CRICOTHYROIDOTOMY AND THE DIFFICULT AIRWAY

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## CONTENTS

ANATOMY .......................................................................................................................... 3
INTRODUCTION ................................................................................................................. 4
Figure 3: The tracheotomy procedure depicted in 1666 [16] ........................................ 4
Cricothyroidotomy ........................................................................................................... 4
THE NAP 4 STUDY ........................................................................................................... 5
LITIGATION ....................................................................................................................... 6
THE ROLE OF EVIDENCE BASED MEDICINE IN AIRWAY MANAGEMENT ............... 7
IMPORTANT FINDINGS RELATED TO ANAESTHESIA IN NAP 4 STUDY ............... 8
ICU ..................................................................................................................................... 8
NEEDLE CRICOTHYROIDOTOMY ....................................................................................... 9
CHANGING OF PRACTICE .............................................................................................. 10
ULTRASOUND ................................................................................................................ 10
Post- extubation stridor .................................................................................................... 10
DEVICES THAT ASSIST IN THE DIFFICULT AIRWAY .............................................. 11
VIDEOLARYNGOSCOPY .................................................................................................. 11
Key features of PLAN C .................................................................................................. 13
THE LARYNGEAL HANDSHAKE .................................................................................... 14
Impalpable cricothyroid membrane ............................................................................... 14
THE CRICOTHYROID APPROACH .................................................................................. 15
WIDE BORE CANNULA OVER GUIDEWIRE ................................................................ 17
Non Seldinger wide bore technique ............................................................................... 17
Post-operative care and follow up ................................................................................. 17
PAEDIATRIC GUIDELINES .............................................................................................. 18
OBSTETRIC GUIDELINES ............................................................................................. 19
NAP4 Recommendations ............................................................................................... 19
EXTUBATION ................................................................................................................... 20
FAILURE OF NARROW BORE AND WIDE BORE CANNULA .................................... 20
Narrow bore cannula ...................................................................................................... 20
Wide bore cannula ......................................................................................................... 20
DISCUSSION .................................................................................................................... 21
REFERENCES .................................................................................................................. 22
CRICOThYROIDOTOMY AND THE DIFFICULT AIRWAY

ANATOMY

EXTRINSIC

- Thyrohyoid
- Cricothyroid
- Cricotracheal

Fig 1: Surgical Anatomy of the larynx [1]

Fig 2: Surface anatomy of the neck [2]
INTRODUCTION

The tracheotomy surgical procedure dates back to Egyptian times circa 3600BC, which were depicted on tablets. Documented on papyrus dating around 1550BC, another Egyptian medical (Ebers) papyrus refers to the tracheostomy.

Medical history documents that the first successful tracheotomy was performed by Prasovala in the 15th century.
By the 16th century, Guidi had devised a unique method for tracheotomies. Between 1500 and 1833 there are reports of only 28 successful tracheotomies.

Figure 3: The tracheotomy procedure depicted in 1666 [16]

Cricothyroidotomy

(may also be known as: crike, thyrocricotomy, inferior laryngotomy, intercricothyrotomy, coniotomy or emergency airway puncture) which is an incision that is made through the skin and cricothyroid membrane in order to create a patent airway in potentially life-threatening situations, such as airway obstruction by a foreign body, angioedema, or massive facial trauma.

The procedure which was documented in 1805 was described first by Félix Vicq-d'Azyr, who was a French anatomist and surgeon.
THE NAP 4 STUDY

4th national audit project of the Royal College of Anaesthetists and the Difficult Airway society – major complications of airway management in the United Kingdom. Together they endeavour to provide a strategic way to help the clinician to manage the situation of unanticipated difficult tracheal intubation which is based on published evidence and where it is insufficient, relies on the clinical expertise and correspondence from the Difficult Airway Society members. It is obvious that airway management may be problematic and complicated due to the vast diversity of human anatomy present and the ever changing disease spectrum, however the frequency and nature of these sometimes unanticipated events was not really surveyed thoroughly.

So the 4th national audit set out to address a number of questions

- The type of airway devices used and frequency
- The frequency of major complications which can lead to serious harm which is associated with airway management in general anaesthesia, ICU and emergency departments
- The circumstances surrounding these events and lessons learnt in order to reduce morbidity and mortality

Each case reported was screened by a panel of experts in order to ensure that only the correct cases were involved and the learning points were maximised. In total 186 made the cut, with an estimate that the study may of detected 1 in four relevant cases. It was for the first time that a prospective study was done in the four United Kingdom's four countries during Anaesthesia, Intensive Care Unit and emergency department and provides analysis of emergent themes.

They do stress however that the NAP4 report should not be used as a textbook or primer of airway management. It also is not in a position to condemn or support a particular practice of airway management. The report instead makes recommendations and which are intended to change our approach to minimise a bad outcome.

Annually in the UK approximately 2.9 million general anaesthetics occur in the National Health Service. With about 56% of those cases, the majority of airway management is with a (SAD) supraglottic airway device, and a tracheal tube forming 38% and the remainder of 6% with a face mask. NAP 4 examined a significant array of major complications that were airway related (ultimately progressing to unexpected ICU admission, brain damage, emergency surgical airway or death in the department of emergency medicine, intensive care medicine and anaesthesia.

There are Separate guidelines in existence for difficulty in intubation for the departments of obstetric anaesthesia, paediatric anaesthesia, and for extubating a difficult airway patient. It is noted that Anaesthetists should not work in an isolated fashion and is in fact part of a team. An airway assessment should be done on every patient including front of neck access for a surgical airway. The best alternative decision when difficulty arises should be made and discussed with the anaesthetic assistant prior to commencing induction of anaesthesia. The guidelines recognise the difficulties of decision making in the process of an emergency. [3]
They include a stepwise approach to assist the anaesthetic team in formulating the right approach, ultimately limiting the number of attempts of securing the airway, encouraging that a declaration of failure by placement of a (SAD) supraglottic airway device even though face-mask ventilation is possible, and explicitly recommending a time to stop and formulate a plan as to how to proceed further.

1. Ventilation by face mask fails in about 1 in 1500 cases.
2. Tracheal intubation has a failure rate in around 1 in 1–2000 cases that are routine
3. Placement of a Laryngeal mask in around 1 in 50 cases
4. A situation where intubation and ventilation has failed (the ‘Can’t Intubate Can’t Ventilate’ scenario – CICV) is rare in about 1 in 5,000 to 10,000 cases.
5. CICV has accounted for over 25% of all deaths that are anaesthesia-related

- In emergencies Failed Tracheal Intubation has been reported between 1 in 300 and 1 in 800
- In the emergency department CICV can occur as much as 1 in 200 cases

When failure occurs other complications become more likely. These include:
- hypoxia (with its consequent outcome of, cardiac events, brain damage and death)
- aspiration
- hypoventilation
- airway trauma (both minor and major life-threatening)
- Awareness.
- oesophageal intubation

LITIGATION

Information provided by the American Society of Anesthesiologists Closed Claims. Project (ASACCP) analysis report that respiratory cases represent about 20% (which include Airway events) of the total claims. The big three in the litigation claims were inadequate ventilation, oesophageal intubation and difficult intubation which account for approximately 60% of the total of respiratory claims, and approximately 5 per cent being associated with pulmonary aspiration. [7]

A review done in 2005 of 179 Difficult airway claims established that death and brain damage were described in more than 50% of claims and ‘less than appropriate’ care was judged in 50%. There were no restrictions to the infirm and geriatric patients, and median age of the claimants being 40. 43% ASA 1–2 and 75% related to anaesthesia for elective surgery. [7]

Approximately 50% of the claims came from patients where a prediction of difficult airway was made: and most of them still had a ‘standard general anaesthetic’. Two-thirds of the anaesthesia claims came from induction events while cases that occurred after induction had a worse outcome. The majority of oesophageal and lower airway injuries were linked with difficulty in intubation: as these can presented later and have a 20% of mortality rate. Laryngeal injuries on the other hand, comprises in total 33%, of the airway trauma claims occurring in about 80% of the cases, after an intubation that was routine. [3]
THE ROLE OF EVIDENCE BASED MEDICINE IN AIRWAY MANAGEMENT

Some interesting questions can be posed in airway management

- Is it correct practice to administer neuromuscular blocking agents before confirming whether you are able to ventilate the lungs of the patient's?
- Does (RSI) rapid sequence induction decrease or increase overall safety?
- What is the best method to manage an airway that is obstructed?
- In an emergency is a cannula of small or large bore effective or accessing the trachea via a surgical airway the best option?

There is a vast database on these particular questions and some feel it is largely opinion based which is partially supported by some related data. The medical equipment industry is highly regulated and the rate of new equipment that is being developed makes it very difficult for research to keep up. [8] [9]

There has been incomplete evaluation of the majority of airway devices in use and some pertinent questions arise:

- Which SAD (supra glottic airway device) is appropriate during advanced indications such as obesity, laparoscopy, ventilation and lithotomy?
- The safe weight limit – does one exist for the use of a SAD?
- In managing low risk emergencies, can some SADs be used safely??
- If the patient regurgitated, which SAD offers the most protection?
- During CICV which SAD is the most effective to safely and successfully rescue the airway?
- The most effective and safest bougie in an emergency?
- The latest videolaryngoscopes and how commonly used are they used to rescue a difficult intubation??
- Which SAD is best suited as a fibreoptic conduit so it can be guided so intubation can be rescued?
- For difficult extubation, how safe is an airway exchange catheter?
- Which cricothyroidotomy catheter should be chosen for use?

Why is research in this field being hampered? A number of factors contribute to this:

1. Some clinicians including ethics committees think it is unethical to find patients where the risk of complications is higher.
2. Most ethics committees encourage recruitment of low risk patients
3. Different major complications occur in different settings which cannot be encompassed in one study
4. In the event of approval the study has to be conducted for prolonged periods of time at multiple sites to sufficiently gather patient numbers
5. Funding is difficult to acquire
6. Due to the infrequency of Major events a substantial amount of studies need to be conducted to test the differences between the technique or device involved. [3]
IMPORTANT FINDINGS RELATED TO ANAESTHESIA IN NAP 4 STUDY

1. Greater than 50% of the patients included were male of ASA 1–2, below 60 years of age and majority of events occurred during surgery that was elective with an anaesthetic consultant in charge.
2. The most common cause of airway-related mortality in anaesthesia was Aspiration.
3. A disproportionate number of patients were obese.
4. Obstructive lesions in the airway spawned a significant number of complications, many reported showing that poor planning of initial and rescue interventions, was evident.
5. Cricothyroidotomy done by anaesthetists was linked with a high failure rate.
6. One of four cases occurred either at the end of anaesthesia or in the early recovery room.
7. Omission/incorrect capnography interpretation ultimately led to oesophageal intubation that was undiagnosed.
8. An observation of substandard management was identified and it was evident in the majority of airway complications and most fatalities.

ICU

It was observed that although ICU contributed to less than 20% of notifiable events approximately half of the fatal cases had occurred in that department. Death or brain damage was found to be lower in anaesthesia which was 14%, as compared to ICU where it was greater than 60% of reported events. It is known fact that patients in ICU often had an ASA grading that is high, multi-organ failure and were treated with higher fractions of inspired oxygen, the overall high rate of obesity and increased BMI (almost 50%) of patients experiencing major airway complications is a new and substantial finding.

Issues that arose where a combination of a factors including

Lack of training and inadequate experience
Equipment not available or insufficient training to use it
The lack of consideration with regards to use of the correct equipment
Rescue techniques (face mask ventilation, LMA, ventilation, cricothyroidotomy) ultimately had failure rates that were high
Preparation issues were also noted
Absence of capnography or failure to interpret it properly

A study by Mort involving greater than 10,000 intubations in an emergency, away from an operational theatre discovered that numerous attempts at intubation is associated with substantial increases of elevated hypoxaemia rates (11.8% vs 70%), cardiac arrest (0.7% vs 11%), gastric contents regurgitation (1.9% vs 22%), aspiration (0.8% vs 13%), bradycardia (1.6% vs 21%). [3]
NEEDLE CRICOTHYROIDOTOMY

An unexpected finding was that Needle cricothyroidotomy was found to have a high failure rate. There have been number of debates as to which approach to establish direct tracheal access is best: Seldinger, needle or surgical approach.

An argument can be made that the NAP 4 project provides conclusive evidence that needle cricothyroidotomy has a significant failure rate and therefore we should be abandoning its use, especially due to the fact that a surgical approach had higher rates of success. (Even in the event where needle cricothyroidotomy was attempted and failed). Some contributing factors are cephalad placement of the device, mechanical failure of a Ravussin cannula and attempting to ventilate with a low pressure gas source through a fine bore needle.

Fig 4: Ravussin device [4]

Fig 5: Capnograph trace confirming correct placement during ongoing CPR for cardiac arrest [3]
CHANGING OF PRACTICE

Appropriate abolition of airway reflexes:
This reflex can hamper attempts at Face mask and SAD’s, increasing difficulty.
Although you abolish the reflex it is at the expense of removing spontaneous breathing and waking the patient up if needs be. There seems to be a trend of moving away of checking face mask ventilation. It’s up to the anaesthetist to make a judgement in each individual case.
Difficulties mask ventilating or ventilating through LMA: the findings were that there seemed to be a reluctance to give more anaesthetic agent or muscle relaxant as the patient was light. [3]

Things to consider:
- Aspiration and RSI
- Blood clot causing tracheal obstruction
- Placement of an airway exchange catheter prior to extubation in difficult airway
- Foreign body
- Ultrasound

ULTRASOUND

Useful in assessment of airway anatomy, The ability to predict difficult intubation if the hyoid bone is not visualised in sublingual ultrasound, which the study by Hui et al showed a high positive likelihood ratio of 21.6 with a moderate negative likelihood ratio of 0.28. [11][13]

A study by Kim et concluded Ultrasound could also detect LMA malrotation with high sensitivity (93%) and specificity (82%) and accuracy of 87%. This was accomplished by filling the cuff with saline to make it easier to detect and graded arytenoid cartilage elevation [12]

Post- extubation stridor

Measuring of the air column width at the level of the vocal cords potentially can predict the possibility of post- extubation stridor although it has shown good results a bigger sample size is required to determine a reliable cut-off point. [13][14][15]

The ASA (American Society of Anaesthetists) have a developed their own airway algorithm, which is based on the Task Force on Difficult Airway management report, published in 2003. Some feel it is not as user friendly as the DAS algorithm which have evolved from 2004
The Difficult Airway Society algorithm is more precise and easy to understand which allows the clinician to arrive at a decision far quicker.

A systematic review by Duggan et al concluded that trans-tracheal jet ventilation (TTJV) should be abandoned due to the vast array of complications and failures which included TTJV associated subcutaneous emphysema which obscured airway landmarks and therefore made it difficult to establish a surgical airway or tracheal intubation. [10]

TTJV may lead to breath stacking or barotrauma in the scenario of partial or complete upper airway obstruction where there is obstruction to exhalation. [10]
DEVICES THAT ASSIST IN THE DIFFICULT AIRWAY

Fig 6: The Bonfils device [17]

VIDEOLARYNGOSCOPY

It is predicted that videolaryngoscopy will become the first line device for airway management. Many are pushing for it but the cost seems to be the only thing holding it back. The best device is yet to be determined as newer and improved versions are produced relatively quickly. [19] Its use has been recommended to intubate obese patients who are associated with a higher risk of complications.

The force required to intubate is less than direct laryngoscopy resulting in decreased risk for trauma to the soft tissues or teeth. [19, 20, 21] First time use prevents the swap of device and resulting desaturation when some difficult intubations are not anticipated. With trainees the consultant can also visualise and see if the intubator is struggling early on and formulate a plan far quicker than direct. [19] [20]
It can serve as a digital record for medicolegal purposes and training. Presently there is little high quality evidence comparing the performance of different videolaryngoscopes.\[19\]

Short rules with regards to videolaryngoscopy:

- Experienced clinicians with a standard macintosh does not mean skilled with a videolaryngoscope – training is required
- Experience with a particular brand does not equate with skill across the brand range
- A good view of the cords does not mean an easy intubation
- A bougie has limitations when there is difficulty – disposable tends to uncurl lacks memory of original gum elastic bougie
- Correct videolaryngoscope for the case

![DAS Difficult intubation guidelines – overview](image)

**Fig 8: Key features of PLAN A [6]**

- Maintenance of oxygenation is the priority
- Advantages of head-up positioning and ramping are highlighted
- Preoxygenation is recommended for all patients
- Apnoeic oxygenation techniques are recommended in high-risk patients
- The importance of neuromuscular block is emphasized
- The role of videolaryngoscopy in difficult intubation is recognized
- All anaesthetists should be skilled in the use of a videolaryngoscope
- A maximum of three attempts at laryngoscopy are recommended (3+1)
- Cricoid pressures should be removed if intubation is difficult [5]
Fig 9: Key features of PLAN B

- Declaration of Failed intubation
- Oxygenation via a SAD is emphasised
- Recommendation for the use of Second-generation SADs
- The recommendation of a maximum of 3 attempts of SAD insertion
- During RSI, the removal of cricoid pressure is advocated for facilitation of SAD insertion
- Attempts to blindly intubate through a SAD are not recommended [5]

Key features of PLAN C
CICO can’t intubate cant oxygenate

- Declaration of Failed SAD (supraglottic airway device) ventilation
- Oxygenation by face mask should be attempted
- Paralyse the patient if face-mask ventilation is not possible
- Wake up the patient if face-mask ventilation is a possibility, maintain oxygenation
- Declare CICO and start Plan D
- Continue attempting to oxygenate via face mask, nasal cannulae and SAD. [5]
THE LARYNGEAL HANDSHAKE

![photo a]

**PHOTO A**

The index finger and thumb grasp the top of the larynx (the greater cornu of the hyoid bone) and roll it from side to side. The bony and cartilaginous cage of the larynx is a cone, which connects to the trachea.

![photo b]

**PHOTO B**

The fingers and thumb slide down over the thyroid laminae.

![photo c]

**PHOTO C**

Middle finger and thumb rest on the cricoid cartilage, with the index finger palpating the cricothyroid membrane.

**Impalpable cricothyroid membrane**

Equipment: Scalpel with size 10 blade, as broad as the tube (size 6.0 cuffed) and bougie. In the event of an impalpable cricothyroid membrane: the scalpel finger bougie technique is advocated by making a vertical 8-10cm vertical incision which is caudad to cephalad. Using blunt dissection and the fingers of both hands —try to separate the tissues and using your left hand identify and stabilise the larynx.

Proceed to scalpel technique thereafter.
THE CRICOTHYROID APPROACH

A: Identify the cricothyroid membrane

B: Make transverse stab incision through cricothyroid membrane

C: Rotate scalpel so the sharp edge points caudally

D: Pull the scalpel towards your direction to open up the incision, slide coude tip of bougie down the scalpel blade into trachea

E: Railroad tube into trachea [5]
Failed intubation, failed oxygenation in the paralysed, anaesthetised patient

CALL FOR HELP

Continue 100% O₂
Declare CICO

Plan D: Emergency front of neck access

Continue to give oxygen via upper airway
Ensure neuromuscular blockade
Position patient to extend neck

Scalpel cricothyroidotomy

Equipment: 1. Scalpel (number 10 blade)
2. Bougie
3. Tube (cuffed 6.0mm ID)

Laryngeal handshake to identify cricothyroid membrane

Palpable cricothyroid membrane
- Transverse stab incision through cricothyroid membrane
- Turn blade through 90° (sharp edge caudally)
- Slide coude tip of bougie along blade into trachea
- Railroad lubricated 6.0mm cuffed tracheal tube into trachea
- Ventilate, inflate cuff and confirm position with capnography
- Secure tube

Impalpable cricothyroid membrane
- Make an 8-10cm vertical skin incision, caudal to cephalad
- Use blunt dissection with fingers of both hands to separate tissues
- Identify and stabilise the larynx
- Proceed with technique for palpable cricothyroid membrane as above

Post-operative care and follow up
- Postpone surgery unless immediately life threatening
- Urgent surgical review of cricothyroidotomy site
- Document and follow up as in main flow chart

Fig 12: CICO protocol [5]
WIDE BORE CANNULA OVER GUIDEWIRE

The Cook Melker emergency cricothyrotomy set uses a wire guided, essentially Seldinger technique. This technique is less invasive than a surgical cricothyroidotomy – therefore there is no need for special equipment for ventilation. Using a guide wire is familiar to an anaesthetist however due to the requirement of fine motor skills. And a stressful situation with time constraints, the guide wire could possibly be unsuitable. A surgical cricothyroidotomy is more reliable and faster in a situation where efficiency is key.

Non Seldinger wide bore technique

This requires the use of wide bore cannula over trochar devices. There have been successful cases of its use in the CICO – however there has been no large studies of these devices to test it in clinical practice. The use of ultrasound can be used pre operatively as an airway assessment tool, and if switched on and nearby it can be used, however it should not delay establishment of a definitive airway and oxygenation. [5]

Post-operative care and follow up

An airway management plan should be formulated and the patient should obviously be monitored closely post operatively. The Anaesthetist should detail a complete summary of the airway event and handover to the caring physician, making sure to follow up. The reason being that difficult intubation often leads to airway trauma and its associated complications and follow ups can recognise them early and institute treatment plans.

Injury to the pharynx and oesophagus are often difficult to diagnose, with pneumothorax, pneumomediastinum and surgical emphysema appearing in 50 per cent of patients. Mediastinitis is the most deadly complication often associated with a very high mortality. Careful observation of the triad of:

Pain (deep cervical, dysphagia, chest pain, odynophagia)
Fever
Crepitus

The patients should be notified of these symptoms and urged to seek immediate attention should these delayed symptoms of airway trauma unfold.

A morbidity and mortality discussion is advisable and should follow a failed intubation, emergency front of neck access and airway related unplanned admissions.

A central database or a form of coding needs to exist to ensure that patients that have an established difficult airway can be identified easily and managed appropriately. The use of medic alert bracelets have also been promoted as a possible precaution.[5]
Fig 13: Paediatric guidelines CICV [6]

Fig 14: Paediatric guideline for difficulty in mask ventilation [6]
OBSTETRIC GUIDELINES

Fig 15: Obstetric guideline algorithm [6]

NAP4 Recommendations

- A second generation supraglottic airway device with suctioning capabilities should be used
- Ramping of obese patients can improve oxygenation and laryngoscopy
- Awake fibre optic intubations have a role to play in selected patients
- Training of support staff
- Multidisciplinary approach in complicated patients
EXTUBATION

FAILUERE OF NARROW BORE AND WIDE BORE CANNULA

Anaesthetists in the study had almost exclusively chosen the cannula technique to try to rescue the airway but was associated with substantial failure rates

Narrow bore cannula

Attempted in 19 patients – failed in 12 cases (63%) problems included misplacement, misuse, device failure (detachment from the hub and kinking)

7 of the failures required urgent surgical tracheostomy with 3 developing surgical emphysema due to attempts with high pressure source ventilation

Wide bore cannula

Showed a failure rate of 43% with it being the first choice in 7 patients

Numerical analysis in Anaesthesia: 58 cases had reported that there was an attempt to establish an emergency surgical airway.

- 43 were head and neck cases
- 15 of the others had come from a variety of surgical specialties which included 2 caesarean sections, 3 laparotomies, 3 thoracic surgery cases, 2 incision and drainage of abscess and 5 other cases (cervical vertebral fracture, fractured arm, minor gynaecology, hernia, PEG ).
- 4 patients had died due to airway complications.
• 2 patients had partially recovered: one resulted with a permanent tracheostomy, the other patient had continuous respiratory compromise.
• 50 patients were reported to have made a full recovery
• In 8 of the 58 cases emergency surgical access had failed completely to establish an airway and 2 patients died, 1 was woken up and the remaining 5 cases had been rescued by tracheal intubation
• In 13 cases it was found that more than one technique was utilised before restoration of oxygenation or attempts to establish a surgical airway were abandoned

In the cant intubate cant ventilate situation the NAP 4 study showed that in just over half of the cases, the SAD was not attempted as a rescue, before the attempt of establishing an emergency surgical airway.

The consensus that appropriate muscle relaxant and dose must be given to negate the contributory effects of laryngospasm [3].

DISCUSSION

• The study of supra glottic devices and its use in the NAP 4 study revealed a common theme when it came to difficulty in airway management
• Poor patient selection, operation selection and inexpert use with aspiration coming out as causing the most severe problems
• Be aware that the obese patient can pose a significant challenge with airway alone and this population is increasing therefore you are more likely to encounter them frequently.
• Fibre optic intubation threshold should be lowered – thus improving the skill and with guidance from expert help improves the safety
• Adopt early acceptance of failed intubation and insertion of SAD/secondary device, avoid multiple attempts at laryngoscopy.
• All anaesthetists and critical care physicians should be trained to perform an emergency cricothyroidotomy, and use of capnography is essential.
• Needle cricothyroidotomy shows a high failure rate and should not be used to assist ventilation especially in out of theatre setting where jet ventilation is not possible which in itself a problem due to the barotrauma. In a study done by Stacey et al, cannula tracheotomies conducted on rabbit tracheas which are anatomically similar to an infant’s showed a 60% success rate and was fraught with complications further discouraging its use. [23]
• Training, teamwork, proper equipment and the ability to recognise a difficult situation, CALLING FOR HELP and declaring the cant intubate can’t ventilate.
• Adherence to a protocol can prevent litigation and unnecessary morbidity and mortality.
• Instituting an anaesthetic checklist and going through the possible problems with the assistant before hand to ensure preparation is adequate.
• The importance of first pass success and limiting subsequent attempts which have been associated with high failure rates.
• Simulation in anaesthesia could be ideal training tool, which can also be self directed to ensure appropriate skill. As little as a one hour training protocol can raise the competence of novice doctors. [22]
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