Tracheostomy: General Information

Paediatric tracheostomy is a rewarding but challenging procedure. Over the last several years, there has been a perceived increase in tracheostomy related complications reported throughout the UK.

To investigate this further we conducted our own audit of all paediatric tracheostomy patients followed at our institution in order to identify the number and nature of reported adverse events with the goal of reducing their incidence.

Adverse events occurring both in hospital and in the home setting were included. Adverse events were classified according to the following categories: bleeding from tube, blocked tube, accidental decannulation, emergency equipment missing, incorrect humidity, excoriated neck, incorrect tube management, wrong tube, wrong HME (Heat and Moisture Exchanger) and loose tapes.

Our audit revealed an alarming rate of complications in this population. Each tracheostomised child is in a potentially dangerous situation, at risk of minor and life threatening but generally avoidable complications. Management of the paediatric tracheostomy requires a working knowledge of the child's underlying medical condition, respiratory status and indication for the tracheostomy. Of utmost importance is that all practitioners caring for these children should be appropriately trained and have adequate knowledge of all aspects of tracheostomy care.

Most common indications for tracheostomy in children:

1. **Cystic Hygroma**
   An anomaly of the lymphatic system. It is a soft, smooth, non-tender mass of almost fat like consistency. It is grey and oedematous in appearance. It can involve the neck, mucosal surfaces of the mouth, tongue, larynx and pharynx causing a potential airway obstruction.
2. **Haemangioma**
   A swelling containing abnormal blood vessels that can form at all levels of the respiratory system. As the child grows the haemangioma growth slows with or without treatment but it can initially obstruct the airway, which requires support.
3. **Laryngomalacia**
   The structures of the larynx are particularly soft and collapse inwards as the child breathes. This can cause varying degrees of obstruction. As the child grows older the larynx becomes more rigid and the condition may resolve allowing for decannulation.
4. **Papillomatosis**
   Benign wart-like lesions that are caused by Human Papilloma Virus. Their growth and the extent of disease varies considerably in children, but essentially the lesions can occupy and obstruct any part of the child's airway from the mouth and nose right through to lower airway structures.
5. **Sub-glottic stenosis**
   Sub Glottic Stenosis is a narrowing of the upper part of the trachea just below the larynx/ voice box. This may be congenital or acquired usually from prolonged intubation periods and or trauma at the time of tube insertion. Depending on the extent a child may recover from this or will require reconstructive surgery later in life.
6. **Tracheal stenosis**
   Narrowing of the tracheal diameter, which may be congenital or acquired, possibly through trauma or previous surgery. If the stenosis is high enough

the trachea may be stented by the tracheostomy tube, if not separate tracheal stents may have to be inserted to support the affected areas.

7. **Tracheomalacia**
   An area of softening in the trachea, which may collapse inwards as the child breathes and may obstruct respiration. This condition usually resolves with time as the trachea enlarges and becomes more rigid. The tracheostomy tube may be useful in stenting the area of the collapse. Some children may require positive pressure ventilatory support if the lower tracheal area is collapsing.
8. **Bronchomalacia**
   An area of softening in one or both of the bronchus, which may collapse inwards as the child breathes. As with all malacia this condition usually resolves as the child becomes older. Until this time the child may require positive pressure ventilatory support.
9. **Trauma**
   Direct trauma (for example burns) to the upper airway or surrounding structures can cause a potential airway obstruction and or narrowing.
10. **Vocal cord immobility**
    Immobile vocal cords may be caused by injury during intubation/ and or surgery, or due to an underlying neurological condition. Dependent on whether the cords are fixed open or closed the airway may be compromised.
11. **Tumour**
    Tumours of any part of the respiratory passage may cause an airway obstruction due to the potential nature, growth and shape.
12. **Long-term respiratory support**
    A tracheostomy may be required to facilitate long-term respiratory support, which would otherwise have to be managed with an endo-tracheal tube. The latter would lead to a variety of problems: including security of the tube, stimulation and development of the child, it would also mean hospitalisation. A tracheostomy is the preferred long-term option.

Paediatric tracheostomy tubes

The first types of tracheostomy tubes were made of sterling silver. As other synthetic materials have developed they have improved the flexibility and comfort of paediatric tracheostomy tubes. (Tweedie, Skilbeck and Cooke, 2007)

Tracheostomy Size Chart

All tracheostomy tubes have similar parts. In particular paediatric tubes are designed to accommodate the paediatric and neonatal neck shape; they provide stability and a means of securing the tube in place.

15mm termination port
A universal 15mm port providing the means of connecting additional equipment, such as speaking valves and HME's or ventilatory equipment. It also provides an extension to prevent occlusion from the child's chin (not present on the GOS Rusch®, Silver tubes).

Cannula
Paediatric tubes generally have a single cannula to allow for maximum internal diameter. However tubes are available with both an inner and outer cannula for older children; the cannula can be fenestrated to allow air to pass upwards through the vocal cords to aid phonation.

Obturator (introducer)
This should always be used when inserting the tracheostomy tube, as it provides rigidity to the tube, allowing a smoother insertion.

Extensive selections of paediatric tubes are currently available, driven by a variety of specific clinical requirements. Choosing an appropriate tube is just one of the preliminary steps in the management of a child with a tracheostomy. The Consultant and/or Tracheostomy Nurse Practitioner (TNP) will decide the design and size of tube to suit the child. They should be consulted if it is necessary to change the size or style of the tube in the future.

Sizes of tubes are generally measured by the internal diameter (ID). For the majority of children this is the only measurement required. However, some require specifically shorter tubes, for example neonates, whilst others need longer tubes if there is an element of collapse or an obstruction distal to the tube tip.

The list below briefly outlines the tubes that are most commonly used at GOSH. Practitioners are to seek advice from the TNP, ENT team, and manufacturer if more information is required;

Bivona®
The Bivona (Word document, 2.0 MB)® tube is the most commonly used tube at GOSH, largely replacing other varieties on grounds of comfort and versatility. The range is based around a standard shaft, manufactured from opaque, white siliconised PVC. It is latex free and hydrophobic, hindering protein adhesion and thereby limiting secretion build up and bacterial colonisation. For this reason, these tubes can remain in place for up to 28 days. The silicone is reinforced with wire, producing a tube that is flexible conforming to the shape of the trachea, but resists kinking. An integrating 15mm swivelling adapter reduces torque on the shaft and is universally compatible with ventilation appliances. There are two versions: Paediatric (of standard length) and Neonatal (shorter length). The tubes come in a variety of styles, some with independent flexing proximal and distal shafts, which are beneficial for children requiring ventilation (Flextend (Word document, 1.0 MB)®); some tubes also have adjustable flanges so that the shaft length can be altered (Hyperflex (Word document, 647 KB)®).

The tubes can be Uncuffed or cuffed. The Fome® cuff is a self inflating tube, providing a high level of protection from aspiration whilst providing optimal comfort for the child. Practitioners must ensure that they are familiar with the specifics of this tube when removing and inserting it as it is very different from other tubes. The Tight To Shaft (TTS) is a high-pressure low volume cuff. The cuff is filled with sterile water not air. Care must be taken not to overfill the cuff, and practitioners should only inflate the cuff enough to support artificial ventilation. The cuff can be deflated completely to assume the profile of an Uncuffed tube, which makes it very useful when weaning children from the ventilator. This is not a first line tube if ventilatory support is required & other tubes may be appropriate.

Bivona® tubes can be sterilised and re-used (maximum of five times or when the integrity of the tube is broken). New ‘in hospital and at home’ cleaning recommendations are now available from the TNP or the company direct.

The Great Ormond Street Hospital tube

This series is still produced, but no longer commonly used. There are two versions: flat and extended (external fenestrated extension). The extended version is suitable

for children whose chin might obstruct the standard flat tube. Both types of tube are made of Polyvinyl Chloride (PVC) and are clear/brown in colour, with a bevelled tip to facilitate introduction into the stoma and soft, atraumatic flanges. They are available in sizes from 3.0 mm ID to 7.0 mm ID, designed for single use only. More Importantly, these tubes are not compatible with ventilator tubing or resuscitation equipment. A Smiths Portex® male/female adapter of appropriate size will be required in such situations but this method is only temporary. If long-term treatments are required then practitioners should change the tube to one with a 15mm termination.

Shiley®
Not commonly used at GOSH. This product range is manufactured from opaque, thermo sensitive, latex-free PVC, with a thin-walled shaft, tapered tip and universal 15mm connector. Tubes are available in *neonatal*, *standard paediatric* and *long paediatric* varieties, with optional cuffs for the paediatric series. The sizing system used for the Shiley® range was updated several years ago: the internal diameter (mm) is now quoted for reference, in line with other manufacturers' products. From our experiences a weekly tube change is recommended. The Shiley® tube has been superseded by the Bivona® as the product of first choice in this department. However, a long paediatric tube (size 5.0 to 6.5) is not made by other manufacturers, such that the Shiley® remains a unique option for a limited number of children who require a tube which is midway between typical paediatric and adult lengths.

Smiths Portex™
Not commonly used at GOSH. There are two versions available, one without a termination and the other with a 15mm standard termination. This enables them to be used with anaesthetic and ventilatory equipment. They are made of a clear PVC material with a blue radio-opaque line. Paediatric sizes range from 3.0mm ID to 7.0mm ID. Cuffed and fenestrated (to facilitate vocalisation) versions are available.

Silver tubes
A number of silver tubes have been developed. Their designs and general principles remain unchanged for a number of years now. While seldom used by children in GOSH, silver tubes have some important qualities that confer advantages over plastic varieties in certain circumstances. Most significantly, the tubes can be manufactured with very thin walls, permitting the use of an inner tube without compromising airflow. This can be removed and cleaned without taking out the whole tube. Silver tubes may remain *in* situ for up to one month, a particular advantage for those children requiring long-term tracheostomy.

However, silver tubes have certain disadvantages. For example, they are rigid and do not conform to the trachea, which some children find uncomfortable. Additionally, each tube is unique; the unit cost is high (although far fewer tubes are required in the long term) and the components are not interchangeable, creating compatibility problems. Sizes are measured in the French Gauge (FG) and are not comparable to the metric measurements of the plastic tubes. They are not compatible with MRI scanning and they may distort CT images of the head and neck. For resuscitation and ventilatory purposes a Smiths Portex™ male/female adapter of appropriate size will be required in such situations. The Sheffield © tube is the only silver product commonly used at Great Ormond Street Hospital.

Caution
Silver tubes are not compatible with MRI scanning and they may distort CT scan pictures of the head, neck and chest. After discussion with the TNP or

the child's consultant a suitable alternative must be inserted for the duration of the scan.

Paediatric tracheostomy accessories

There are many products available to facilitate the care and management of a child with a tracheostomy. As with many items, several companies manufacture their own brands of the same piece of equipment. Sometimes, the only important difference is the price but in the majority of cases, the variation in design or function of the equipment can affect the decision to select or reject. Careful consideration should be given to the specific needs of the individual child before the accessory is purchased.

Speaking valves
Several manufacturers, for example Smiths Portex™, Shiley®, and Rusch® make these. They are designed to facilitate speech in the child with a tracheostomy. A joint decision is made between the ENT Consultant, TNP and the SALT to use a speaking valve, as changes often need to be made to the existing tracheostomy tube to accommodate it. They **must not** be fitted or used without a full assessment by the child's SALT or TNP.

We commonly use the Rusch® valve for our initial assessments and then use the Passy Muir © for long-term use.

A tracheostomy alters a child's ability to communicate (speak) by affecting the passage of air through the voice box (larynx) and mouth for speech. Air from the lungs passes out of the tracheostomy tube instead of passing up through the larynx and out of the mouth.

A speaking valve is a one-way valve that sits on the end of the tracheostomy tube. The valve opens as the child breathes in and closes as the child breathes out, directing air up through the larynx and out of their mouth. This allows the child to create sounds and words. Not all children will tolerate a speaking valve, as a good air leak around and above the tube is essential. The speaking valve must **NOT** be used whist the child is asleep or when using a cuffed tracheostomy tube.

Some variations include the facility for oxygen delivery.

Tracheostomy humidifiers:

Maintenance of the humidity and warmth of inspired air is an essential part of tracheostomy management, as the normal functions of the upper respiratory tract have been bypassed. (Harkin and Russell, 2001). The nose and naso-pharynx normally ensure that inspired air reaches a temperature of 37^{o}C and 100% relative humidity; bypassing these with a tracheostomy dedicates such functions to the lower airways, which are poorly suited to the task. Inspiration of cool and dry air may create many problems for the tracheostomised child. Impairment and destruction of cilia reduces the proximal transportation of mucus, (Jackson, 1996) Secretions become increasingly thick and tenacious, making their expulsion difficult. This may lead to blockage of the tube. Additionally, cold inspired air increases heat loss from the respiratory tract, a particular danger for the small infant (American Thoracic Society, 2000)

Heat and Moisture Exchangers (HME)

HME's consist of multiple layers of water repellent paper or foam membranes, which trap heat and moisture during exhalation. Cold inhaled air is then warmed and moisturised, thus maintaining the optimum respiratory tract environment.

Several varieties of HME may be used, but a number of important aspects should be considered. The HME must be lightweight to avoid traction on the tracheostomy tube as this may cause skin irritation or even accidental decannulation. For similar reasons, ventilation attachments should be used with care. Additionally, the internal volume of the HME will add to respiratory dead space, increasing the work of breathing. This may be further increased by the accumulation of secretions within the device; manufacturers therefore recommend changing the HME daily or whenever contaminated.

Note: There are several types available and care should be taken to ensure that the correct HME based on the weight of the child is used. In GOSH the Gibeck Mini Vent® is used for Infants under 1 year (usually under 10kgs), which are specially designed for smaller tidal volumes and cause minimal resistance to breathing. Children over One year or 10kg (whichever comes first) should wear the Thermovent T™ from Smiths Medical, and infants and children requiring additional Oxygen should use the Trachphone™ from Platon Medical. These provide the child with an excellent way of providing heat and moisture to inspired air; they are small, easy to use and allow the child to be mobile. They should be worn at all times, where possible. For children who refuse to wear the HME, practitioners should trial the Trachphone as they can suctioned through. As a last resort, a Buchanan bib could be used, which contain a foam layer that absorbs moisture from the child's expired gases.

Saline nebulisers

The ill/hospitalised child may require extra humidity and this can be delivered as a Nebuliser or by a continuous humidity system.

Nebulisers provide aerosol droplets in a saturated vapour. The advantage of using water droplets in the respiratory tract is not well documented or understood and some argue that excessive saturation of the lower airways may cause atelectasis and impair the function of distal cilia (Conway 1992; Harris, 1967). For this reason Nebulisers should be used as an addition to and not replace a primary method of humidification.

Water humidifiers are particularly useful when there is a higher requirement for humidification, for example, when the child requires a high minute volume during an acute respiratory illness or post anaesthesia (Klein, 1974). Care must be taken when assessing the effectiveness of water humidifiers; water droplets must be visible along the whole of the elephant tubing. Warmed humidity must be used for small and vulnerable infants.

It is also important that the tracheostomised child remains systemically hydrated and practitioners should consider increasing the child's intake during times of illness such as vomiting, diarrhoea, pyrexia, etc.