Embrace
Airway Management Guideline

Reference:	1813v3
Written by:	Suvradeep Basu, Dan Gilpin,
Re-written by:	Julian Howes, Ian Braithwaite & Nia Evans
Peer reviewer:	Steve Hancock
Approved:	December 2021
Review Due:	December 2024

Purpose

This document is intended for staff at Embrace who provide airway management during the resuscitation, stabilization or transport of a neonate or infant.

Intended Audience

This document is intended for use by Embrace clinical staff who are involved in the airway management of neonates and children during the transfer process.

Table of Contents

1. Introduction

This guideline highlights the theoretical and practical aspects of airway management during the transport process of an acutely ill child or neonate.

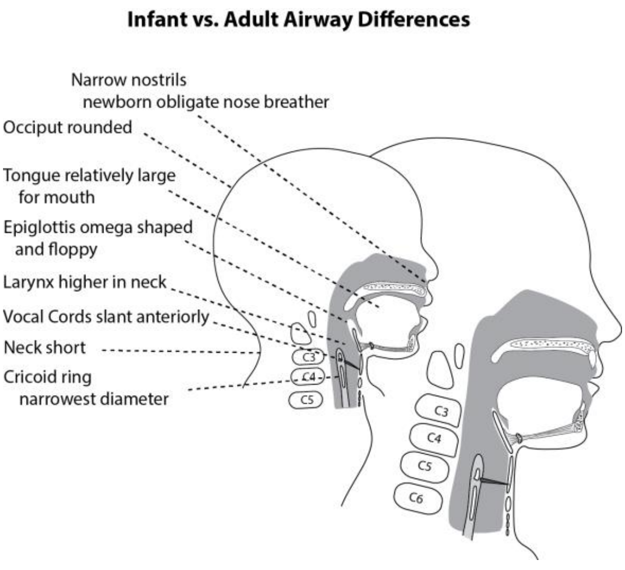
The primary goal of airway management is to ensure adequate oxygenation and ventilation. Face mask ventilation technique is the cornerstone for success. This requires knowledge, teaching and regular practice: Learn, See, Practice, Do, Maintain.

Children may have a difficult airway. A structured approach to their management is vital to ensure safety. The identification of potential difficult airways allows planning and early senior, specialist involvement.

2. Intended Audience

This document is intended for use by Embrace clinical staff who are involved in the airway management of neonates and children during the transfer process.

3. Guideline Content



3.1. – Anatomy and physiology of paediatric airways

The upper airway of an infant is considerably different to that of an adult or even an older child.

-They have **a large head, short neck** and a **prominent, rounded occiput**.

- The epiglottis is long, stiff and U-shaped. In younger children it can obscure the glottic view on direct laryngoscopy and may need to be lifted up directly with the laryngoscope blade.

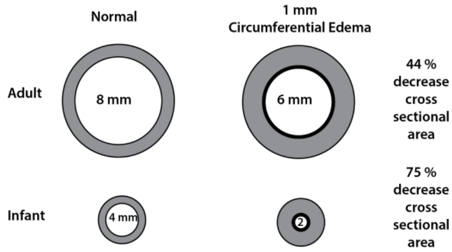
-The glottis is higher in relation to the spine in infants (C2/C3) and descends to around C5 after 2 years.

- The vocal cords are shorter in the infant and comprise about 50% of the anterior glottis in contrast to two-thirds in an older child.

- The larynx is conically shaped in the infant and approximately cylindrical in the older child.

Structural differences mean that an infant's airway and respiratory system is more susceptible to obstruction:

1. The tongue of an infant is much larger, taking up more space in the pharynx.
2. The epiglottis is generally larger and it flops posteriorly.
3. The trachea is much narrower and less rigid and the right main bronchus (RMB) divides off the trachea at a similar angle to the left making endobronchial intubation of the right or left main bronchi just as likely. In older children, however, the RMB divides off the trachea at a steeper angle than the left making RMB intubation more likely.
4. At the cricoid cartilage the airway constricts proportionally more than an adult's and is easily obstructed by swelling or foreign objects.
5. Because the airway of an infant is narrow, a small amount of oedema can produce severe obstruction.



Physiology

- Children have a low functional residual capacity (FRC) and this, together with the higher oxygen demand, increased carbon dioxide production and increased closing capacity, results in a very low tolerance of apnoea, rapidly leading to significant hypoxaemia and respiratory acidosis.

- The closing volume is larger than the FRC until 6-8 years of age. This causes an increased tendency for airway closure at end expiration therefore children respond well to PEEP.

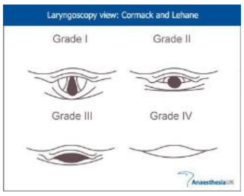
- Children have a highly compliant chest wall with horizontally positioned ribs. This makes the chest a less effective pump and results in a smaller resting volume, which predisposes them to atelectasis and reduced oxygen reserves.

- Neonates and babies in their first few months of life are obligate nasal breathers. Obstruction to their nasal passages can lead to respiratory compromise.

3:2 – Anticipating a difficult airway

Anticipating airway problems in children can be difficult. There are a number of factors which can predict a difficult airway. These can be categorized as **anatomical** or **functional** and can make either intubation or face mask ventilation difficult.

Useful information is the previous operator's view of the vocal cords during intubation. This is graded using the Cormack and Lehane system. Note, however, that the grade of intubation may change due to a number of factors and may be better or worse than previously.



Grade I: complete glottis visible
Grade II: anterior glottis not seen
Grade III: epiglottis seen, but not glottis
Grade IV: epiglottis not seen

The Mallampati Classification is sometimes used electively before theatre to describe the structures visualised with maximal mouth opening and tongue protrusion in the sitting position. It is classed from I-IV. This is difficult to perform with the paediatric patient, especially in an emergency situation.

The clinical examination of the child or infant is key to predicting airway difficulties. It may reveal predictive markers of a difficult intubation such as:

- Obesity
- Short neck
- Small mandible
- Reduced neck movement
- Large tongue
- Poor mouth opening
- Poor jaw mobility

These predictive markers may or may not be associated with congenital disorders. Some conditions associated with particular syndromes can cause airway problems:

Condition	Potential Problems	Associated Syndromes
Hypoplastic mandible (micrognathia)	Can cause difficult intubation	Pierre Robin sequence Treacher Collins Goldenhar syndrome (Hemifacial microsomia)
Midface hypoplasia	Can cause difficult face mask ventilation	Apert syndrome Crouzon syndrome Pfeiffer syndrome Saethre-Chotzen syndrome
Macroglossia	Can lead to both difficult face mask ventilation and difficult intubation	Down's syndrome Hurler's/Hunter's syndrome (mucopolysaccharidoses) Beckwith-Wiedemann syndrome

A review of the patient and their history may reveal a number of conditions that should raise concerns about a potential difficult airway including:

- Subglottic stenosis
- Laryngeal atresia
- Epiglottitis
- Retropharyngeal abscess

- Laryngeal or tracheal webs
- Glottic oedema
- Tonsillar hypertrophy
- Haemangioma
- Foreign body aspiration
- Trauma
- Spinal fusion
- Burns contractures

Functional problems can also be encountered during intubation or face mask ventilation. These can cause airway difficulties and can be divided into upper and lower airway problems. It is important to prevent or treat these as required during airway management:

Upper airway	Lower airway
Laryngospasm	Opioid-induced muscle rigidity
Inadequate anaesthesia	Bronchospasm
Opioid-induced glottic closure	Alveolar collapse
	Over inflated stomach

3.3 - Face Mask Ventilation

Good face mask ventilation is the cornerstone to good airway management. This requires training and practice.

Airway positioning - Appropriate airway positioning varies with patient age. In general, there should be horizontal alignment of the ear and sternal notch. Neonates and infants should be positioned with the head in the neutral position. A folded towel placed under the neck and shoulders may help. As children become older, optimal positioning changes. An older child may need more extension of the neck to open their airway.

Face masks/adjuncts - There are two main types of face mask. Some conform to the anatomy of the face and some are circular. They should be transparent in order so see the child's colour and any vomit present. Often, the airway management of neonates and infants is easier with a circular soft mask which covers their nose and mouth. Be aware that the smallest size of some brands of mask is too large for many preterm infants. Anatomical shaped masks of a size to cover the nose and mouth are more useful in the older child.

An oropharyngeal (OP) airway should always be available during an intubation. They should be sized from the level of the incisors (or where they would be) to the angle of the jaw. They should then be kept with the appropriate sized face mask as emergency equipment during the transfer.

Nasopharyngeal (NP) airways are useful in the conscious or semi-conscious patient. NP and OP airways are found on the intubation board of the blue and green transport bags.

Self-inflating bag-valve-mask - These should be available at all times during a transfer. They are available in two sizes, paediatric and adult, and are important pieces of emergency equipment as they can still deliver positive pressure ventilation after a gas supply failure. Usually however, they should be connected to oxygen with a flow rate of 15L/min.

An appropriate sized face mask should be attached to the device before placing on the patient. A self-inflating bag should not be used to support a spontaneously breathing paediatric patient due to the high pressures required to ventilate against the valve. To deliver CPAP or pressure support to a spontaneously breathing patient, an T-piece system or breathing circuit should be used.

T-piece system (e.g. Tom-thumb, Neopuff) - These can be used to provide CPAP or positive pressure ventilation to neonates and are available on neonatal units and on all Embrace road ambulances. When using it to ventilate, it is important to look for good chest wall rise and not just observe the rise on the pressure gauge. In an occluded airway, the pressure gauge will rise but no flow will be delivered. The inspiratory pressure and PEEP can be adjusted as required.

Ayres T-Piece and Waters circuit - These are both types of breathing circuits. They can provide additional oxygen for spontaneously breathing patients, provide CPAP, assist spontaneous ventilation or provide complete positive pressure ventilation. Unlike the self-inflating bag, they require a constant gas flow to work.

An Ayres T-Piece (or more correctly the Jackson Rees modification of the Ayres T-Piece, Mapleson F) can be used for neonates, infants and children up to around 20kg. It has a 500ml bag attached to the expiratory limb of the circuit. The movement of this bag allows spontaneous respiration to be easily monitored or compressing the bag allows for assisted ventilation. There are two types of bag. One has a hole in it's tail which can be occluded to provide positive pressure. The other has an adjustable valve to do this. If the fresh gas flow rate into the circuit is too low, rebreathing of expired gas will occur. As a guide, the flow rate required to prevent this should be around 2 to 2.5 times the patient's minute volume. $ETCO_2$ monitoring can provide evidence of rebreathing if the trace does not return to zero on inspiration.

The Waters circuit (Mapleson C) is for children over 20kg. It has a 2000 ml bag with no hole. An Adjustable Pressure Limiting (APL) valve is used to adjust the pressure in the circuit to allow CPAP or positive pressure ventilation. A fresh gas flow of around 2 times the patient's minute volume is required to avoid rebreathing.

3.4 - Indications for neonatal/paediatric intubation

Extreme Pre-term	Less than 27 weeks gestation
Neonate	up to 44 weeks post-conceptual age
Infant	up to 12 months of age
Child	1 to 12 years old
Adolescent	13 to 16 years old

Extremely pre-term infants will usually be intubated electively at birth whereas more mature preterm infants may not initially require ventilation. There should be a low threshold for intubation and ventilation as transfer may be associated with clinical deterioration. Hence, problems should be anticipated and stability must be achieved prior to transfer.

Every clinical situation is different but some relative indications for urgent neonatal intubation include:

- Grunting or respiratory distress.
- SaO_2 less than 88%.
- PaO_2 less than 6.5 kPa.
- $PaCO_2$ more than 7 kPa (infants with chronic lung disease or long term CPAP may have higher pCO_2).
- Recurrent apnoeas.
- Mean BP less than post-conceptual age in weeks.
- Also consider intubation when FiO_2 is more than 0.5.

Whenever possible, paediatric endotracheal intubation should be an elective procedure, anticipating and preventing further deterioration in respiratory function. It is best performed by someone experienced in both the procedure and the use of appropriate anaesthetic/sedative agents.

Where necessary, the Embrace team should seek senior anaesthetic support.

Indications for urgent paediatric intubation include:

- Airway obstruction.
- Airway protection.
- To enable positive pressure ventilation.

Positive pressure ventilation may be necessary due to increased work of breathing, acute respiratory failure, chest trauma, inadequate respiratory muscle function, raised intracranial pressure, shock etc.

3.5 - Endotracheal tubes (ETT)

The Embrace drugs chart should be used to select an appropriate size ETT. The diameter should ideally not be smaller than 2.5 mm as it is virtually impossible to suction through a very small tube (Appendix 4).

The following formula can also be used to estimate the size for paediatric patients:

$$\text{ETT diameter in mm} = \frac{\text{Age in years}}{4} + 4.0$$

It is important to avoid endobronchial intubation by ensuring that the ETT is not passed too far through the cords. Conversely, a tube that is too short may result in an excessive leak and increases the risk of accidental extubation. The estimated length for the ETT can also be found on the Embrace drugs chart. The lengths are quoted as measured at the lips or the nose. This should be used as a guide only. Always confirm the position clinically and on X-ray. The formula for estimate ETT lengths in paediatric patients is:

$$\text{Oral tube length in cm} = \frac{\text{Age}}{2} + 12$$

$$\text{Nasal tube length in cm} = \frac{\text{Age}}{2} + 15$$

Another guide is that the tube should be passed through the cords a distance in cm equivalent to its internal diameter in mm. e.g. a 4.5 ETT should be 4.5cm at the cords.

The ETT must be confirmed to be in the trachea after intubation. This is best done by a combination of clinical observations.

1. Clearly observing the ETT pass through the vocal cords.
2. Observing symmetrical chest movement. This may be difficult to see in pre-terms soon after birth.
3. Rise in heart rate, especially in pre-term infants.
4. Auscultation of symmetrical air entry in both lungs and no noise over stomach.
5. Use of waveform capnography.

Caution should be used in interpretation of end-tidal carbon dioxide monitoring in extreme pre-terms where the tidal volume is low. Also, in cardiac arrest, there may be insufficient expired CO_2 to detect.

ETTs are not usually cut to length but left uncut to allow for fixation, later adjustment and some flexibility if the child moves his/her head.

Oro-tracheal intubation is usually performed in the first instance to secure the airway. Oral tubes are sometimes later changed to nasal if there are no contraindications e.g. basal skull fracture / coagulopathy and staff feel confident to change them.

Securing endotracheal tubes:

The ETT must be secure and should not become dislodged during transport. The standard neonatal ETT securing device for Embrace is the Neo-Fit™. Embrace secures paediatric ETTs using a "double trouser leg" technique with Elastoplast tape. The crucial part of this technique is to ensure that ETT tube is against the "crotch" of the trouser leg before the leg is wrapped around in order to ensure firm anchoring.

The ETT must be secure and a child should not be accidentally extubated during transfer. This is deemed an Embrace "Never Event". Prior to any transfer of an intubated infant or child there should a "push test" to check the ETT is secure and this should then be documented in the transfer records.

Radiographic confirmation of ETT:

The optimal position of the tip of an ETT on X-ray is at the level the body of the second thoracic vertebrae in the mid-trachea and above the carina. The head should ideally be in the neutral position for x-ray.

Cuffed endotracheal tubes:

Cuffed ETTs are available in paediatric sizes and their use in infants and small children is increasing. Care needs to be taken to reduce the risk of subglottic stenosis. Smaller tubes can be difficult to place in such a way that the cuff is completely through the vocal cords with the tip above the carina. With small tubes, the reduction in internal diameter associated with a cuffed tube can also make it more difficult to suction secretions.

When intubation or re-intubation of children, outside of the neonatal period, we recommend placement of a cuffed ETT. They are highly recommended when the compliance of the child's chest is likely to be poor (severe respiratory failure or sepsis) or in situations where the tube is being up-sized because of excessive leak.

If a cuffed endotracheal tube is used in a child then:

- Consider placing a tube with an internal diameter 0.5mm smaller than that expected.
- There should be an audible leak present before the cuff is inflated.
- The cuff should only be inflated if ventilation is inadequate.
- A pressure manometer must be used to ensure safe cuff pressures.

Care must be taken to ensure that the cuff is fully though the vocal cords and the tip of the tube on X-ray is above the carina.

3.6 - Advanced Airway Equipment

Laryngoscopes

The McGrath is a video laryngoscope that is carried on all Embrace ambulances. It has a colour camera embedded in a curved laryngoscope blade. It requires a different technique to intubate compared to a direct laryngoscope and should only be used after adequate training. The McGrath should be seen as the primary intubation device for all Embrace patients except for the smallest premature babies. There are four standard Macintosh-style blades and one hyper-angulated "X blade" for difficult and extreme airways. See Appendix 9.

There are two main types of direct laryngoscope blades, the straight and curved blades.

The Miller blade is the most popular of the straight types. The side of the flange is reduced to minimize trauma and the curve at the beak or tip is extended to improve lifting of the epiglottis. These improvements facilitate greater exposure of the larynx in difficult-to-intubate patients. The straight blade is used to directly lift the epiglottis and tends to allow better views of the larynx in infants up to around 1 year old.

The Macintosh blade is the predominate model of the curved blade types. During laryngoscopy, the tip of the blade is compressed into the angle formed by the base of the tongue and the epiglottis, indirectly raising the epiglottis. The curved blade tends to allow better views of the larynx in older children although it may be useful in infants too.

Capnography

Waveform capnography should be used during all intubations and during every transfer of a ventilated patient. The sample line can be attached to a bagging circuit while pre-oxygenation the patient. At intubation, the waveform can provide verification of successful tracheal intubation. The value of the end-tidal CO_2 measurement ($ETCO_2$) and the shape of the waveform can reflect clinical changes with the patient. The $ETCO_2$ value can be used in relation to the pCO_2 on the pre-departure gas to help adjust ventilation. The $ETCO_2$ value may not correlate well with the pCO_2 in neonates. Other factors such as low cardiac output or low pulmonary flow can lower the value.

Bougies, Stylets

A bougie is an endotracheal introducer that is firm, slender and easily manipulated. It can be passed into the trachea and then used to guide an ETT into the airway. Bougies should be used with extreme caution in neonates and only with appropriate training. There is a risk of causing a tracheal perforation and pneumothorax. In older children, bougies can be used more safely for aiding both primary intubation when a difficult view is found or for the changing of an ETT. This requires practice and training. It is recommended that all ETT placements over a bougie should still be conducted under direct vision of the larynx.

A stylet is a malleable, coated wire that can be inserted into an ETT, helping it to hold it's shape during intubation.

Bougies are found in the suction catheter metal box on the road transport incubators and trolleys. They are also available on the flight stretchers. Stylets are in the transport kit bags.

3.7 - Induction Agents

In extremely pre-term infants, intubation at birth is usually a semi-emergency procedure and therefore induction agents are not routinely used. However, if re-intubation is required or intubation is elective to prevent further deterioration in respiratory function, there is clear evidence that intubation is quicker, easier and physiologically more stable if sedation and paralysis are used. This also provides analgesia for what is a painful procedure.

Using any induction agent requires an understanding of their pharmacology and the contraindications to their use. It is recommended that this is not attempted by personnel without the appropriate training.

In the shocked child:

- Titrate induction doses carefully, using the minimum effective dose.
- Ensure fluid resuscitation before intubation if possible.
- Have fluid boluses and adrenaline prepared in appropriate doses.

Appropriate drugs and dosages can be found on the Embrace drugs chart:

Neonates: Atropine 10-20 micrograms/kg should always be drawn up and may be used prophylactically to prevent profound bradycardia.

Induction agent - Fentanyl 2-5 micrograms/kg
Muscle relaxant - Atracurium (300-500 micrograms/kg)

Paediatric patients: There are a variety of induction agents for paediatric patients. The first choice for Embrace is usually:

Induction agent - Ketamine 1-2 mg/kg
Muscle relaxant - Rocuronium 1 mg/kg

The pharmacological properties of ketamine may mean it is specifically indicated if a patient is shocked, hypotensive, asthmatic or has known cardiac abnormalities. Alternative induction agents may be used after discussion with Embrace Consultant. These include Propofol and Thiopentone.

The specific reversal agent for Rocuronium is Sugammadex. This is not carried by Embrace but may be available in the referring hospital. Do not assume this will reverse apnoea as it is unlikely to do this in critically ill patients.

Atropine at a dose of 20 micrograms/kg (minimum dose 100 micrograms, maximum dose 600 micrograms) should always be drawn up and available to treat critical bradycardia.

3.8. Method of Induction and Intubation

Use the intubation checklist (Appendix 1). This is important to ensure the appropriate teams and equipment are available and to provide a challenge-response system. It also allows a framework to record details about the intubation, analysis of which is important to ensure intubations are maintained at a high quality. A clear management plan should be discussed with the team including the planned approach to any difficulties.

If there are any concerns at all about a potential difficult airway, advice and help from an Embrace consultant, senior anaesthetist or ENT surgeon should be sought before starting.

The general approach to induction and intubation is:

- Set up the correct team and environment using the pre-intubation checklist.
- Discuss the intubation plan and approaches to deal with a difficult airway.
- Apply monitoring and obtain baseline readings.
- Pre-oxygenate for 3 minutes with oxygen via a high flow breathing system. Titrate to effect for pre-term neonates to avoid hyperoxia. Attach end-tidal capnography to the circuit.
- Administer induction drugs and allow time for them to work.
- During this time provide gentle ventilation aiming to move the chest but avoid stomach distention.
- Intubate patient orally.
- Confirm correct placement of endotracheal tube clinically and with capnography.
- If endotracheal intubation is not achieved then follow the failed intubation

guidance, prioritising oxygenation and ventilation.

- Boluses of sedation and muscle relaxant may be required once oral intubation has been successful.
- Perform a chest X-ray to confirm correct ETT placement.
- Measure blood gases to verify correct ventilator settings after approximately 30 minutes.

3.9 - Dealing with leaks

There should always be a small leak around an uncuffed ETT. However, if the tube has passed through the cords with minimal force we tend to leave it alone, even if there is no leak. If a cuffed ETT is placed then there should be a leak before there is consideration of inflating the cuff.

Sometimes the tube has a substantial leak which interferes with ventilation. This may be manageable by adjusting the inspiratory pressure if ventilation is adequate and the ventilator is not alarming.

If the leak is too large then either increase the size of the tube or consider placing a cuffed tube of the same size. If using a cuffed tube, don't inflate the cuff initially. Reassess the situation and see if you can ventilate adequately with a deflated cuff.

Sometimes it is difficult to get adequate alveolar recruitment because of the size of the leak and changing the tube is a worrying prospect because of low saturations. In this situation applying cricoid pressure or, on very rare occasions, temporarily packing the pharynx can reduce the leak for long enough to allow some more alveolar recruitment, improve the SpO_2 and give you some "breathing space" before changing the ETT (upsize and/or cuffed). Packs have risks involved with their use and they can be accidentally left in the airway. **Do not** place one if you are in-experienced, use cricoid pressure instead. **Children should not be transferred with a pack in situ**.

3.10 - Management of Difficult Airways

If there are any concerns about a potential difficult airway, senior specialist help should be sought before any intubation attempt. Unexpected difficult airways can occur and a structured plan to managing these is vital to ensure safely. This plan should be made pre-emptively before inducing the patient.

The management of difficult airways should follow the principles set out by the Difficult Airway Society. While providing a good framework to thinking about difficult airways, they have a theatre bias and were only written for children aged 1-8 years. The principles, however, are easily applied to the transport setting and the Embrace Difficult Airway Guideline is based on these (Appendix 3).

Attempts at Intubation

The initial intubation plan should consider details about the techniques and equipment to be used. The importance of effective face-mask ventilation must be emphasised.

Remember that if it is possible to face-mask ventilate a child then it may be safer to wait for help rather than continuing with further intubation attempts. There should usually be no more than 4 attempts at intubation and any individual operator should usually only have 2 attempts.

Once direct laryngoscopy is found to be difficult, the first important stage is to identify and communicate this with the team. This is followed by giving **100% oxygen and calling for senior, specialist help**. This may be obtained by putting out an emergency 'Crash Call'. Maintaining oxygenation by face-mask ventilation is vital.

An intubation attempt is defined as an interruption to face mask ventilation in order to pass the laryngoscope into the mouth. Each new intubation attempt must be preceded by a change to improve the airway. At all times it is important to verbalise to the wider team what problems are encountered.

An example of the approach to 4 intubation attempts in this plan is as follows:

If 1st attempt fails:

Ensure oxygenation and adequate face mask ventilation. Consider waiting for further help.

Vocalise to the team what the problem is. State what the grade of view is. State what needs to be remedied. For example:

- "no view because of airway soiling with blood - please pass the suction "
- "grade 4 view, unable to see cords - I am reverting to face mask ventilation "
- "grade 1 view, unable to pass tube through cords - please pass me the size ETT"

For poor views consider one of the following:

- Is the patient positioning still optimal? Improved positioning may involve putting pads under the head in larger children or under the shoulder blades in babies.
- Is the head still in the midline?
- Try another size laryngoscope blade or alternate blade
- Relax cricoid pressure
- Relax MILS (Manual inline stabilization)
- Check patient is still anaesthetised with adequate paralysis
- Use McGrath if not already

If 2nd attempt fails:

- Ensure oxygenation and adequate face mask ventilation
- Consider changing to second operator
- Consider cricoid manipulation or BURP (Backward, Upward, Right pressure)
- Consider bougie insertion and passing ETT over bougie

If 3rd attempt fails:

- Ensure oxygenation and adequate face mask ventilation
- Try guiding the bougie behind epiglottis in a grade 3 view

If 4th attempt fails:

- Ensure oxygenation and adequate face mask ventilation
- Declare that this is a 'Failed Intubation'

Secondary attempt at ventilation

After a failed intubation, there must be a secondary plan to ventilation the patient. The patient should be ventilated with a face mask or it may help to insert a supraglottic airway device (e.g. LMA). There should be no more than 3 attempts at inserting this and there may be consideration of upsizing it once if the ventilation is inadequate with the size used. The use of a third generation LMA such as the Ambu AuraGain could be considered. Oxygenation and ventilation should be attempted via the face mask or through the LMA. If this is successful and oxygenation is maintained, there should be a senior discussion about further plans. Expert assistance may be gained from Embrace consultants, senior anaesthetists or ENT surgeons.

If ventilation using the LMA is unsuccessful, it should be declared that this is now a 'Failed Ventilation'

Final Attempt at face mask ventilation

If the attempt to insert a supraglottic airway device fails, there should be a final attempt to ventilate the patient with a face mask. Head position should be optimised and a two person bag-mask technique, CPAP and an oro/nasopharyngeal airway may be required. **Ensure the patient is muscle relaxed.** Gastric distension should be managed with an OG/NG tube. If this attempt is successful, there needs to be a senior discussion about the plan.

If this final attempt at face mask ventilation fails, it should be declared that this is a 'Can't Intubate, Can't Oxygenate' (CICO) scenario.

Can't Intubate, Can't Oxygenate

Identification of a CICO situation and communication with the wider team is vital. 100% oxygen via a face mask should be delivered. Senior, specialist help, including ENT should be called for again if it has not arrived.

If an ENT surgeon is present then they can consider a surgical tracheostomy or rigid bronchoscopy. If they are not available then needle or surgical cricothyroidotomy should be performed.

3.11 - Needle cricothyroidotomy

In children under the age of 8 years needle cricothyroidotomy is preferred to surgical cricothyroidotomy. In the adolescent, either technique can be used but the surgical technique allows better protection of the airway.

In a very small baby, or if a foreign body is below the cricoid ring, direct tracheal puncture using the same technique can be used.

Maintain passive oxygenation with face mask oxygen while setting up and performing the procedure.

- Extend the neck, using a shoulder roll if required.
- Stabilise the larynx with non-dominant hand.
- Insert a 14/16 gauge cannula through the cricothyroid membrane at a 45 ° angle caudally, aspirating as the needle is advanced.
- When air is aspirated, advance the cannula over the needle, and withdraw the needle.
- Re-check that air can be aspirated from the cannula.
- Attach the cannula to an oxygen flow meter via a Y-connector.
- Match the oxygen flow rate in l/min to the child's age in years.
- Occlude the open end of the Y-connector with a thumb for 1 second to direct gas into the lungs.
- Allow passive exhalation via the upper airway by taking the thumb off for 4 seconds.
- Cautiously increase the oxygen flow rate to achieve adequate chest expansion.
- Maintain upper airway patency to aid expiration.

Chest movement should be observed to confirm adequate inflation. Check the neck to exclude swelling from the injection of gas into the tissues rather than the trachea. Secure the equipment to the patient's neck and arrange a more definitive airway procedure, such as tracheostomy or intubation if more skilled help has arrived.

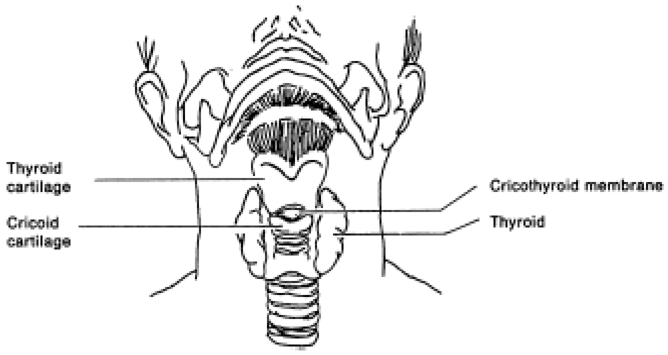


Figure 2

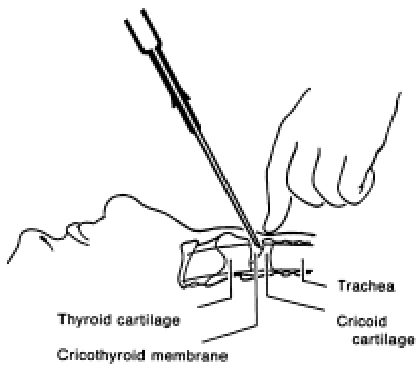


Figure 3

Important notes about cannula cricothyroidotomy:

- It is not possible to ventilate a patient via a needle cricothyroidotomy using a self-inflating bag. The maximum pressure from a bag is approximately 4.5 kPa and this is insufficient to drive gas through a narrow cannula. In comparison, wall oxygen is provided at a pressure of 400 kPa.

- Expiration cannot occur through the cannula as the intratracheal pressure during expiration is usually less than 3 kPa. Expiration must occur via the upper airway, even in situations of partial upper airway obstruction. Should upper airway obstruction be complete, it is necessary to reduce the gas flow to 1-2 l/min. This provides some oxygenation but little ventilation. Nevertheless, insufflation buys a few minutes in which to attempt surgical airway.

3.12 Surgical cricothyroidotomy

This should be considered in the older child, 8 years or over:
Equipment required:

- Scalpel
- Appropriate sized Bougie or Airway Exchange Catheter
- Appropriately sized lubricated endotracheal tube (likely to need smaller size than orally maximum size 6.0)

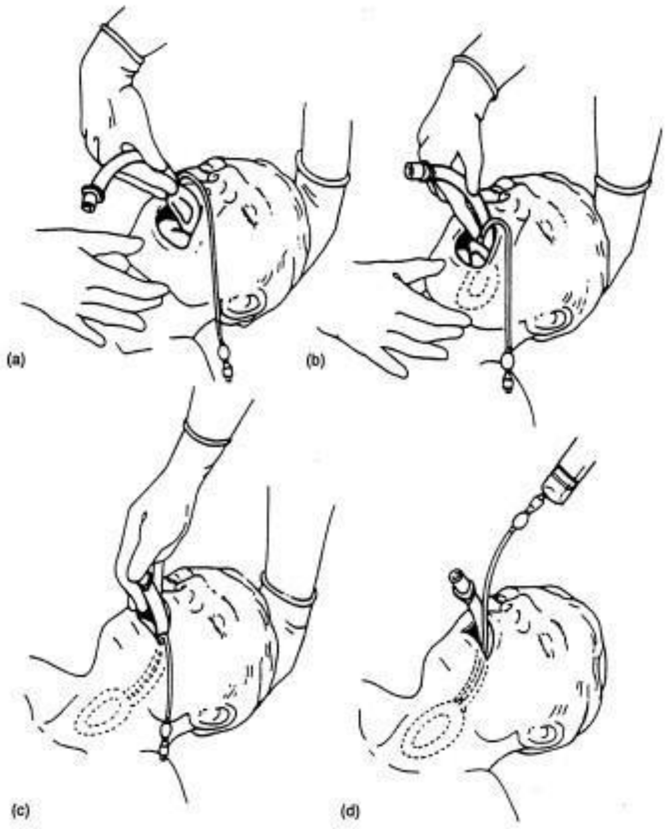
- Place your non dominant on the neck to identify and stabilise the cricothyroid membrane.
- Make a transverse stab incision through the skin and cricothyroid membrane using a scalpel.
- Turn the blade 90 degrees so the sharp edge is facing caudally.
- Insert the tip of a Bougie down the side of the blade. Rail road an appropriately sized endotracheal tube into the trachea.
- Use a slightly smaller size than would have been used for an oral or nasal tube
- Ventilate the patient, check that this is effective, and confirm end tidal carbon dioxide is present.
- Secure the tube to prevent dislodgement.

3.13 - Supraglottic airways

Laryngeal mask airway (LMA) insertion (Ambu Auru-Gain size 1 should be used below 5kg)

- Choose appropriate sized LMA (see below or product packaging)
- Check that the LMA inflates with a syringe.
- Deflate the cuff and lightly lubricate the back and sides of the mask.
- Tilt the patient's head if safe to do so, open the mouth fully, and insert the tip of the mask along the hard palate with the open side facing, but not touching the tongue (Figure 1a).
- Insert the mask further, along the posterior pharyngeal wall, with your index finger initially providing support for the tube (Figure 1b).
- This may be easier if an assistant lifts the jaw upwards.
- Resistance is felt as the tip of the LMA lies at the upper end of the oesophagus (Figure 1c).
- Fully inflate the cuff (Figure 1d).
- The LMA will rise up slightly at this point.
- Secure the LMA with adhesive tape and check its position during ventilation as for a tracheal tube.
- You will often not obtain a completely gas-tight fit, but if excessive leak may need

a larger or smaller size.
- If insertion is not accomplished in less than 30 seconds, re-establish ventilation using a face mask.



Sizes of Supraglottic Airway (Approximate size ideal weight based)

Size 1	AuraGain LMA - <5kgs	
Size 1.5	**LMA**	5 – 10kg
Size 2	**LMA**	10 – 20kg
Size 2.5	**LMA**	20 – 30kg
Size 3	**LMA**	30 – 50kg
Size 4	**LMA**	50 – 70kg
Size 5	**LMA**	70+ kg

I-Gel Insertion – See appendix 5

AuraGain Insertion – See appendix 6

Problems with LMA insertion

- Incorrect size may lead to excessive leak.
- Incorrect placement is usually due to the tip of the cuff folding over during insertion. The LMA should be withdrawn and reinserted.

- The epiglottis can become displaced over the larynx causing difficulties ventilating the patient.
- Rotation of the LMA may prevent its insertion. Check that the line along the tube is aligned with the patient's nasal septum.
- Coughing or laryngeal spasm is usually due to attempts to insert the LMA into a patient whose laryngeal reflexes are still present.
- Inadvertent displacement is common with smaller LMAs, usually due to rotation once a circuit or self-inflating bag is attached.

<u>**3.14 - Management of a tracheostomy emergencies**</u>

There is good guidance on emergency paediatric tracheostomy management provided by the National Tracheostomy Safety Project. A copy of the NTSP patient passport/emergency tracheostomy management flow chart should be completed and easily visible, when transporting all patients with a tracheostomy. (See appendix 2)
A tracheostomy box with spare tubes and tracheal dilators etc should be carried with all patients.

APPENDICES

1. Embrace intubation check list
2. NTSP Emergency Paediatric Tracheostomy Management - Paediatric Bed Head and Algorithm
3. Embrace Difficult Airway Algorithm
4. Endotracheal Tube sizes and positions
5. AuraGain Placement Technique
6. Embrace Needle Cricothyroidotomy Guide
7. McGrath MAC Blade
8. McGrath X Blade

Appendix 1 - Embrace intubation checklist

Advanced

Airway* Placement by Embrace Team, at any time Name of intubator ……………………………………………………….
(*ETT/LMA/tracheostomy/cricothyrotomy)

Pre-Intubation checklist

Decision making
-Why are we intubating this patient?
………………………………………………………………
-Has Embrace Consultant been informed? Y ☐ N ☐

Patient
-Do we have optimal patient positioning/access? Y ☐ N ☐
-Difficult airway anticipated? Y ☐ N ☐
(If so, is Anaesthetics/ENT presence needed?) Y ☐ N ☐
-2 functioning IV lines Y ☐
-ECG, BP (on auto cycle), SATs probe working Y ☐
-Appropriate alarm limits set Y ☐
-Baseline observations done Y ☐
-Temperature management plan Y ☐

Equipment
-Oxygen Y ☐
-Self-inflating Bag Valve Mask Y ☐
-Weight appropriate bagging circuit with Manometer Y ☐
-Waveform capnography attached to bagging circuit Y ☐
-Correctly sized face mask and oropharyngeal airway Y ☐
-2 laryngoscopes "bright and white" Y ☐
-Is the McGrath required? Y ☐
-Suction switched on with Yankeur attached Y ☐
-ETT tube sizes expected ….. …… ….. Y ☐
-Length expected at lips/nares ….. Y ☐
-Syringe for cuffed tube and balloon checked Y ☐ / NA☐
-ETT introducer/Bougie (correct size) Y ☐
-Method of securing ETT Y ☐
-Is a correctly sized LMA available? Y ☐
-Needle / surgical cricoid kit available Y ☐
-Ventilator ready Y ☐
-Stethoscope Y ☐
-Is a mask/visor required? Y ☐ N ☐

Drugs prepared:
-Induction agent: Y ☐
Fentanyl ☐ Ketamine ☐ Other ……………………….. Y ☐
-Muscle relaxant: Rocuronium ☐ Atracurium ☐ Y ☐ N ☐
-Is Atropine required? Y ☐ N ☐
-Maintenance: Midazolam ☐ Morphine ☐ Other ☐ …. Y ☐
-Fluid bolus available? Y ☐ N ☐
-Are inotropes required? Y ☐ N ☐

Team
Assign roles (2 assistants minimum): Y ☐
-Intubators assistant Y ☐
-Drug administration Y ☐
-Cricoid Y ☐ N ☐
-Patient monitoring Y ☐
-Manual in line stabilisation Y ☐ N ☐
-Verbalise… The airway plan is: Plan A….Plan B…. Plan C… and Plan D… (from failed intubation guideline) Y ☐

Final checks
-Pre-oxygenation optimal Y ☐
-Gastric tube, aspirated Y ☐
-Drugs and flush ready Y ☐
-Final set of observations Y ☐
-Does anyone have any concerns? Y ☐ N ☐
-"Quiet please" Y ☐

Post intubation checks-

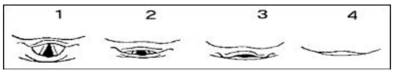
-End-tidal CO_2 detected Y ☐ N ☐
-Bilateral air entry on auscultation Y ☐ N ☐
-Length of ETT …………………… at lips / nares Y ☐ N ☐
-ETT adequately secured Y ☐ N ☐
-ETT cuff pressure <20cmH_2O Y ☐ N ☐
-Post intubation observations stable Y ☐ N ☐
-Sedative/analgesia infusions started Y ☐ N ☐
-Post-placement CXR Y ☐ N ☐

Additional Post-Intubation documentation

-Pre-oxygenated optimally Y ☐ N ☐
-Suction used Y ☐ N ☐
-MILS employed Y ☐ N ☐
-Cricoid pressure employed Y ☐ N ☐
-Laryngoscope blade size used ……………………………

-Attempts* at intubation ……………………………………..

-Grade of intubation



-ETT tube size ………………………………………………

-During the 1st attempt at advanced airway placement was there ……….?:
Newly-falling SpO_2 <90% Yes ☐ No ☐ Do not know ☐
Systolic BP <5th centile Yes ☐ No ☐ Do not know ☐
[(2x age in years) + 65mmHg]

-Oropharyngeal airway used Y ☐ N ☐
-Nasopharyngeal airway used Y ☐ N ☐
-ETT introducer used Y ☐ N ☐
-Bougie used Y ☐ N ☐
-Difficult airway Y ☐ N ☐
If so,
-LMA used ☐ size …………… Type…………
-McGrath used ☐ size ……………
-Surgical airway (needle cricoid or surgical cricoid) Y ☐ N ☐

*[An attempt is the insertion of a laryngoscope of any bougie or advanced airway device past the lips/tracheostomy inlet/touching cricothyrotomy instruments to the neck]

Continuation Notes

Appendix 2 – National Tracheostomy Safety Project Emergency Tracheostomy Management - Paediatric Bed Head and Algorithm

This patient has a

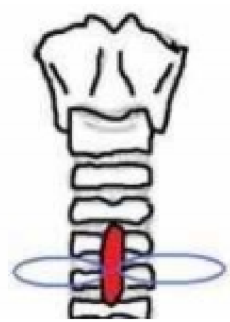
New TRACHEOSTOMY

Patient ID: *Patient Label / Details*

Tracheostomy: Add tube specification including cuff or inner tube

______mm ID, ______ mm distal length

Suction: ______ FG Catheter to Depth ______ cm



Indicate on this diagram any sutures in place

UPPER AIRWAY ABNORMALITY: Yes / No

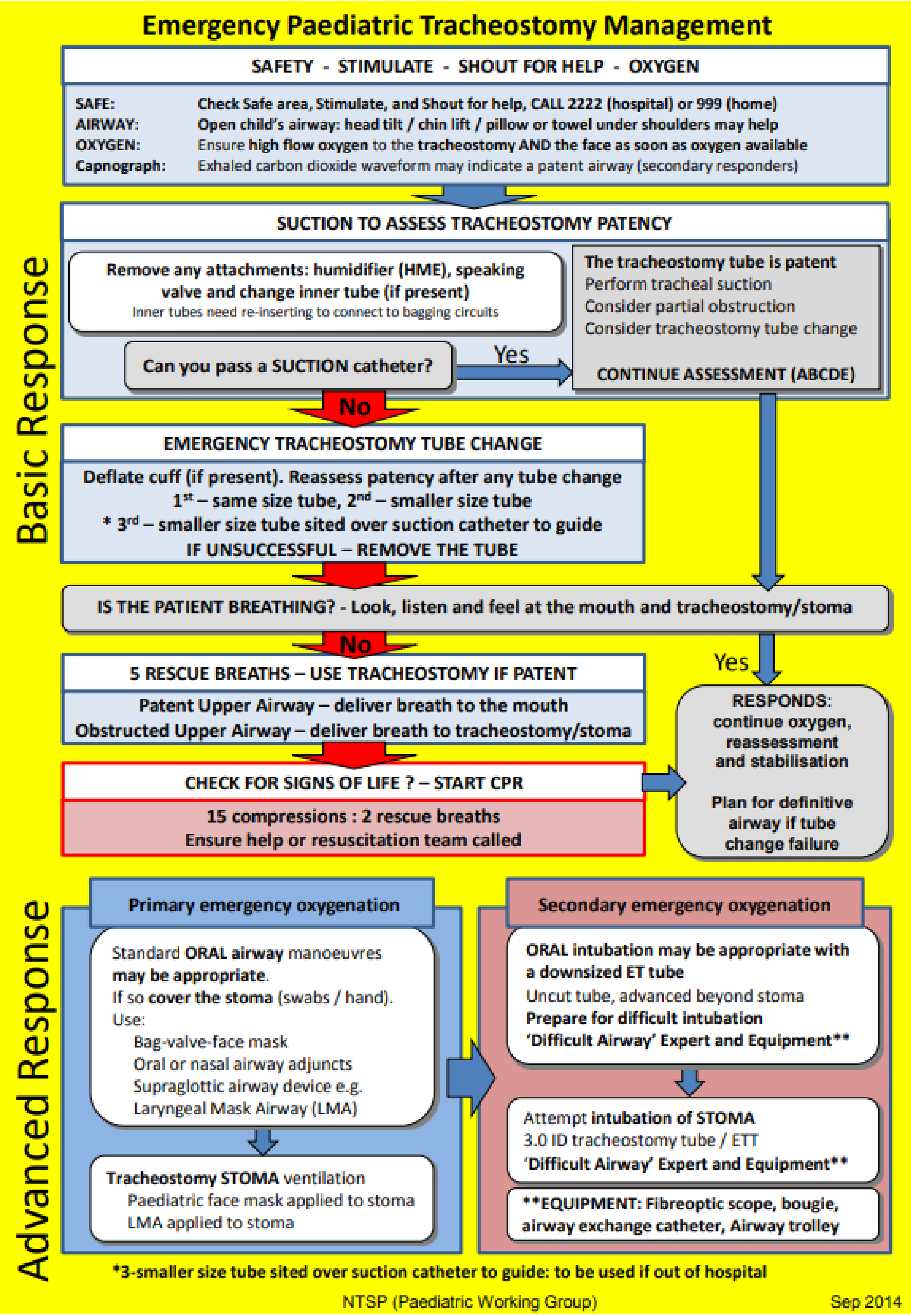
Document laryngoscopy grade and notes on upper airway management or patient specific resuscitation plans

Due 1st tracheostomy change: ___ / ___ / ___ (by ENT ONLY)

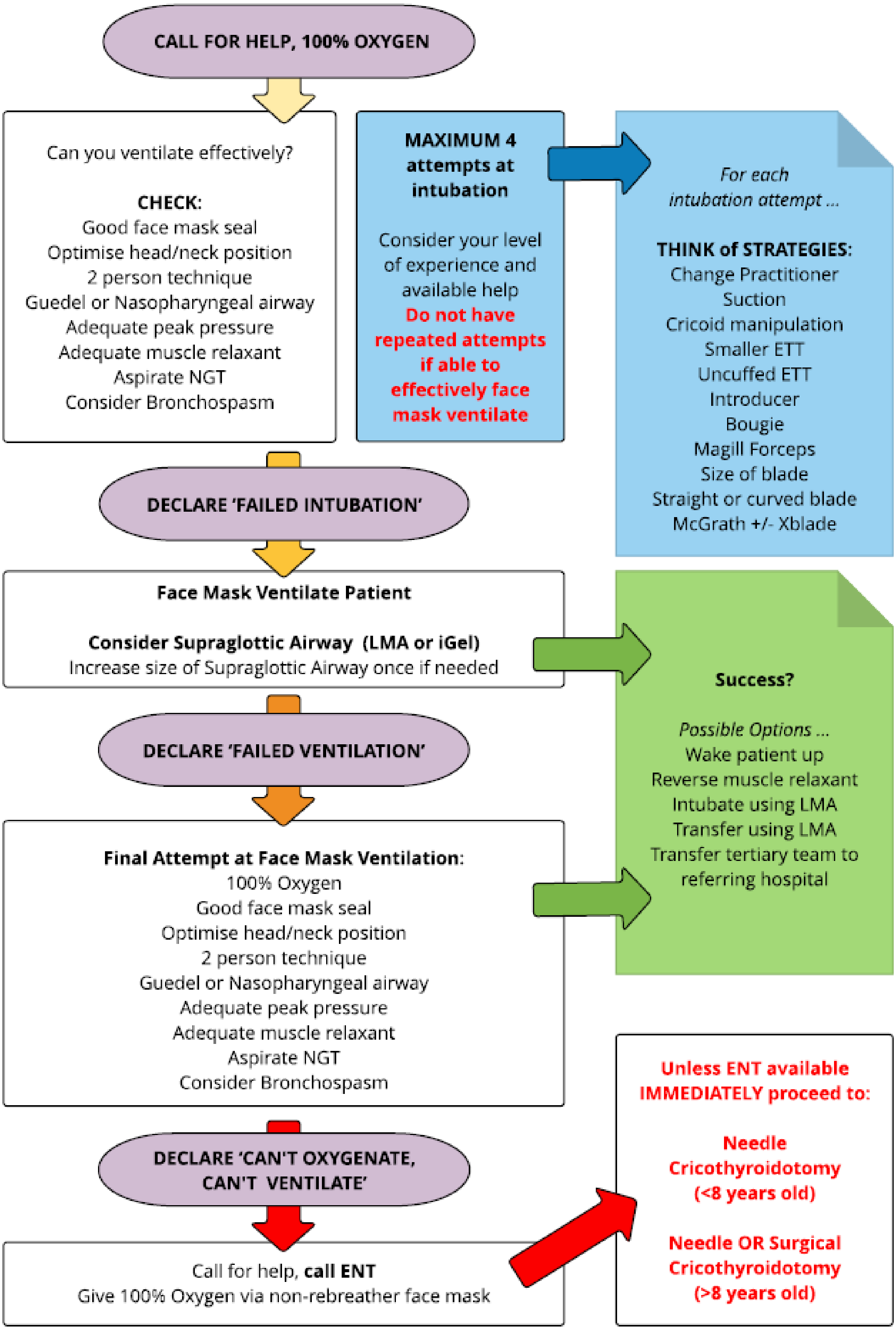
In an Emergency: Call 2222 and request the Resuscitation Team and ENT surgeon
Follow the Emergency Paediatric Tracheostomy Management Algorithm on reverse

Authors: Suvradeep Basu, Dan Gilpin, Julian Howes, Ian Braithwaite & Nia Evans

Appendix 2 – National Tracheostomy Safety Project Emergency Tracheostomy Management - Paediatric Bed Head and Algorithm



Appendix 3 Embrace Difficult Airway Algorithm



Appendix 4 Endotracheal tube sizes and positions

Neonatal Endotracheal Tube sizes

Age	Weight	ETT size	At lip (cm)	At nose (cms)	Suction (fg)
23-24/40	0.6	2.5	6	7	6
25-26/40	0.75	2.5	6.5	7.5	6
27-29/40	1.0	2.5	7	8	6
30-31/40	1.5	2.5	7.5	8.5	6
32-33/40	1.7	3.0	8	9	7
34-35/40	2.0	3.0	8	9.5	7
36-37/40	2.5	3.0 –3.5	8.5	10	7-8
38-39/40	3.0	3.0-3.5	9	11	7-8
Term	3.5	3.5	9.5	11.5	8

Paediatric Endotracheal Tube sizes

Age	Weight	ETT size	At lip (cm)	At nose (cms)	Suction (fg)
3 month	5.5	3.5-4.0	10	12	8
1 year	10	4.0	11	14	8
2 year	12	4.5	12	15	8
3 year	14	4.5	13	16	8
4year	16	5.0	14	17	10
6 year	25	5.5	15	19	10
8 year	31	6.0	16	20	10
10 year	37	6.5	17	21	12
12 year	43	7.0	18	22	12
14 year	50	7.5	19	23	12
Adult	60	8.0	20	24	12
Adult	70	9.0	21	25	12

Appendix 5 – AuraGain Placement Technique

The airway tube is held like a flute, with three fingers placed on the flat part of the bite absorption area and the thumb on the vertical line on the bite absorption area, which is oriented anteriorly toward the patient's nose. Your other hand should be placed under the patient's head.

Insert the tip of the cuff pressing upwards against the hard palate and flatten the cuff against it. Look carefully into the mouth to verify that the tip of the cuff is correctly flattened against the palate before proceeding – push the jaw gently downwards with your middle finger to open the mouth further.

As the tip of the cuff is placed correctly in the mouth opening, continue the movement by swinging the mask inward with a circular motion, pressing the contours of the hard and soft palate. Then advance the Ambu AuraGain into the hypopharynx until a definite resistance is felt The motion of the placement should be smooth. Do not use force.

The Ambu AuraGain should now be correctly located with its tip resting against the upper esophageal sphincter. For pediatric patients a partial rotational technique is recommended in case of placement difficulties.

After insertion, the vertical line on the airway tube should be oriented anteriorly towards the patient's nose. The typical range of intended depth insertion is marked by the two horizontal lines on the airway tube.
The AuraGain is inserted correctly when the patient's incisors are between these markings.
Reposition the mask if the patient's incisors are outside this range.
Without holding the tube, inflate the cuff with just enough air to obtain a seal.
Maximum inflation cuff pressures:
#1 – 4mls
#1.5 – 7mls
#2 – 10mls
#2.5 – 14mls
#3 – 20mls
#4 – 30mls
#5 – 40mls
#6 – 50mls
Inflate to a maximum of 60 cm H2 O. In many cases, only half of the maximum volume is sufficient to achieve a seal.
Check the cuff pressure with a cuff pressure gauge.

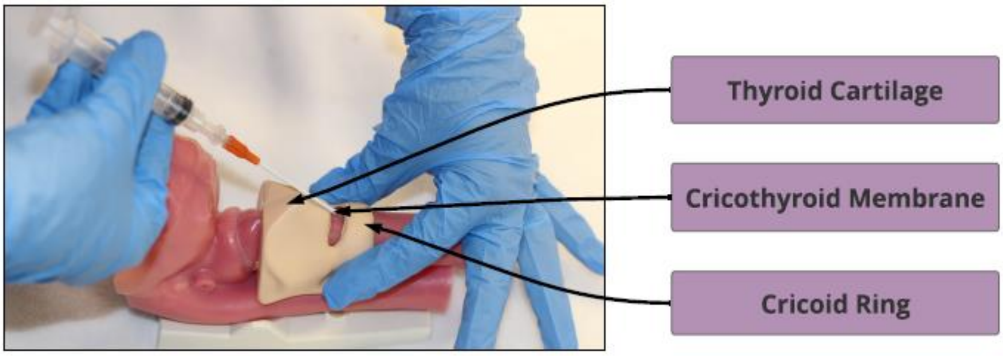
Appendix 6 – Embrace Needle Cricothyroidotomy Guide

Needle Cricothyroidotomy Guide

Embrace
Yorkshire & Humber Infant & Children's Transport Service

Gather Equipment:

Shoulder roll to extend neck
Large bore cannula (orange or green) attached to a 5ml syringe partly filled with saline
Non-rebreath face mask with 100% oxygen
Green oxygen tubing attached to a Y-connector



Identify cricothyroid membrane & clean site

Stabilizing the front of the neck with the left hand, insert cannula into trachea at 45 degrees with right hand, whilst aspirating for air

Advance cannula over needle into trachea

Remove needle, leaving cannula in place, re-aspirate air to confirm position

Attach green tubing to oxygen flowmeter and attach Y-connector to the cannula

Set oxygen flow: L/min = age in years

Occlude Y connector for 1 second and release for 4 seconds (passive exhalation)

If no chest wall rise, increase flow by 1 L/min until chest rise is observed

Check the neck to exclude swelling from injection of gas into tissues rather than trachea

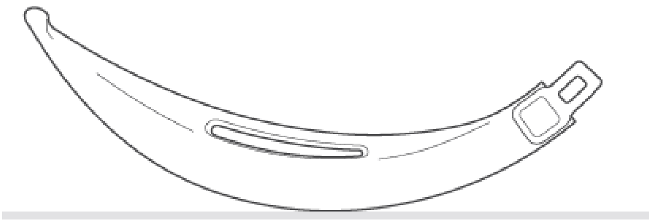
Place gauze under cannula and secure to neck with an occlusive dressing (i.e. Tegaderm / IV3000)

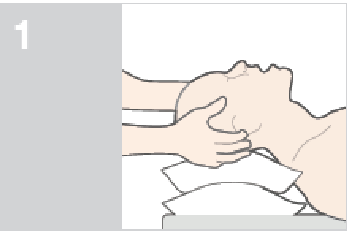
Plan for definitive surgical airway procedure

Appendix 7 - McGrath MAC Blade

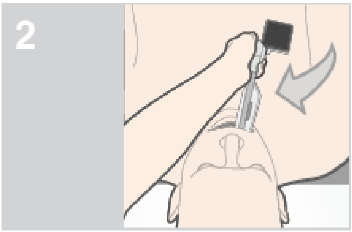
McGRATH®
MAC blade

USING THE LARYNGOSCOPE - McGRATH® MAC blade range

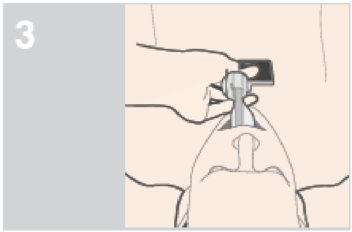




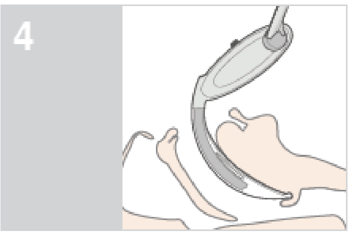
If possible, position the patient in the optimal position for direct laryngoscopy.



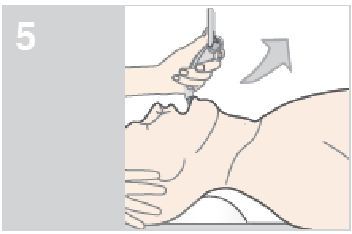
Look into the mouth; insert the blade into the right side of the mouth.



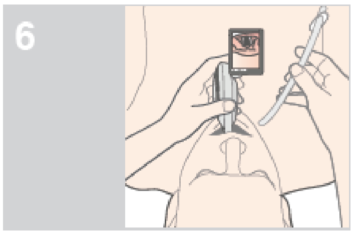
Move the device to a central position while sweeping the tongue to the left.



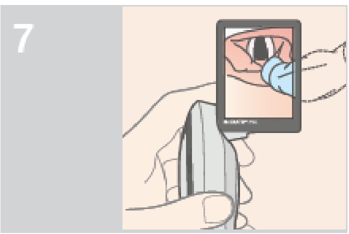
Advance the tip of the McGRATH® MAC blade into the vallecula.



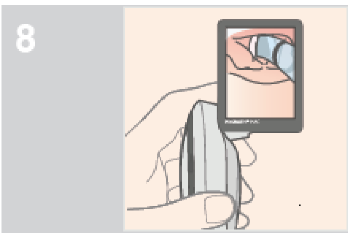
Visualise the epiglottis on the screen. Lift the anatomy forwards and upwards to expose a direct and indirect view of the glottis. When the device is in the optimal position the glottis should be viewed in the central upper section of the screen.



Advance the tube gently and atraumatically through the vocal cords. Tube placement can be performed either by looking directly in the mouth, indirectly on the screen or a combination of both(1).



Indirectly visualise the tube placement through the vocal cords. In optimal tube placement technique, the E.T. tube will enter from the right hand side of the display.

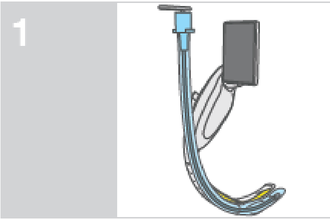


The screen view can be used to confirm the correct insertion depth of the endotracheal tube.

Appendix 8 - McGrath X Blade

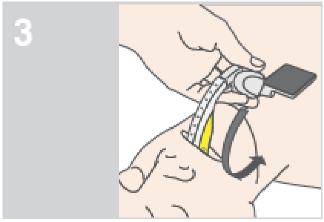
McGRATH®
X blade™

USING THE LARYNGOSCOPE - McGRATH® X blade™

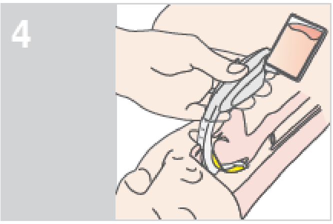


Load the E.T. tube onto a stylet(1) and form to the curvature of the X blade™.

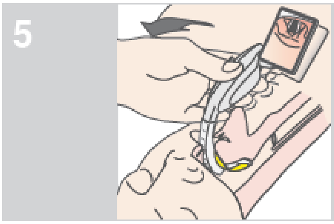
Where possible, elevate the patient's head into the "sniffing" position for optimal access.



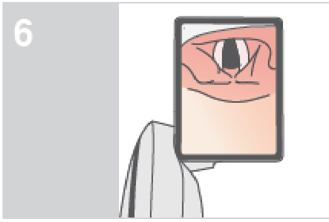
Using a mid-line approach roll the blade into the mouth. Ensuring the anterior side of the blade maintains contact with the tongue, advance the blade until the epiglottis is seen on the top of the screen.



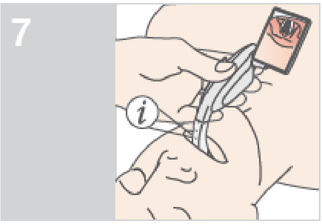
Place the tip of the X blade™ into the vallecula.



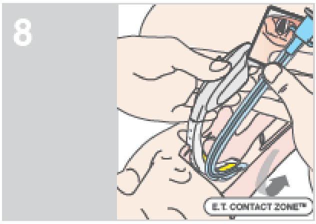
Using minimal force, rock the device back towards the user to lift the epiglottis and obtain an indirect view of the glottis.



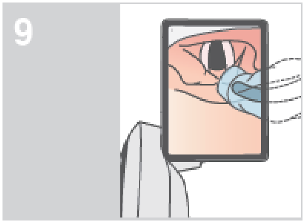
When the device is in the optimal position the glottis will be viewed in the central upper section of the screen(2).



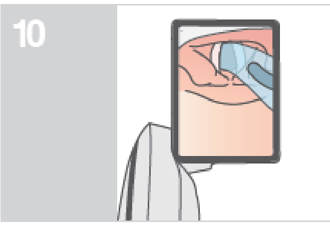
The DepthGuide™ numeric markings on the posterior side of the blade may be used as an indication of the depth of blade insertion(3).



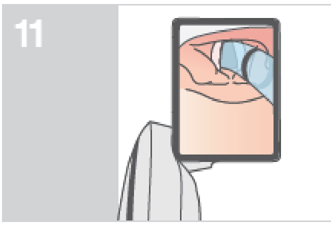
Insert the E.T. tube at the right side corner of the mouth. Advance in a rolling movement following the curvature of the blade, ensuring it maintains contact with the section of the blade labelled E.T. CONTACT ZONE™.



When using optimal technique, the E.T. tube should enter the screen on the right hand side; advance the tube until the tip is in front of the vocal cords.



Holding the stylet secure, slide the tube off the stylet and through the cords, ensuring the stylet does not pass through the cords. Once the tube has passed through the cords remove the stylet completely.



The screen view can be used to confirm the correct insertion depth of the endotracheal tube.

(1) Clinical experience has shown that intubation without any introducer, or with a bougie, will not facilitate optimal tube placement.
(2) It is important not to advance the blade too deep in order to maintain maximum space to facilitate the E.T. tube placement.
(3) Reference to these numbers can be useful during training to avoid inserting the blade too far.

References

1: Advanced Resuscitation of the Newborn Infant Skills Station: Advanced Airway

2: Schmidt AR, Weiss M, Engelhardt T. The paediatric airway: Basic principles and current developments. Eur J Anaesthesiol 2014; 31:293–299

3: Jagannathan N, Sohn L, Fiadjoe JE. Paediatric difficult airway management: what every anaesthetist should know! Br J Anaesth. 2016 Sep;117 Suppl 1:i3-i5.

4: DASGuidelines https://das.uk.com/guidelines/das_intubation_guidelines

5: O'Shea JE, Thio M, Owen LS, et al Measurements from preterm infants to guide face mask size Archives of Disease in Childhood - Fetal and Neonatal Edition 2016;101:F294-F298.

6: Doherty C, Neal R, English C, Cooke J et al. Multidisciplinary guidelines for the management of paediatric tracheostomy emergencies. Anaesthesia. 2018, 73: 1400-1417.