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.

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.

Common Reasons for Paediatric Tracheostomy;

There are many reasons why we at this Institution would insert a tracheostomy, below are the most common reasons;

- **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.
- **Haemangioma** A swelling containing abnormal blood vessels that can form at all levels of the respiratory system.
- **Laryngo-malacia** The structures of the larynx are particularly soft and collapse inwards as the child breathes. This can cause varying degrees of obstruction, in extreme cases or if this is in addition to another airway problem we may insert a tracheostomy. As the child gets older the larynx becomes more rigid and the condition may resolve allowing for decannulation.
- **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.
- **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.
- **Tracheal/ Bronchial stenosis** Narrowing of the tracheal diameter, which may be congenital or acquired, possibly through trauma or previous surgery. If the narrowing is high enough the trachea may be stented by the tracheostomy tube, if not separate tracheal/bronchial stents may have to be inserted to support the affected areas.

- **Tracheo-malacia** 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 ventilator support if the lower tracheal area is collapsing.
- **Broncho-malacia** 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 ventilator support.
- **Trauma** Direct trauma (for example burns/injury) to the upper airway or surrounding structures can cause a potential airway obstruction and or narrowing.
- **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.
- **Tumour** Tumours of any part of the respiratory passage may cause an airway obstruction due to the potential nature, growth and shape.
- **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.
- **Supporting** the airway during head/neck surgery
- **Protecting** the airway from potential aspiration due to possible impaired neurological function/ damage to structures following surgery

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, 2014)

- **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. (Johanna please can you link to this)

- **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. The tube choice will be determined by the TNP/ENT Surgeons at the time of surgery.

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

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®

This is the most commonly used tube at GOSH, largely replacing other varieties on grounds of comfort and versatility. These tubes do have metal in them, caution with MRI scanning.

- 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). With three types of flange shape and size to suit all neck shapes and ages.

Flextend®

- The tubes come in a variety of styles, some with independent flexing proximal and distal shafts, which are beneficial for children requiring ventilation or with neck masses.

Hyperflex®

- Some tubes also have adjustable flanges so that the shaft length can be altered which is useful to bypass distal anomalies, or to fit an abnormally short trachea- this is a temporary tube as the securing button can easily be opened by children. The TNP will design and customise a tracheostomy based on the required style/dimensions.

Most Paediatric tubes are uncuffed but if ventilation cannot be achieved fully, or there is risk to the lower airways from secretions then a cuffed tube may be considered;

The Fome cuff®

- 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. A 3 way tap needs to be used when removing and inserting it. (This will be determined by the TNP on an individual basis- seek advice)

The Tight To Shaft® (TTS)

- 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 use minimal volumes in which to achieve effective ventilation. The cuff requires regular deflations (This will be determined by the TNP on an individual basis- seek advice)
- The TTS cuff can be deflated completely to assume the profile of an Un-cuffed tube, which makes it very useful when weaning children from the ventilator. This is not a first line tube if ventilator support is required & other tubes may be appropriate.

Bivona® tubes can be sterilised and re-used. Do not dispose of the obturator after insertion. (maximum of five times or when the integrity of the tube is intact). 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 no longer produced, some families bought up a large amount of stock, so practitioners may still see them coming into the hospital.
There are two versions: flat and extended (external fenestrated extension). The extended version is suitable

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.
They also offer the alternative when children who have a Bivona tube in situ to insert a Shiley tube for the scan.

At GOSH we also use the Shiley as the backup tube during the emergency procedures as they can be inserted without the obturator (see the GOSH Resuscitation guideline)

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

The Sheffield © tube is the only silver product commonly used at Great Ormond Street Hospital.

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. See sizing chart for further details.

They are not compatible with MRI scanning and they may distort CT images of the head and neck.

For resuscitation and ventilator purposes a Smiths Portex ™ male/female adapter of appropriate size will be required in such situations.

Great Ormond Street Hospital Chart for Paediatric Airways

			Preterm-1 month		1-6 months	6-18 months	18 mths - 3 yrs	3-6 years	6-9 years	9-12 years	12-14 years
	Trachea (Transverse Diameter mm)		5		5-6	6-7	7-8	8-9	9-10	10-13	13
PLASTIC	Great Ormond Street	ID (mm)		3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0
		OD (mm)		4.5	5.0	6.0	6.7	7.5	8.0	8.7	10.7
	Shiley	Size		3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
		ID (mm)		3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
		OD (mm)		4.5	5.2	5.9	6.5	7.1	7.7	8.3	9.0
		Length (mm) Neonatal		30	32	34	36				
	*Cuffed Tube Available	Paediatric		39	40	41*	42*	44*	46*		
		Long Paediatric						50*	52*	54*	56*
	Portex (Blue Line)	ID (mm)		3.0	3.5	4.0	4.5	5.0	5.0	6.0	7.0
		OD (mm)		4.2	4.9	5.5	6.2	6.9	6.9	8.3	9.7
	Portex (555)	Size		2.5	3.0	3.5	4.0	4.5	5.0	5.5	
		ID (mm)		2.5	3.0	3.5	4.0	4.5	5.0	5.5	
		OD (mm)		4.5	5.2	5.8	6.5	7.1	7.7	8.3	
		Length Neonatal		30	32	34	36				
		Paediatric		30	36	40	44	48	50	52	
	Bivona All sizes available with Fome Cuff, Aire Cuff & TTS Cuff	Size	2.5	3.0	3.5	4.0	4.5	5.0	5.5		
		ID (mm)	2.5	3.0	3.5	4.0	4.5	5.0	5.5		
		OD (mm)	4.0	4.7	5.3	6.0	6.7	7.3	8.0		
		Length Neonatal	30	32	34	36					
		Paediatric	38	39	40	41	42	44	46		
	Bivona Hyperflex	ID (mm)	2.5	3.0	3.5	4.0	4.5	5.0	5.5		
		Usable Length (mm)	55	60	65	70	75	80	85		
	Bivona Flextend	ID (mm)	2.5	3.0	3.5	4.0	4.5	5.0	5.5		
		Shaft Length (mm)	38	39	40	41	42	44	46		
		Flextend Length (mm)	10	10	15	15	17.5	20	20		
	TracoeMini	ID (mm)	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	
		OD (mm)	3.6	4.3	5.0	5.6	6.3	7.0	7.6	8.4	
		Length (mm) Neonatal (350)	30	32	34	36					
		Paediatric (355)	32	36	40	44	48	50	55	62	
SILVER	Alder Hey	FG		12-14	16	18	20	22	24		
	Negus	FG			16	18	20	22	24	26	28
	Chevalier Jackson	FG		14	16	18	20	22	24	26	28
	Sheffield	FG		12-14	16	18	20	22	24	26	
		ID (mm)		2.9-3.6	4.2	4.9	6.0	6.3	7.0	7.6	
	Cricoid (AP Diameter)	ID (mm)		3.6-4.8	4.8-5.8	5.8-6.5	6.5-7.4	7.4-8.2	8.2-9.0	9.0-10.7	10.7
	Bronchoscope (Storz)	Size		2.5	3.0	3.5	4.0	4.5	5.0	6.0	6.0
		ID (mm)		3.5	4.3	5.0	6.0	6.6	7.1	7.5	7.5
		OD (mm)		4.2	5.0	5.7	6.7	7.3	7.8	8.2	8.2
	Endotracheal Tube (Portex)	ID (mm)	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0
		OD (mm)	3.4	4.2	4.8	5.4	6.2	6.8	8.2	9.6	10.8

Table reproduced from 'Choosing a paediatric tracheostomy: an update on current practice'
DJ Tweedie, CJ Skilbeck, LA Cochrane, J Cooke, ME Wyatt. The Journal of Layrngology & Otology, 2007

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. 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

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.

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.

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® valve for the initial assessment, and then use a Passy Muir® for longer term use.

Tracheostomy humidification;

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.

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 moistened, 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.
- The internal volume of the HME will add to respiratory dead space, increasing the work of breathing.
- The HME is changed daily or whenever contaminated.

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.

The Gibeck Mini Vent®

Used for Infants under 1 year (usually under 10kgs), which are specially designed for smaller tidal volumes causing minimal resistance to breathing. The device protrudes forwards accommodating the neonatal/infant 'no neck'.

Thermovent T® from Portex Smiths Medical

Used for Children over 10kg

Trachphone® from Platon Medical.

There are no specific TV restrictions but Practitioners should assess suitability for smaller infants. Oxygen can be delivered via this HME, suctioning can also be carried out through the device without having to remove it, so is useful when some groups of children requiring supplementary Oxygen therapy are sensitive to suctioning /and or removal of the supply.

It can also be used as a phonation device when a speaking valve cannot be tolerated.

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. Refer to the GOSH nebulizer guidelines.

Continuous Humidity

Continuous Humidity via 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, new tracheostomy or post anaesthesia.

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. (Refer to main tracheostomy guidelines for more information).