main disadvantages of long-term intubation are:

1. The need for adequate patient sedation in order to tolerate the tube.
2. The possibility of accidental extubation or misplacement into a main bronchus.

3. Laryngeal damage, which can be very serious. This is rarely a problem if proper tubes are used, and the intubation period limited to 2 weeks. Laryngeal oedema may be a problem following extubation.

4. Tracheal stenosis - this is now a rare problem with the use of low-pressure cuffs.

Care of the Intubated Patient

The tube must be well secured with the adaptor and ventilator hoses adequately supprted. Tapes, if used to secure the tube, should not be tied too tightly. Care should be taken to avoid skin abrasion around the mouth or venous occlusion of the neck, especially if intracranial hypertension is present. The tube should be marked where it emerges from the mouth or nose to enable displacement to be quickly detected. Mouth care is important regardless of whether an oral or nasal tube is used. The cuff should be kept inflated at all times. Intermittent deflation of the cuff offers no advantages. When it is necessary to change or reposition a tube, it is worthwhile to check the intracuff pressure after inflation (with an aneroid manometer) to avoid overinflation beyond 30 cm water (3.0 kPa).

Tracheostomy

Tracheostomy should not be embarked on lightly, because of the considerable morbidity as well as an associated mortality of approximately 3%. Nonetheless, the relative safety of the actual tracheostomy operation in critically ill patients has been demonstrated. In some circumstances, a cricothyroid minitracheotomy may be considered rather than formal tracheostomy. In general, the indications for tracheostomy are:

1. The need for an artificial airway for longer than 2 weeks.

2. Prolonged absence of laryngeal reflexes or the ability to swallow (ie, after a cerebrovascular accident).

3. Considerable sputum retention. A tracheostomy may be needed for adequate tracheobronchial toilet.

4. Injuries to head and neck.

5. Upper airway obstruction. A tracheostomy is more commonly required in chronic obstructions above the trachea. An acute upper airway obstruction can nearly always be managed initially by endotracheal intubation. An elective tracheostomy may then be performed at leisure, if an indication arises.

6. Reduction of anatomical dead space was previously suggested as an advantage of tracheostomy but cannot be considered an indication.

Respiratory Failure

The operation of tracheostomy should in most instances be carried out in an operating theatre, with an endotracheal tube in situ. General anaesthesia is preferred but there are times

when local analgesia may be justified. The need for "crash" tracheostomy is almost non-existent in centres where good care is provided by competent staff.

The actual operation is important. If the incision is made too high, damage to the larynx can result. It is extremely important never to damage the cricoid ring and the first tracheal cartilage, as subglottic stenosis is often a late complication. Tracheostomy should not be left for the inexperienced surgical trainee to perform without adequate supervision. An inverted U incision (Bjork flap) will facilitate replacement but is best avoided, as this may result in stenosis at the stomal site. Strong stay sutures should be inserted, as these can be lifted to enable reinsertion of the tube when required. The wound should be dressed with a dry dressing. Tracheostomy in children is discussed in Chapter 96.

Tracheostomy Tubes

As with endotracheal tubes, low-pressure, high-volume cuffs are used. The commonly used tubes are made of polyvinyl chloride (PVC), silastic, or metal. PVC and silastic tubes meet most clinical requirements. Metal tubes are usually used for long-term tracheostomy, especially when a cuff is not needed. The thin wall of the tube enables a changeable inner tube to be used. A correctly shaped tracheostomy tube should not exert pressure against the trachea posteriorly with its convex contour, nor direct its tip against the anterior tracheal wall.

Minitracheostomy

Minitracheotomy tubes (ie, Portex "Mini Trach") are small diameter (4.0 mm), cuffless tubes inserted percutaneously through the cricothyroid membrane, after infiltration with local anaesthesia. Placement using the Seldinger technique of first inserting a guidewire and then inserting the tube with dilator over the wire is probably less traumatic. They are useful for suctioning lung secretions in patients with sputum retention, while avoiding endotracheal intubation or formal tracheotomy. Glottic function is maintained. The necessity for a small 10 FG suction catheter excludes its use in small children. These tubes may also be inserted in an emergency, in life-threatening, upper airway obstruction. Potential complications include haemorrhage, surgical emphysema, displacement, and inhalation of flangeless tube. Minitracheostomy tubes are contraindicated in acute respiratory failure and in comatose patients without a cough reflex, ie, when orotracheal intubation or formal tracheostomy are necessary.

Connector

A swivel connector should be used to reduce movement at the tracheostomy site.

Speaking Tubes

As speaking is impossible with a cuffed tube, there are tubes designed to enable phonation with the cuff inflated. Many of these tubes use a separate gas flow which, when required, is diverted into the trachea above the cuff and through the larynx. The spontaneously breathing patient can also be enabled to speak during exhalation by deflating the cuff and intermittently occluding the tracheal orifice. Alternatively, one-way speaking valves permit

inhalation through the tube and exhalation through the larynx with the cuff deflated. A fenestrated, non-cuffed tube can also be used to facilitate this.

Care of Tracheostomy

The following are important points in the care of a tracheostomy:

1. Warmed humidified gases are used.

2. Fixation must be secure. A double tape is used, and this is changed at least once a day.

3. A dry dressing is used, changed 6-hourly or as frequently as needed. The wound is cleaned with a bactericidal solution.

4. Suctioning is carried out with a sterile suction catheter, using a sterile glove.

5. A chest X-ray is taken to confirm the position of the tip.

6. The tube is left in place for 7 days and thereafter changed every 4 days. Replacing the tube earlier than a week can be difficult as a tract may not have formed. If the tube needs to be changed earlier, or if it becomes dislodged, the stay sutures mentioned previously can be helpful. With the Shiley silastic tube or with the metal tubes, an inner tube can be changed frequently without replacing the main tube.

7. Frequent sputum and wound culture are taken.

8. Equipment must always be at the bedside to deal with an emergency. This should include the following:

(a) a new tracheostomy tube similar in size to the one in situ, plus another tube one size smaller;

(b) tracheal dilators, a nasal speculum and paediatric laryngoscope which may be used to dilate the stoma when replacing the tube;

(c) suction equipment and facilities for mechanical ventilation;

(d) resuscitator bag with facemask, laryngoscope and endotracheal tubes. If the tracheostomy tube cannot be reinserted, then orotracheal intubation should be carried out. It is often forgotten, in the heat of the moment, that the patient is able to be ventilated via the larynx.

Complications of Tracheostomy

The main complications can be classified as immediate, delayed or late.

1. *Immediate*

(a) Perioperative complications such as haemorrhage, surgical emphysema, pneumothorax, air embolism, and cricoid cartilage damage.

(b) Accidental disconnection.

(c) Misplacement in pretracheal tissues or right main bronchus.

(d) Compression of tube by cuff herniation.

(e) Occlusion of the tip against the carina or tracheal wall. This occurs if the tube used has an inappropriate length of shank or of the intratracheal portion.

2. *Delayed*

(a) Blockage with secretions. This may be sudden or gradual, but is rare with adequate humidification and suction.

(b) Infection of the tracheostome or the tracheo-bronchial tree.

(c) Distension of trachea with high-pressure cuffs, proceeding to ulceration and other sequelae.

(d) Mucosal alteration caused by the tip. This is due to asymmetrical inflation of the cuff.

(e) Deep erosion. This may lead to bleeding from the innominate artery or development of a tracheo-oesophageal fistula.

3. *Late*

(a) Granulomata of the trachea. These may cause respiratory difficulty when the tube is removed.

(b) Persistent sinus at tracheostomy site.

(c) Tracheomalacia and tracheal dilation.

(d) Tracheal stenosis. Some post-tracheostomy patients have radiological evidence of a small degree of narrowing which is more common at the cuff site than at stomal level. Stricture formation with severe obstruction usually occurs after several months and is commonly due to infection in the upper trachea. Treatment is by dilation or excision.

Decannulation

When the patient has been weaned from the ventilator, or when other indications for tracheostomy are no longer present, the tube can usually be removed, and the wound dressed

and allowed to close spontaneously. Rarely, patients becomes emotionally "tied" to the tracheostomy, making decannulation difficult.

Management of the Obstructed Airway

The handling of the patient who has an obstructed airway is a delicate and often very difficult proposition. Specific management depends on the site, cause and severity of the obstruction.