



British Association of  
Perinatal Medicine



# Managing the Difficult Airway in the Neonate

Resource Materials  
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**Cover Photo:** Photo shows a baby with a difficult airway being ventilated using a supraglottic airway device and is published with parental consent. Published with kind permission of Joyce O'Shea

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### Useful Information for implementation of the BAPM framework

This resource materials document is designed to be read in conjunction with the BAPM framework for managing BAPM framework for managing the difficult airway in the neonate. It is intended primarily for nominated Neonatal Airway Leads to aid discussions around logistics and procurement issues when implementing the framework for practice but may help anyone who is working with neonates and may be called upon to manage a difficult airway. Where specific courses, approaches or equipment are mentioned, this is **not** endorsement or recommendation over other available products. The neonatal airway leads will be responsible for which products/training they institute at their centres as there will be multiple factors which inform these decisions (such as cost, familiarity, availability, use elsewhere in the clinical environment).

## Examples of specific conditions which might present with an airway difficulty: 'trigger list'

The following is a list of conditions/syndromes which can present an airway challenge in the neonatal period. Awareness of an association of these conditions with a potentially difficult airway can allow for planning for this circumstance ahead of the need arising to address it.

1. External airway compression from neck masses including:
  - a. cystic hygroma
  - b. vascular malformations/ vascular ring
  
2. Structural compromise to the airway including:
  - c. laryngomalacia
  - d. laryngeal cysts
  - e. subglottic stenosis
  - f. laryngeal web
  
3. Craniofacial structural abnormalities including cleft palate, craniosynostosis and syndromes affecting maxillofacial structures including (but not exclusively):
  - g. Pierre Robin sequence (most common)
  - h. Stickler syndrome
  - i. Down's syndrome
  - j. Beckwith-Wiedemann syndrome
  - k. Treacher-Collins syndrome
  - l. Goldenhar syndrome
  - m. Crouzon syndrome
  - n. Apert syndrome
  - o. Rubinstein-Taybi syndrome
  - p. Klippel Feil syndrome
  - q. achondroplasia
  - r. fibrodysplasia ossificans progressive
  
4. Neuromuscular abnormalities including:
  - s. global hypotonia
  - t. severe limb and muscle contractures restricting jaw opening e.g. arthrogryposis

The occurrence of a 'difficult airway' from any single condition is rare in a population sense. For example, tracheal atresia (an example of congenital airway anomaly) occurs in around 1 in 50000 livebirths. However, the quoted total incidence of incidents occurring around intubation <1year of age may be as much as 0.6%<sup>1</sup> emphasising the importance of good skills training and preparation for the difficult airway.

## Human Factors

Human factors are the physical and mental characteristics of people along with organisational factors that can influence the outcome in healthcare. The Clinical Human Factors Group ([www.chfg.org](http://www.chfg.org)) was established following the tragic death of Elaine Bromiley who had airway difficulties in theatre. There are excellent resources on this site.

Managing a baby with a difficult airway has the potential to be extremely stressful. Multiple teams may be working together in a pressured environment and clear communication of plans is essential.

The human factors surrounding the management of the difficult airway can be thought of in the following areas: (these are based on the clinical human factors group classification)

- Organisational factors: including systems, workforce and training
- Individual factors: including teams, safety, contributory factors, and design

## Organisational factors

### Systems

Hospitals are complicated places. They are often large and involve different teams of people working in different environments. Babies with a difficult airway may be managed on a delivery suite, in an obstetric theatre, in a paediatric anaesthetic room, or on the neonatal intensive care.

It is important to think about how these systems work together locally when planning a difficult airway guideline. It is important that teams are aware where key equipment can be found, how to access help quickly and how to efficiently move a baby to the most appropriate location if required.

Examples of systems that are involved in managing a difficult airway are:

- Equipment: is the right equipment available, working and checked. Is there additional unnecessary clutter that may cause confusion? Does everyone know where the equipment is?
- Bed Space / Room design: Can the team get to the airway; can you get the baby out of the incubator quickly (particularly challenging in a transport environment). Can you call for help easily (alarms/ buzzers/ presence of a phone line)
- Signage: Can your theatre team find your unit quickly in an emergency?
- Guidelines: Do you have a guideline? Do your team know about it? Can you make it more accessible (e.g using tablets, smartphones, shortcuts on unit computers) Can you get to the important algorithms quickly?

It is worth looking at your own facilities and considering whether the systems in place are appropriate or could be improved. Remember that a difficult airway may occur in a location away from your usual workplace and think about how you would manage this- do you plan to have mobile equipment, or multiple difficult airway boxes for different locations?

### Workforce

Intubating a small baby can be challenging, when considering the management of the difficult airway, thought should be given to the workforce. What staff are available locally and elsewhere in the hospital? What is their level of experience? How should additional help be summoned and how quickly can help be available?

From a neonatal perspective, this might include what resources are available in individual units, but it is also worth considering transport services and advice from larger centres.

### Training

Most neonatal airways can be managed easily with a face mask, and difficulty in intubation is relatively rare.

It is important to train and practice skills regularly so that when a critical event happens, the right care can be provided. All members of the multidisciplinary team need to be able to access appropriate training. Training for the management of the difficult airway can be done in many ways. There are specific courses (for example the MPROVE academy Neonatal Airway Skills course<sup>2</sup>), regional multi-departmental training (for example completed by the Make the Airway Safe Team (MAST)<sup>3</sup>) and national life support courses such as the Newborn Life Support Course and the Advanced Resuscitation of the Newborn Infant Course<sup>4</sup>,

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run by the Resuscitation Council UK, which have a major emphasis on airway management. The Vortex approach<sup>5</sup> is a specific approach to managing the difficult airway used in some adult centres but is not promoted as a tool for paediatric or neonatal airway management.

Training using 'skills drills' and task trainers can be useful to allow staff to familiarise themselves with equipment that they may only rarely use.

Simulation programs, using simulation centres or in situ simulation can allow teams to practice together and can provide an invaluable training in communication and human factors as well as allowing staff to practice clinical skills. Regular practice is the key.

## Individual Factors

### Team working

Clinical teams need to work together to get the optimal patient outcome. The situation can become more complex for a team looking after a baby with a difficult airway. There may be team members from different backgrounds who don't usually work together: ENT surgeons, anaesthetists, neonatologists, operating department practitioners and nursing staff.

### Leadership

Clear leadership needs to be established and verbalised. All communication and suggestions should be directed through the team leader, and it can help situational awareness if the team leader is not involved in performing 'hands on' practical skills.

It is helpful for the team leader to set the direction and strategy: for example:

- 'The anaesthetist will have one more attempt to intubate- if this is not possible, the next step is to try a video- guided intubation. If this is not successful we will aim to move to theatre to prepare surgical options.'

### Followership

Equally important is the concept of good followership: this is the ability to provide information and suggestions, to the leader and wider team, without being obstructive, remaining calm and focussed on the goals.

Communication between team members, needs to be specific, to a named individual and its useful to check understanding. There are ways of doing this, including 'communication receipts,' repeating back the instruction, or using a 'Challenge and Response' style particularly when using algorithms and checklists.

Team members should be aware about the common human factors that often lead to error:

- Confirmation bias: This is the tendency to look for information that fits with previous experiences rather than having an open mind. An example might be 'The end tidal CO<sub>2</sub> capnograph is not changing colour: this must be because the baby is preterm' rather than considering the option of unrecognised oesophageal intubation.
- Lack of situational awareness: It is important for the team leader to keep a 'global overview' of what everybody is doing. It is surprisingly easy not to notice things in a stressful situation: an example might be a ventilator oxygen disconnect alarm that isn't noticed as the team are busy with other tasks.
- Cognitive factors: Humans can only cope with a certain amount of information before they become overloaded. If this is happening, taking a pause and asking 'can anyone see anything I have missed?' can be helpful
- Task fixation: It is easy to become overly focussed on a task that isn't the most important: an example would be going through the ventilator settings in detail and not noticing that the tracheal tube has become disconnected.
- Distractions and interruptions: these can significantly affect the effectiveness of a team and can often be simply resolved. Once acknowledged, silence alarms, avoid unnecessary side conversations and ask staff who are not actively involved or required to leave or step back.



- Fatigue and stress: The effect of fatigue and tiredness on psychomotor skills is often underestimated by healthcare professionals: is the consultant who has been up all night the best person to attempt a complex intubation?

### Improving team communication

There has been increasing work looking at ways to reduce clinical risk and a number of these can be applied to management of the difficult airway. Team working techniques that are particularly useful include:

- The use of team 'huddles' and hand overs on every shift and as required to identify babies at risk of having a difficult airway
- At the start of a complex procedure, use the 'safer surgery check list' principles on the unit: for example, team members give their name and role, team roles are identified, and plans are clarified, with a pause so that all team members are empowered to raise concerns.
- Using standardised guidelines and checklists and verbalising these out loud. When designing local difficult airway guidelines, it is very useful to have a laminated sheet in the difficult airway box that is read out loud with a 'challenge and response' An example would be. "We are at Plan B, we can't ventilate effectively with a mask. Let's check the following: Head position, presence of NG tube, Neopuff set in 100% oxygen, mask size and hold, check help has been urgently called' with a confirmed verbal response after each question.
- Using a 'Stop the line' command. It can be helpful to have a standard command to 'stop the line' if any team member has a concern about safety. If this command is given, all team members stop what they are doing, the team leader checks and gives appropriate instructions. This can be useful to make sure that critical problems are heard and acted on. An example might be 'Stop the Line! The arterial line has been knocked and is bleeding.'

### Declaring the emergency

One specific moment of communication with particular importance in management of the difficult airway is the moment of declaring the emergency. Delay in instigating response to an emergency situation in a team can occur when no-one 'states the obvious', or overtly recognises that an emergency is happening. A specific comment, much like the 'stop the line' command can bring everyone in the team to alignment and to allow a specific process to then be followed by the whole team for the benefit of the patient. There is no clear evidence to support any 'absolute' when a difficult airway situation should be declared in neonatal practice. The linear nature of response in most centres to a neonatal emergency (junior staff attend first, followed by increasingly senior staff until a team is assembled) means that there may be multiple attempts at managing a baby's airway, or intubation, by inexperienced staff creating the impression of a difficult airway without there being any actual problem (anatomical or otherwise) for it to be a 'true' difficult airway. In these circumstances, what the baby needs is actually a skilled member of staff to manage the 'normal' airway with conventional techniques.

For the difficult airway emergency to be declared, we therefore recommend that this occurs when an **experienced** intubator has had two failed attempts to intubate the baby OR judges the airway to be a difficult airway. For most centres, this will likely be a Paediatric or Neonatal Consultant, but may also include senior anaesthetists, respiratory or ED physicians, depending on the staff in any given centre. **This threshold should be decided locally** and be clear and agreed in the centre to allow everyone to be aware when the difficult airway process should be instigated.

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At the point that it is clear that a difficult airway situation is at hand, any team member can declare “**This is a difficult airway situation**” aloud, to align the team and begin dealing with the process of following the framework algorithm.

## Challenge and Response

The framework algorithm template is written specifically to make use of 'challenge and response' technique during a difficult airway situation. Conventional uses of 'checklists' in healthcare either rely on a pause to check that a process has been completed before starting a procedure (for example the WHO surgical checklist) or training beforehand which teams rely on to have recall of the process during the event (such as the NLS algorithm). For regularly encountered situations the latter can work well, and the former is good for ensuring coherent team working in a task to come, but neither approach works well in rare, high-stress situations outside usual practice.

The challenge and response paradigm relies on one team member speaking out loud (challenge) set text to the team (most often questions/statements) in a stepwise fashion moving through a defined series of clinical steps, which require confirmation (yes/no response) at each stage. This ensures that the team move forward through escalating levels of care in a coordinated way to a defined plan giving the best opportunity for a successful outcome. It moves the algorithm from a reference tool to an active intervention. Use of this technique is key to successful use of the framework algorithm.

### The three-question (Q<sup>3</sup>) approach

Along with challenge and response, progressing through the algorithm, especially to the point of secondary intubation attempts (Plan C) and beyond to rescue techniques requires the team to be able to consider the reasons for not being able to achieve a managed airway at that moment, in a structured fashion. There are a number of techniques (for example verbalisation of actions during skills tasks such as intubation, micro-summaries after intervention) that can help in team alignment when coupled with the dyad of good leadership and followership, in order to allow a team to work out why something is not working and how to move forward. One specific approach which is taught on the difficult neonatal airway course run by the MPROVE academy, is to ask three key questions at each stage of failed intervention. These (Q<sup>3</sup>) are:

- Is intubation or a rescue technique really needed immediately, or can we achieve ventilation/oxygenation with the technique we are using now?
- IF there is a decision to attempt again to intubate the baby (secondary intubation in particular), what was the likely reason for the first attempts failing?
- What therefore needs to change to improve the chances of success (and how to correct this)?

The first question is particularly pertinent if only a junior team is present and is less likely to be answered positively in a true difficult airway situation as its primary aim is to prevent multiple unnecessary attempts at intubation. Consideration by the team of the second and third questions is sensible when approaching the difficult airway at any point of action from Plan A to Plan D.

## Safety Culture

Having an open safety culture on the neonatal unit is important to aid recognition of potential risks and threats to patient safety.

Safety can be designed into the day to day working of neonatal units. Examples might include:

- The use of safety huddles to identify potential risks
- A 'no blame' open culture where staff are actively encouraged to raise concerns
- When near misses occur they are reported appropriately and action plans are carried out effectively. It can be helpful to feed any latent threats to patient safety identified during simulation and training into the unit governance processes.

Following any acute difficult airway, a 'hot debrief' can be a rich source of practical and useful data to improve team performance. There are many models- an 'after action review' rapid debrief is particularly useful in these settings.

Once problems are identified, it is important to embed new changes quickly, communicate rapidly with the whole team and to check that changes are in place and working

Checklists can be useful before key interventions: a simple pre- intubation checklist can prompt staff to consider the risk of a difficult airway, and check that difficult airway equipment is available and ready for use.

## Summary

When considering the management of the difficult airway it is important to consider human factors at a number of stages, including organisational factors and individual factors. An understanding of how humans behave under stress and common error that occur can help to improve team performance.

## Equipment

It is important to plan for a potentially difficult airway. Managing a baby that is difficult to ventilate has the potential to be extremely stressful and appropriate equipment should be immediately to hand, checked and ready for use.

Difficult airway equipment will only rarely be needed on a neonatal intensive care unit, and it is important that equipment is accessible quickly and that neonatal teams know what equipment is available and how to use it. It is likely that for any given clinical area, a mobile difficult airway equipment trolley or box will be useful, and that where two different specialties may share responsibility, as much common equipment as possible is used. Where teams are called for later elements of the airway algorithm, they should have a mobile system to bring their own, familiar equipment where possible.

When planning equipment, it is useful to think about where that equipment is to be used. There is often the temptation to include large amounts of equipment that may not be needed. This can cause confusion and delay.

Theatres: In hospitals that provide neonatal surgery, there is likely to be a difficult airway trolley in the anaesthetic department. The difficult airway society has produced guidance for managing the difficult airway in a theatre setting in both adults and paediatrics:

[https://www.das.uk.com/files/Difficult\\_airway\\_trolley\\_DAS.pdf](https://www.das.uk.com/files/Difficult_airway_trolley_DAS.pdf)

Theatre equipment may include video assisted intubation devices, and equipment for emergency tracheostomy. It may be less helpful to have this equipment on the neonatal intensive care unit. The exact choice of equipment will vary depending on the local availability of staff and expertise. There is also a benefit in neonatal operational delivery networks (ODNs) having a joint approach to the management of the difficult airway.

On the neonatal unit, the equipment required in a difficult airway box *in addition* to that which should be on a standard neonatal resuscitation trolley, can be considered under the following headings:

- Guidelines
- Video Assisted Intubation
- Different Types of laryngoscope blade
- Neonatal Bougies / Magills Forceps
- Supraglottic Airway Devices
- Equipment for ENT intubation and/or a surgical airway (see below)

## Guidelines

Managing a difficult airway can be challenging. There is a risk that the team may become fixated on the task of intubation and may lose sight of the evolving clinical situation. The framework algorithm describes the airway strategy and options to help the team retain focus.

It is helpful for the algorithm to be laminated and presented in a way that allows it to be read out loud during the emergency so that all options are appropriately considered.

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There is increasing evidence that the use of checklists is useful in enhancing patient safety. Consideration should be given for having a 'preintubation checklist' available in the difficult airway box.

## Video Assisted Intubation

There are 2 types of video assisted intubation devices available.

1. Anatomically shaped devices: These are designed with an anatomical curve and can be useful if it difficult to visualise the vocal cords. The Glidoscope™ (Pic 1) comes in a neonatal size and can be very useful in a difficult

A less costly alternative that may be more appropriate in Local Neonatal Units or Special Care units would be a single use device such as the Airtraq™ (Pic 2) which has a similar shaped blade.



Pic 1. Published with kind permission of Verathon



Pic 2. Published with kind permission of Airtraq

2. Standard blade video laryngoscope: These have a shape similar to a standard laryngoscope. They do have a magnifying camera and often provide a clearer view of the airway. There is increasing evidence that they increase the chance of successful intubation. There are 2 common examples used in UK units.

- a. The Infant View System (Pic 3): This has the advantage that blades are made to the smallest size, including 00 blades suitable for the smallest preterm infants.



Pic 3. Published with kind permission of Joyce O'Shea

b. The Storz CMAC system is similar (Pic 4)

Both of these have the advantage that the motor skills required to intubate are the same as a standard laryngoscope and staff do not need to learn a new technique. These devices can be invaluable in teaching the skill of intubation on the neonatal unit.



Pic 4. © KARL STORZ – Endoskope, Germany

### Different Types of Laryngoscope blade

Most neonatal units routinely use Miller or Wisconsin 'flat' laryngoscope blades for infant intubation.

In the event of a difficult view, a curved Macintosh style blade may be helpful. This blade has a wider shape and can be useful in larger babies, particularly if the tongue is obstructing the view.

The Seward blade is wider than a standard Miller blade and may be helpful in larger babies.

Blades are now available as single patient use items and it is worth having at least one different shape of laryngoscope blade available.

### Neonatal Bougies

A bougie can be useful when a partial view of the vocal cords is obtained. This can be passed through the vocal cords and a tracheal tube 'railroaded' into place. Bougies are extensively used in adult and children's anaesthesia but less used in the neonatal setting. It should be noted that a bougie is different than a 'stylet' used to stiffen a tracheal tube. A stylet should not be used as a bougie, as tracheal perforation has been described as a complication of injudicious stylet use.

### Supraglottic Airway Devices

Supraglottic airway devices can be invaluable when it difficult to ventilate a baby with a mask. There is increasing evidence about their role in neonatal resuscitation and they have been shown to be an effective way to ventilate infants. There are two types of devices, those with an inflatable cuff such as a laryngeal mask and newer supraglottic airway devices such as the i-gel™ (Pic 5 include gels with thermoplastic properties: These are easy to insert and do not require cuff inflation.)





Pic 5. Published with kind permission of Intersurgical

### Detection of exhaled carbon dioxide

In situations where the trachea has been intubated, the use of exhaled carbon dioxide detection is gold standard in confirming that the tracheal tube sits within the airways. In adult and paediatric practice, especially in the context of intubation in theatre, there is widespread access to, and experience in interpreting, waveform capnography. Anaesthetists consider this technique the benchmark and its use in their day-to-day practice of intubation and management of invasively ventilated patients is mandatory.

In neonatal situations, waveform capnography has yet to be proven as superior to other methods of detecting exhaled CO<sub>2</sub> (for review see Dempsey et al<sup>6</sup>). In the context of the unexpectedly difficult airway in non-anaesthetic environments, availability, and familiarity of neonate-appropriate colour-change devices may mean they are preferable in the first instance.

A recent study suggested colorimetric CO<sub>2</sub> detectors used in neonatal practice would not be as sensitive as waveform capnography in confirming presence of exhaled CO<sub>2</sub>, but this was based on measured levels of CO<sub>2</sub> detected using a capnograph referenced against the quoted manufacturer's thresholds for colour change rather than device comparison. The extra time to reach the slightly higher levels of CO<sub>2</sub> was also in the order of seconds and therefore not likely to be a disadvantage in the process of establishing whether there was exhaled CO<sub>2</sub> present<sup>7</sup>.

Exhaled CO<sub>2</sub> detection may also have some utility in confirmation of effective ventilation, by mask or supraglottic devices. Other limitations around tidal volumes generated in the smallest babies may exist in neonates which are not present in older patients<sup>8</sup>.

Most UK neonatal teams<sup>9,10</sup> have access to colorimetric devices which can be inserted inline in a hand-ventilating circuit to provide continuous detection of exhaled CO<sub>2</sub>, though the number with access to waveform capnography is also increasing. As with all devices, the limitations of use must be known and interpretation of a colour change (or lack thereof) put into the context of the problem at hand. For example, lack of colour change in conjunction with a normal laryngeal inlet at intubation, but inability to advance the tube more than a centimetre or so, may indicate a high obstruction such as tracheal atresia. However, contamination of the membrane with liquids such as adrenaline, or failure to give adequate ventilation after intubation and allow time for the CO<sub>2</sub> to reach the detector might be misinterpreted without correlation with other clinical features at the time of intubation such as heart rate, misting in the tube, and visible chest movement.

It is essential, whichever method of detecting exhaled CO<sub>2</sub> is used, that team training ensures that no fixation errors occur in the team as a result of using the device. Further research is likely to provide more information about what type of CO<sub>2</sub> detection is best for neonates, limitations therein, and help ascertain when to use which technique.

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It is expected that in any centre where a baby might require intubation, the standard resuscitation and intubation equipment for neonates available would include a method for detecting exhaled CO<sub>2</sub> to be used at all intubations. In the context of this framework for managing the difficult airway, the locally preferred device should always be available to be used in circumstance of a difficult airway. It is recommended that the chosen device should always be available in the difficult airway box in addition to being present in the 'standard' resuscitation or intubation equipment.

## Surgical options

An emergency neonatal surgical airway carries significant risk. Wherever possible, a surgical airway should be performed by a paediatric ENT surgeon in an operating theatre.

Attempts to perform emergency surgical procedures carry a much higher risk in an infant than a child or adult and are associated with a high failure rate, mortality, and morbidity. They should only ever be attempted as a last resort. The techniques listed here are for interest and to allow non-surgical elements of a difficult airway team to appreciate the techniques and equipment their ENT colleagues are likely to use in a difficult airway situation.

### ENT surgical techniques and equipment

In certain circumstances, equipment utilised by ENT surgeons can help secure an airway where standard and advanced neonatal techniques have not succeeded. If there is an anticipated difficult airway then pre-emptive preparation in terms of the most appropriate location, notification of teams and preparation of equipment is critical. These techniques are best deployed in a theatre environment.

ENT airway equipment is mostly focused on rigid and straight instruments. These have the advantage of being able to negotiate around large masses such as a cyst obstructing the airway, to achieve intubation. In the case of a micrognathia these techniques can also be helpful.

There are two main options in these circumstances:

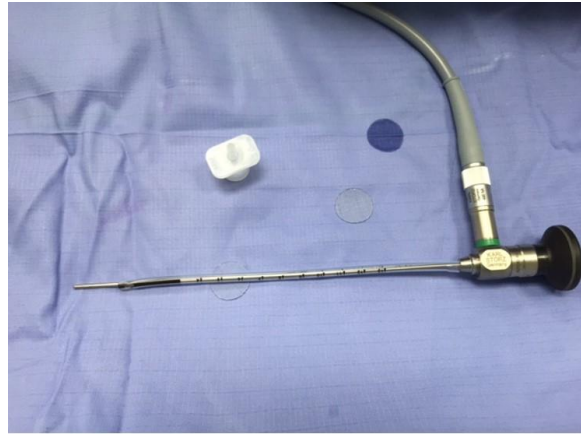
- Rigid endoscopic (eg Hopkins rod) visualization of airway and intubation with tracheal tube
- Ventilating bronchoscope

### Endoscopic visualization of the airway ('ENT intubation')

The Hopkins rod-lens endoscope system is one example of the equipment that may be used. It consists of a series of glass rod lenses separated by air and fiberoptic bundles surrounding the lens for transmission of light. Other examples include angled rigid endoscopes which may be used with the more anteriorly placed larynx (such as a Bonfils or Brambink endoscope).

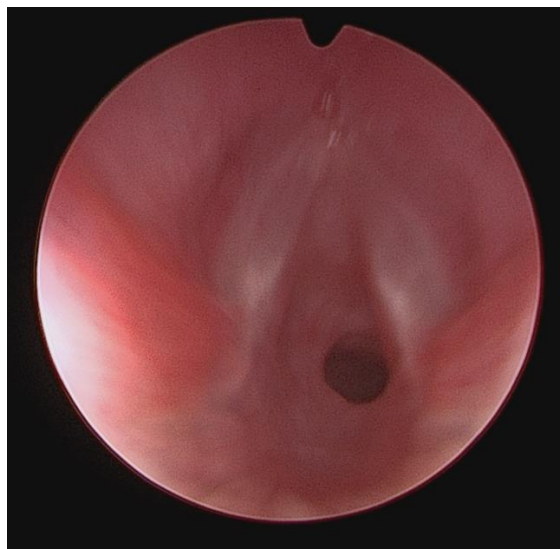
The endoscope is used in conjunction with a straight or curved blade laryngoscope. The laryngoscope is introduced to elevate the tongue and visualization of the supraglottis, glottis and subglottis can be achieved. In the case of an emergency airway, a tracheal tube can be cut at its proximal end so it fits over the length of the Hopkins rod. In a more controlled situation it is helpful to oxygenate via a separate tracheal tube placed as a nasopharyngeal airway, and volatile anaesthetic can also be delivered through this depending on the anaesthetic technique. Spraying of the cords with local anaesthetic will prevent laryngospasm. If there is micrognathia, the rod can be introduced from a low lateral angle at the corner of the neonate's mouth, which will achieve an easier angle of approach to the glottis. When entry into the trachea is confirmed by visualization of the tracheal rings, the tracheal tube can be advanced over the Hopkins rod and then connected to the breathing circuit.

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**Pic 6:** Tracheal tube next to Hopkins Rod

**Pic 7:** Tracheal tube mounted on Hopkins Rod



**Pic 8:** View from a Hopkins Rod: subglottic haemangioma

**Pic 9:** View from a Hopkins Rod: subglottic stenosis



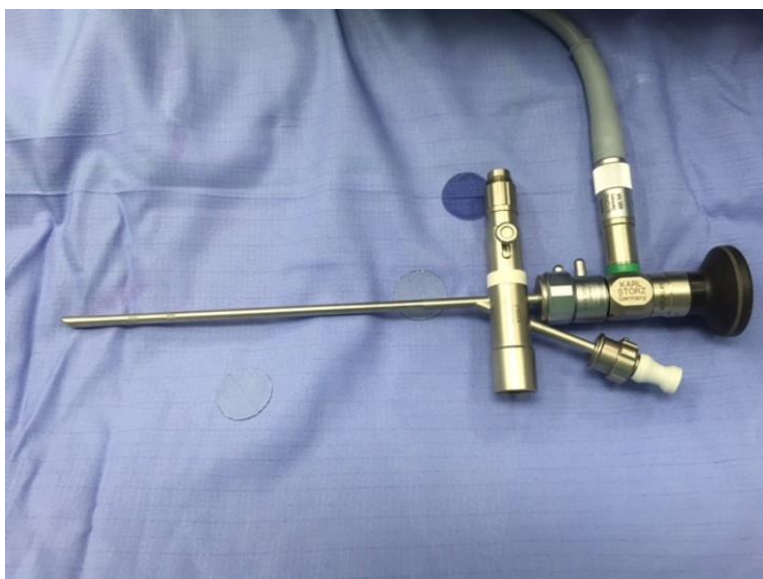
**Pic 10:** View from a Hopkins rod: congenital laryngeal stenosis

Pics 6-10 published with kind permission of Steven Powell

Small endoscopes are not designed to be bent and if they are angled too much the lenses will fracture, the view will be lost, and the endoscope will require repair. If a more rigid system is required then a ventilating bronchoscope should be used.

### Ventilating Bronchoscopes

Ventilating bronchoscopes consist of rigid metal outer tubes which contain openings to allow anaesthetic tubing connectors, insertion of a Hopkins rod, insertion of a suction catheter and a light source. A Hopkins rod is placed within the more rigid outer shell of the bronchoscope and this enables negotiation around masses or through narrower spaces with visualization at the tip of the bronchoscope. The bronchoscope is introduced using a laryngoscope in much the same way a tracheal tube would be. When it is introduced through the glottis and the tracheal rings are visualised, the anaesthetic circuit can be connected and the bronchoscope will function like a tracheal tube. As this is a rigid metal tube it cannot stay in the airway beyond the initial securing of the airway but could be exchanged for a tracheal tube over a bougie, or if it was felt a tracheostomy was required and exchange of the tube was felt to be too risky, a tracheostomy could be carried out.



*Pic 11. Ventilating Bronchoscope. Published with kind permission of Steven Powell*

If facemask ventilation is working and rigid and conventional airway instruments are not obtaining an adequate view, in rare circumstances such as severe micrognathia, a fibreoptic intubation over a flexible bronchoscope trans-nasally may be possible. If the tracheal tube cannot be railroaded using the bronchoscope directly, a radiological guidewire might be passed through the suction port of a small bronchoscope to lie in the trachea, and then used to guide the tracheal tube into place.

### Equipment for a surgical airway

In specialist centres, staff and equipment may be available for establishing an emergency neonatal surgical airway. An emergency neonatal surgical airway carries significant risk. Wherever possible, a surgical airway should be performed by a paediatric ENT surgeon, in an operating theatre and it is acknowledged that it is not a realistic treatment option in most centres without specialist surgical input. In emergency cases (where there is little or no stability of the patient) front of neck airway may be attempted by a suitably qualified and experienced surgeon outside the usual operating environment.

## Anatomical Considerations

The laryngeal and cricoid cartilages in neonates are smaller and more difficult to feel than older children and adults. This can make localization of anatomy difficult. The cricothyroid membrane in neonates has been found to have a mean height of 2.6 mm and a mean width of 3.0mm<sup>11</sup>. This means that it is difficult to localise and it certainly would not be possible to put a conventional tracheal tube through this area.

## Needle Cricothyroidotomy

Needle cricothyroidotomy and tracheostomy tube placement are considered 'front of neck airway' (commonly abbreviated to FONA in some specialities). The small size of the cricothyroid membrane and the neonatal subglottis meant that any type of cricothyroidotomy is unlikely to be effective and will be less successful than other airway visualisation techniques as shown above.

**We do not recommend needle cricothyroidotomy being attempted as part of the neonatal difficult airway process.**

The only group of specialists likely to be able to accurately perform a needle cricothyroidotomy successfully are paediatric ENT surgeons, and they will choose either direct visualisation of the airway or tracheostomy as rescue techniques.

It is recognised that some centres may historically wish, however, to keep needle cricothyroidotomy as part of their centre approach to the difficult neonatal airway. If it is decided by the designated Neonatal Airway lead and their colleagues that needle cricothyroidotomy will be part of their local approach to the management of the difficult neonatal airway, then this needs to be risk assessed and agreed locally acknowledging it is outside the recommended approach in the Framework document. It must be explicitly stated in the local version of the Framework algorithm **who** is expected/allowed to use the technique. The equipment to be used locally must be clearly labelled so that there is no ambiguity in its purpose. Those who may be required to undertake the procedure must all follow an agreed common stepwise process to attempt the procedure. The procedure is of sufficiently high risk and likelihood to be unsuccessful that it warrants a separate set of instructions to be followed during the attempt, which should be included in the difficult airways equipment box. It will be the responsibility of the named Neonatal Airway lead to ensure that their colleagues have both the appropriate training to attempt the procedure and maintain evidence of appropriate maintenance of this skill.

**Given the difficulty of this technique and that it is unlikely to work, we cannot recommend that anyone other than a surgeon who has been appropriately trained and is appropriately experienced to perform this procedure in the neonate (ideally an ENT surgeon) should attempt it.**

Complications of front of neck airway include:

- Bleeding
- Surgical emphysema of air
- Incorrect placement of cannula into lateral tissues or into oesophagus (through back wall of the trachea)
- Oesophageal perforation

- Pulmonary barotrauma or pneumothorax
- Subglottic oedema/ stenosis

There are a wide range of commercially available systems for needle cricothyroidotomy<sup>12</sup>. It is important to ensure that your unit has a system that they are happy with and that staff have regular opportunity to practice via simulation on animal or synthetic models.

It is important to state that the circumstances in which this procedure are likely to be undertaken will be extremely stressful. Clinicians are unlikely to be criticised for making the best attempt at front of neck airway to the airway when other methods have failed, though it is unlikely that it will succeed.

## Tracheostomy

An ENT surgeon with appropriate experience is most likely to opt for an emergency tracheostomy. The technique is included here for interest.

After fixing the larynx with the non-dominant hand, the cricoid is identified and the incision begun below this level. A vertical incision sequentially through skin, fat, strap muscles and thyroid isthmus is made. Care is taken to stay in the midline. A vertical incision through the 2 to 4th tracheal rings is made and an appropriate-sized tracheostomy is inserted. In more controlled circumstances where ventilation is being achieved it may be possible to insert stay sutures into the tracheal wall which can be used to reopen the stoma should the tube be displaced, as well as one or more maturation sutures which close skin to tracheal stoma. In an emergency “crash” situation this may not be possible.

## Tracheostomy tube care and emergencies

It is prudent for all centres routinely caring for children of all ages with tracheostomies (newly fashioned or established) to have emergency protocols for dealing with tracheostomy-specific issues and difficulties in managing the airway in patients with tracheostomy. There are excellent resources available at the National Tracheostomy Safety Project (<http://tracheostomy.org.uk>) which provide information for centres and includes an airway management algorithm for patients with tracheostomy (<http://www.tracheostomy.org.uk/storage/files/Paeds%20Bedhead%20Algorithm%20Combo.pdf>).

## Drugs and the difficult airway: further information

### Routes of administration

In general drugs are given intravenously, but other routes may be used in certain circumstances:

- **Inhalational induction of anaesthesia prior to intubation in the operating theatre.**
- **Intraosseous or intramuscular** in an emergency in the neonate with no iv access

Although it is an infrequent requirement, drugs for intubation can be given either intramuscularly or via an intraosseus needle in, for example, a cardiovascularly compromised neonate who presents to the ED and requires urgent intubation.

**Intraosseus:** All drugs given intravenously for intubation can be given IO. Drug are given in the same dose as intravenously and followed with a saline flush

**Intramuscular:** Drug absorption is more variable depending on muscle perfusion. **Suxamethonium** may be given IM in a dose of 4mg/kg. Onset of action is faster when given into the deltoid rather than quadriceps muscle. Full paralysis occurs after 2-3 mins, but useful muscle relaxation such as resolution of laryngospasm occurs after 30 seconds. The duration of action after IM injection may be up to 15mins. Rocuronium 1mg/kg has also been given IM, although there is little evidence of its use in emergencies. The onset of full paralysis using IM rocuronium may take longer than IM suxamethonium and the duration of action would be around 40 mins.

**Ketamine** can be given IM for sedation or anaesthesia in a dose of 1-4mg/kg with the lower dose in haemodynamically unstable neonates.

### Special consideration in the difficult airway

If difficulty is anticipated, drugs should be selected to optimise intubating conditions and ensure that the neonate is not struggling when the laryngoscope is inserted. Consider whether you need to maintain spontaneous ventilation or whether muscle relaxants can be used. Remember that propofol frequently causes apnoea in neonates as well as sedation. If attempts to manage the airway are prolonged, short acting drugs such as propofol or suxamethonium will wear off and consideration needs to be given to maintaining adequate sedation and if necessary, muscle relaxation.

### The role of muscle relaxants in the difficult airway

Adequate doses of muscle relaxants will ensure paralysis and optimise intubating conditions with no movement or risk of laryngospasm. Mask ventilation is not difficult in the majority of neonates and may be made easier by the use of muscle relaxants, however if there is doubt about the ability to maintain mask ventilation after paralysis, muscle relaxants should not be used, and spontaneous ventilation maintained. These decisions will depend on individual circumstances, the assessment of the airway difficulty and the skills and experience of the clinician.

Commonly used drugs for rapid onset of paralysis are suxamethonium and rocuronium, although the pharmacokinetics of non-depolarising muscle relaxants in neonates ensure the onset of paralysis using atracurium or vecuronium almost as quickly.

**Suxamethonium 2mg/kg** has an onset of muscle relaxation in 30 seconds with a short duration of action, wearing off in about 7 minutes. The effects of suxamethonium cannot be reversed.

**Rocuronium 1mg/kg** has an onset of muscle relaxation in 30 seconds, but a much longer duration of action of about 40 minutes. The effects of rocuronium can be rapidly reversed using the selective binding agent sugammadex.



## Appendix 1 - Example of completed algorithm template (Specialist Centre eg. Regional NICU)

BAPM Framework algorithm:

Unexpected Difficult Airway (Neonates)

Read all text in **BOLD** aloud to the team:

**VERBALISE AS CHALLENGE AND RESPONSE.**

Yes/No responses required from team leader

Immediate actions: **We have a difficult airway situation**

**1) Has someone called for expert help?** Send a specific team member to Call for help (numbers below):

Tell them to state: 'We have a difficult airway situation in (state your location). Please attend immediately'

- Neonatal Consultant on call 29360
- PETAL anaesthetist: 23919
- Paediatric ENT consultant on call via Switch board
- Paediatric Respiratory consultant on call via switchboard

**2) Has the Difficult Airway box been located and retrieved?**

If Not: Retrieve and Open the Difficult Airway Box: Located on WARD 35 (NICU) by ITU DESK

**NOW TURN OVER THIS SHEET AND READ FROM 'PLAN A'**

Other information:

Medication for sedation/paralysis: Fentanyl 3 microgram/kg slow IV (3 minutes)

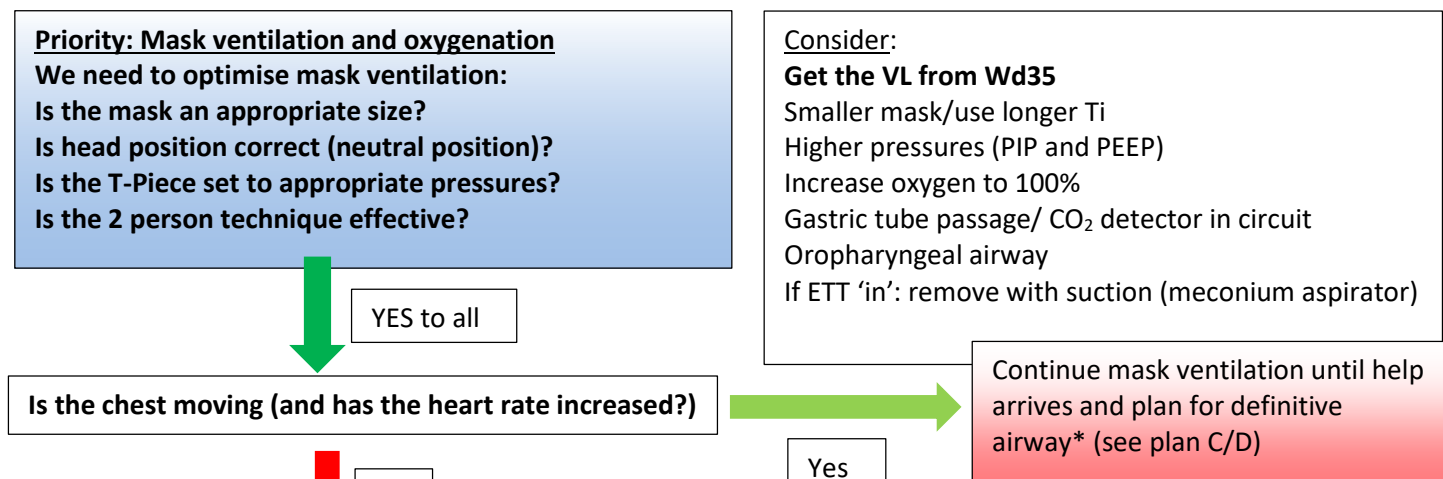
Atracurium 300 microgram/kg IV

Location of specific equipment (e.g. ENT scopes, tracheostomy kit)

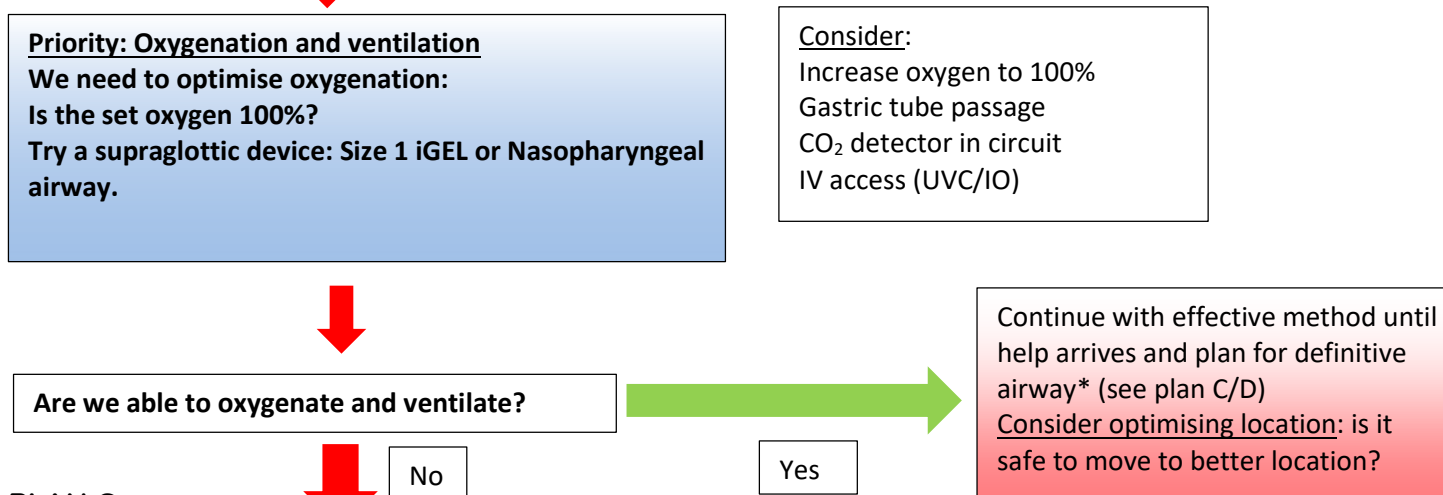
- Rigid bronchoscope: ENT Theatres GNCH
- Emergency Neonatal Tracheostomy kit: ENT Theatres GNCH

To be accessed by contacting Theatre coordinator on 21945

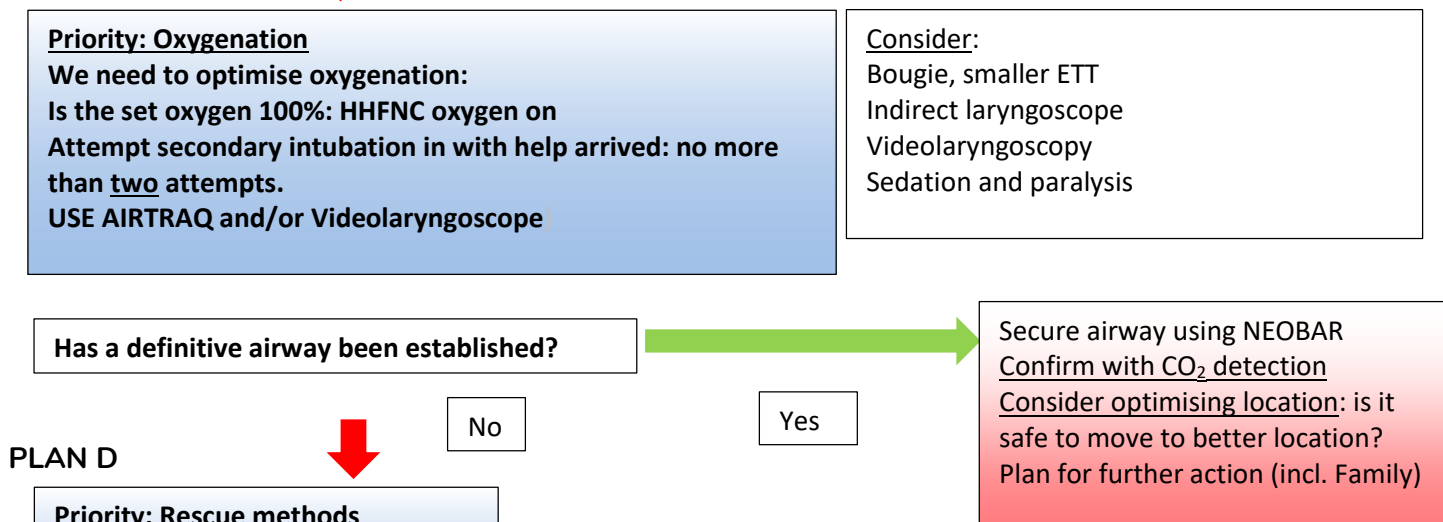
PLAN A



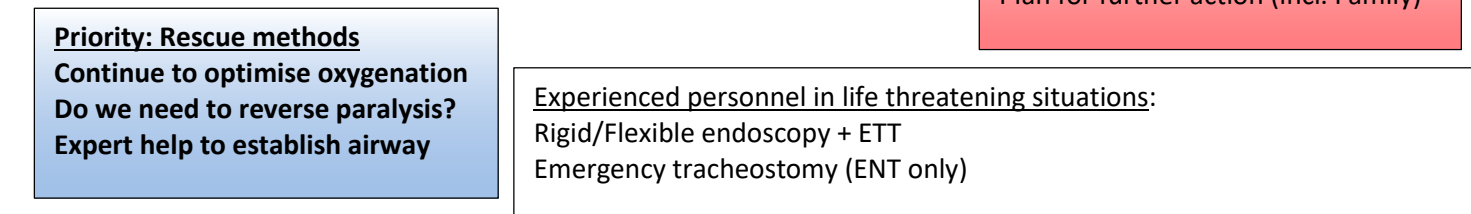
PLAN B



PLAN C



PLAN D



\*IF attempting further intubation consider why the previous attempt(s) failed; what needs to change?

## Appendix 2 - Example of completed algorithm template (Smaller Centre eg. SCU)

BAPM Framework algorithm:

Unexpected Difficult Airway (Neonates)

Read all text in **BOLD** aloud to the team:

**VERBALISE AS CHALLENGE AND RESPONSE.**

Yes/No responses required from team leader

Immediate actions: **We have a difficult airway situation**

**1) Has someone called for expert help?** Send a specific team member to Call for help (numbers below):

Tell them to state: 'We have a difficult airway situation in (state your location). Please attend immediately'

- Paediatric Consultant on call 29360
- Obstetric anaesthetic consultant on call 48114
- Adult ENT consultant on call via switchboard OR the ED consultant on call 21999

**2) Has the Difficult Airway box been located and retrieved?**

If Not: Retrieve and Open the Difficult Airway Box: Located DELIVERY SUITE THEATRE 12 by resuscitaire  
**NOW TURN OVER THIS SHEET AND READ FROM 'PLAN A'**

Other information:

Medication for sedation/paralysis: Fentanyl 3 microgram/kg slow IV (3 minutes)

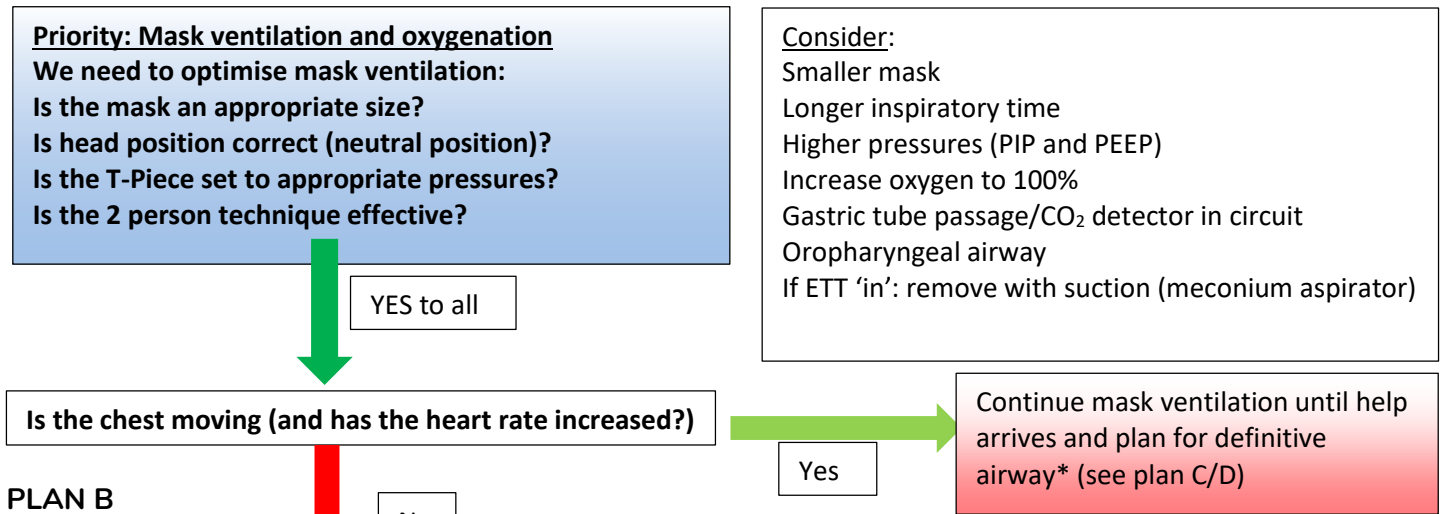
Atracurium 300 microgram/kg IV

Location of specific equipment (e.g. ENT scopes, tracheostomy kit)

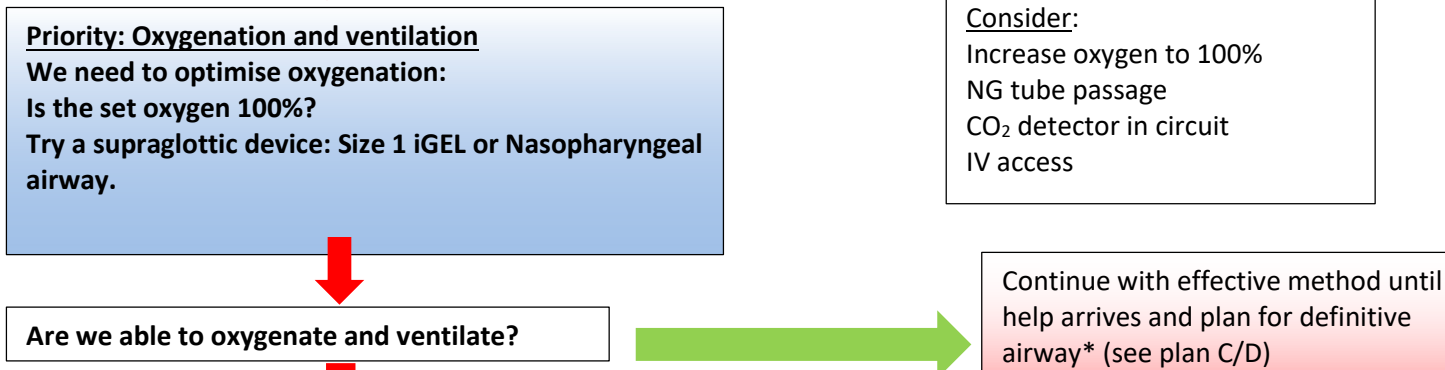
- Glidescope: Adult theatre 9, Level 4
- Glidescope Neonatal Blade: Difficult airway box
- Flexible 2mm bronchoscope: Adult ENT Theatres, level 4

To be accessed by contacting Theatre coordinator on 21945

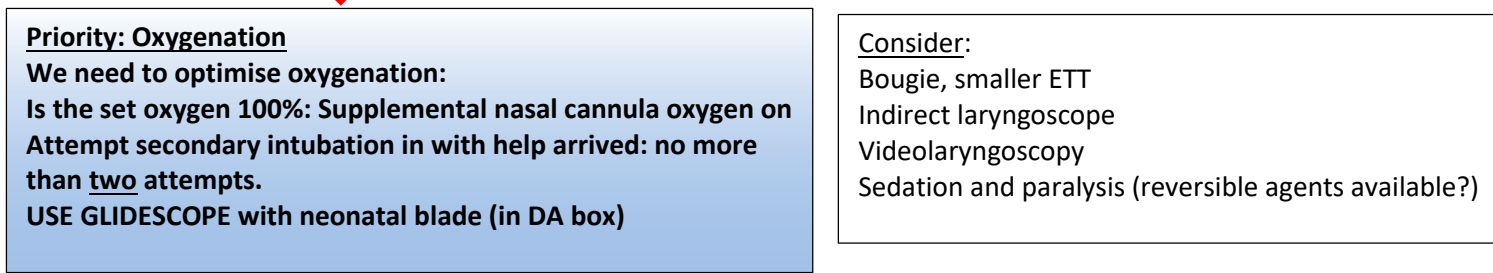
PLAN A



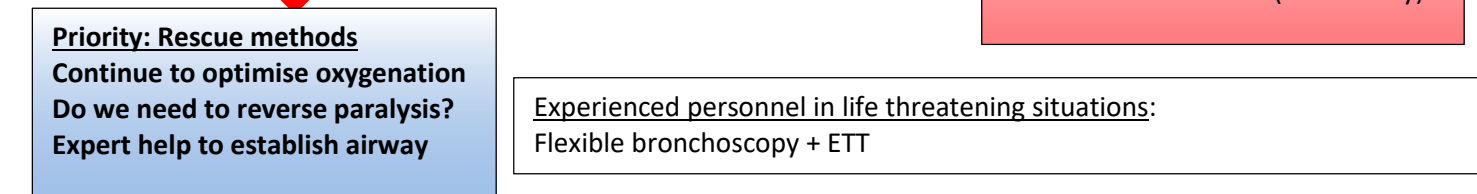
PLAN B



PLAN C



PLAN D



\*IF attempting further intubation consider why the previous attempt(s) failed; what needs to change?

### Appendix 3 - Example of visual inventory for use in a difficult airway box

#### Equipment: visual inventory

PLAN A  
35mm F&P  
mask (Pics 12  
& 13)

Neostat CO<sub>2</sub>  
detector (Pics  
14-17)

BOTH in DA  
box 'A'






Pic 12 Published with kind permission of Fisher and Paykel Pic 13 Permission Rob Tinnion



Pics 14-17. Published with kind permission of Rob Tinnion

Managing the Difficult Airway in the Neonate  
Resource Materials

<p>PLAN B i-Gel  In DA box 'B'</p>	 <p><i>Pic 6. Published with kind permission of Intersurgical</i></p>
<p>PLAN C Glidescope  Adult Theatre 11  Via coordinator Tel 12345</p>	 <p><i>Pic 1. Published with kind permission of Verathon</i></p>
<p>PLAN D Flexible bronchoscope  Will come with adult ENT consultant on call</p>	 <p><i>Pic 18. Published with kind permission of Huger</i></p>

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