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Review Article

Emergency Front of Neck Access in ICU

Amol Kothekar[1], Sheila Nainan Myatra[2]

Abstract

Difficult intubation and difficult mask ventilation are not uncommon in ICU. When intubation in ICU turns out to be difficult, chances of complications may be more due to various reasons like poor physiological reserve and physical status of patient, inadequate experience of operator, unavailability of help from airway experts and certain airway adjuvants. The "cannot intubate cannot oxygenate" (CICO) situation is the most feared complication in airway management, as it can lead to hypoxic brain damage and immediate cardiac arrest leading to death unless situation is rapidly resolved. Emergency cricothyroidotomy can come handy in such potentially life-threatening situations. Cricothyroidotomy and not tracheostomy is the recommended technique of choice for front of neck access in CICO situations with increasing hypoxemia. This article deals with the complexities of airway management in ICU, the various tools and techniques for performing emergency front of neck access by both surgical and percutaneous cricothyroidotomy including ventilation techniques and the current recommendations for performing this procedure. Considering the life saving potential of this technique, every anaesthesiologist, intensivist, or other physician dealing with airway management should be well versed with this procedure.

Key Words: *Front of neck access; cricothyroidotomy; cannot intubate cannot oxygenate; jet ventilation; airway management in ICU*

Introduction:

Tracheal intubation in the Intensive Care Unit (ICU) in the setting of respiratory failure and shock is a life-saving intervention. Difficult intubation and difficult mask ventilation, known as difficult airway are not uncommon in ICU[1-7]. When intubation in ICU turns out to be a difficult airway situation, chances of complications are more due to various reasons like poor physiological reserve and physical status of patient and in addition there may be an inadequate experience of operator, unavailability of help from experts and of airway adjuvants like Laryngeal Mask Airway (LMA ®), Video laryngoscope etc[8].

When attempts at airway management by tracheal intubation, face-mask ventilation, and supraglottic airway device (SAD) like LMA™ fail, it is known as a "cannot intubate cannot oxygenate" (CICO) situation. This is the most feared complication in airway management, as it can lead to hypoxic brain damage and immediate cardiac arrest leading to death unless the situation is rapidly resolved.

1. Dr. Amol Kothekar MD, IDCCM. Assistant Professor, Department of Anaesthesia, Critical Care and Pain, Tata Memorial Hospital, Mumbai, India
2. Dr. Sheila Nainan Myatra MD, FCCM. Professor, Department of Anaesthesia, Critical Care and Pain, Tata Memorial Hospital, Mumbai, India

Corresponding Author :

Professor Sheila Nainan Myatra
Department of Anesthesia, Critical Care and Pain
Tata Memorial Hospital
Dr. Ernest Borges Road,
Parel, Mumbai-400012
INDIA
Email: sheila150@hotmail.com

Emergency cricothyroidotomy can come handy in such potentially life-threatening difficult airway situation progressing to CICO. Airway societies across the globe [9-12] recommend emergency cricothyroidotomy and not tracheostomy, as the technique of choice in CICO situations with increasing hypoxemia. Considering the life saving potential of this technique, every anaesthesiologist, intensivist, or any other physician dealing with airway management in practice should be well versed with this procedure.

What makes airway management in ICU more challenging?

Airway management in critically ill patients is more challenging, difficult and more likely to be associated with complications as compared to that in the operating room[8]. The factors affecting airway management:

1. ICU factors:

The ICU is regarded as 'a hostile environment' for airway procedures[1] because, unlike operation room (OR), the infrastructure is not designed for anaesthetizing patients. Lack of space due to other equipments, poor access to patient's head end, poor lighting can contribute to potential difficulty. Airway devices like fiberoptic bronchoscope, supraglottic airways, videolaryngoscope etc. may not be readily available in ICU.

2. Patient factors:

- There is less time for preparation with progressive illness requiring rapid airway intervention. Also, inefficient pre-oxygenation caused by ventilation perfusion (V/Q) mismatch from the underlying illness, lack of physiological reserve often leads to very rapid hypoxaemia and therefore rapid desaturation allowing less apnoic time for intubation.

- Challenging anatomy associated with injuries in many patients making airway control difficult such as maxillofacial trauma, potential cervical injury, burns, airway tumours, retropharyngeal abscess etc.
- Assessment of the airway is difficult or impossible because the patient is uncooperative
- Patients are usually considered full stomach due to gastroparesis associated with critical illness or due to the urgency of interventions
- Waking up the patient in case of failed airway intervention is often not an option.

1. **Operator skills*:***

- Airway procedures are often performed by junior medical personnel with limited or no airway training experience.
- Procedures are often performed under high pressure because of poor physiological reserve of the patient.
- Procedures are frequently performed out of hours, when senior help may not be immediately available.
- Lack of hard endpoints followed by operator in terms of acceptable desaturation, blood pressure, number of attempts or failures and complications.
- Most of the times, the life threatening CICO situation arises as a consequence of multiple intubation attempts leading to airway injuries and complications.

Can we anticipate a difficult airway in ICU

If we could anticipate a difficult airway, we would be better prepared and call for expert help in advance and prevent a CICO situation. Several tests are available; however, they are often impractical to use and also difficult to assess in the ICU, especially during emergency airway management.

MACOCHA score developed and validated by Jong and colleagues[13] is more effective in predicting difficulty of intubation in ICU patients compared with Mallampati score alone (Table 1). It looks at various parameters like Mallampatti III or IV, Obstructive apnoea syndrome, cervical spine limitation, Mouth opening <3cm, Coma, Hypoxia, and non-trained Anaesthetist. Severe hypoxemia before intubation and coma are the factors specific to ICU patients included in the score. Severe hypoxemia doesn't allow adequate time for preparation and procedure of intubation. It also increases the stress level for physicians performing the procedure. View of the glottis may be difficult in patients with coma due to increased oropharyngeal secretions.

Table 1: MACOCHA score

Factors	**Points**
Factors related to patient	
Mallampatti score III or IV	5
Obstructive sleep apnea	2
Reduced mobility of cervical spine	1
Limited mouth opening 3 cm	1
Factors related to pathology	
Coma	1
Severe hypoxaemia (SPO_2) < 80%	1
Factors related to operator	
Non anaesthesiologist	1
Total	**12**
Scored from 0 (easy) to 12 (very difficult)	

Kim and colleagues[14] have demonstrated that a neck circumference: thyromental distance (NC/TM) ratio >5.0 predicted difficult intubation in obese Asian patients. In their study, the NC/TM ratio >5.0 performed better than BMI measurement and Mallampati score.

While these assessments can give you some idea of airway difficultly, one must remember that one can be face with a difficult airway even when these tests fail to detect it. In addition, due to the factors listed earlier, any airway management in ICU is considered as difficult and high risk and one must be prepared and trained to handle a CICO situation at all times. An algorithm for management of unanticipated difficult airway in ICU is shown in Figure 1.

Why emergency cricothyroidotomy and not tracheostomy is preferred in CICO situations

Cricothyroidotomy is technically easier than tracheostomy due to following reasons:

1. Cricothyroid membrane is more superficial than tracheal rings and can be easily felt between the thyroid and cricoid cartilage.
2. It is less mobile structure as it is held steady in place by the cartilage above and below it.
3. There are less immediate complications as it is relatively avascular structure and placed away from thyroid gland, anterior jugular veins, and laryngeal nerves.

Cricothyroidotomy is thus easier and faster to perform than tracheostomy and the chances of bleeding are also less compared to latter.[15] Cricothyroid membrane is not an alien territory to an anaesthesiologist or a physicians who perform awake fiberoptic bronchoscopy. This is the same membrane which is commonly accessed during trans-tracheal local infiltration prior to fiber-optic bronchoscopy (FOB). Intensivists should familiarise themselves with identifying the cricothyroid membrane which is quite easy to do, so that they

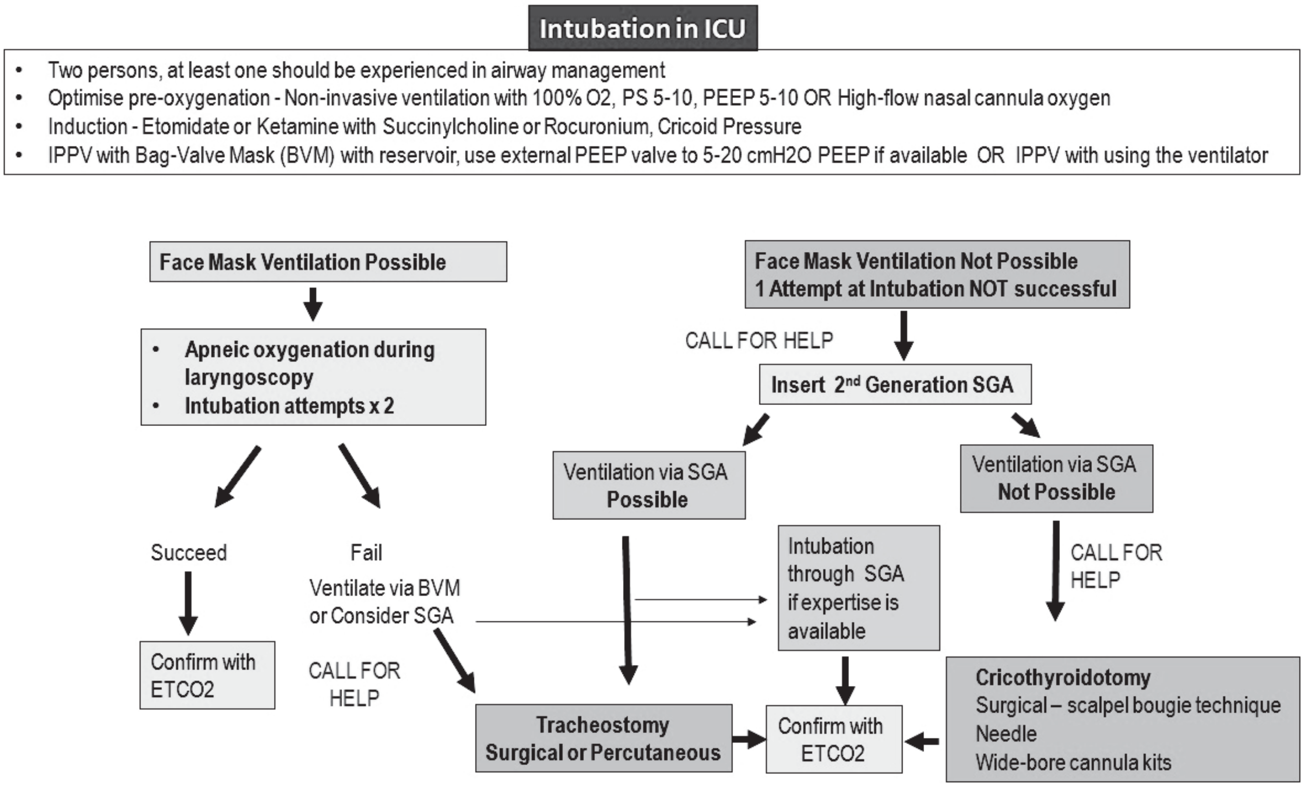

Figure 1: An algorithm for management of unanticipated difficult airway in ICU

Abbreviations: PEEP = positive end expiatory pressure, PS = pressure support, SGA = supraglottic airway device, $ETCO_2$ = end tidal carbon dioxide

can be well prepared for an emergency front of neck access.

CRICOTHYROIDOTOMY

Indication for performing emergency cricothyroidotomy

- CICO with increasing hypoxemia[9]
- Alternative to Surgical Tracheostomy[16, 17] as an emergency airway control in
  - Upper airway obstruction
  - In patients in whom oral or nasal endotracheal intubation is contraindicated, or not possible
  - Emergency airway access in patients with severe facial trauma

Contraindications for performing cricothyroidotomy

- Laryngeal injury[3]
- Any condition that precludes identification of the cricothyroid membrane or distorts the anatomy like stab wounds, large hematoma
- Coagulopathy (relative contraindication)
- In Children less than 8 years of age[18], percutaneous cannula tracheostomy is preferred over surgical cricothyroidotomy unless ENT assistance is available as cricoid cartilage is the narrowest part of airway in children[19] and there are higher chances of laryngeal damage and post procedure airway complications

Techniques of Emergency cricothyroidotomy

- Surgical
- Percutaneous
  - Narrow-bore (<4 mm) cannula
  - Wide-bore (≥4mm) cannula
  - Catheter over guidewire or Seldinger technique (e.g Cook Melker® cricothyroidotomy canula set)
  - Catheter or tube over needle (e.g PCK® Cricothyroidotomy kit - Portex Quicktrach® , VBM® percutaneous cricothyrotomy set)

Patient positioning for cricothyroidotomy

It is critical to understand that sniffing position used for intubation needs to be changed to allow optimal conditions for cricothyroidotomy. Neck extension is vital, which can be achieved by pushing a pillow or folded towel under the shoulders.

How to identify the cricothyroid membrane

The cricothyroid membrane is an elastic tissue attached below the cricoid cartilage, attached in front to the thyroid cartilage and at the back to the arytenoid cartilages (Figure 2) The use of the 'laryngeal handshake' as described by Levitan[20] is very important step for success of cricothrroidotomy[9]. This handshake gives better three-dimensional orientation of laryngeal anatomy. The laryngeal handshake is performed with the non-dominant hand. First, the hyoid and thyroid laminae are identified. Then larynx is identified and stabilized with thumb and middle finger, and fingers and thumb slide down over the thyroid laminae to palpate the cricothyroid membrane with the index finger.

Figure 2: Anatomy of cricothyroid membrane

- **The role of ultrasound in identification of cricothyroid membrane**

Ultrasound of airway can be used electively for identification of cricothyroid membrane especially in anticipated difficult cases in which cricothyroid membrane is not easily identified. Ultrasound examination takes some time and focus in CICO should be on oxygenation. Care should be taken not to delay airway access (avoid fixation error).

Ultrasound cannot be used by an inexperienced operator in an emergency situation. If one anticipates a difficult airway in ICU and the ultrasound machine is readily available, the cricothyroid membrane can be marked easily using ultrasound prior to securing the airway. Difficult Airway Society (DAS)[9] recommends training and use of airway evaluation using ultrasound.

What precautions should be followed while performing a cricothyroidotomy

1. Directing the needle or sharp edge of scalpel caudally can reduce the little chance of injury to vocal cords which are placed a centimeter cranial to the cricothyroid membrane.

2. Cricothyroid artery, a branch of the superior thyroid artery crosses the superior margin of the cricothyroid membrane as it joins the opposite artery in the midline. There are reports of fatal airway haemorrhage due to injury to the cricothyroid artery. Hence the cricothyroid membrane should always be punctured in inferior (caudal) part.[21]

Surgical cricothyroidotomy

1. Classical surgical cricothyroidotomy: Once the landmarks are identified, the thyroid cartilage is stabilized. Vertical Incision is taken on skin and subcutaneous tissue overlying the cricothyroid membrane[16]. Cricothyroid membrane is then opened with a horizontal stab incision with scalpel avoiding depth of more than 1.3 cm (1/2 inch). Larynx is elevated with tracheal hook and Trousseau dilator in inserted to open the membrane vertically. A tracheostomy or cricothyrotomy tube with cuff is inserted, the cuff is inflated and the position is confirmed with end-tidal carbon dioxide $EtCO_2$.

2. Scalpel Bougie Technique: The surgical cricothyroidotomy procedure has been further standardized by Difficult Airway Society (DAS) of UK[9] which recommends use of easily available equipments like scalpel with number 10 broad blade, bougie with coude (angled) tip and a cuffed size 6.0 mm. endotracheal (ET) tube.

If the cricothyroid membrane is well palpable, a transverse stab incision is taken through skin over cricothyroid membrane followed by rotating the blade through 90° keeping sharp edge caudally (to prevent injury to cricothyroid artery). The curved tip of bougie is slipped along blade into trachea and then a well lubricated 6.0 mm cuffed tracheal tube is railroaded over bougie into trachea. The cuff is inflated, the patient is ventilated and the tube position is confirmed with capnography. The tube should be secured like tracheostomy.

In case if cricothyroid membrane is not palpable, an 8-10 cm vertical skin incision is taken caudad to cephalad. Blunt dissection is done with fingers of both hands to separate tissues and to identify and stabilise the larynx.

3. This modified technique has an advantage over classical surgical cricothyroidotomy as it can be performed using readily available equipments unlike the classical method[16] which requires Trousseau dilator. Unlike needle cricothyroidotomy, insertion of a large-bore cuffed tube helps in prevention of aspiration and facilitates adequate ventilation and an unobstructed route for exhalation to monitor $EtCO_2$.

Percutenous cricothyroidotomy using cannula techniques:

1. Narrow-bore (<4 mm) cannula

Narrow-bore (<4 mm) cannula insertion is fast and easy to perform, can be done with readily available equipments. However the failure rate is high due to chances of canula blockage / kinking and need of high pressure oxygen source and jet ventilation. It cannot prevent aspiration and cannot be used for long term.

Procedure*:* Landmark identification and stabilization is similar to surgical cricothyroidotomy. A 14 gauge intravenous canula connected to saline filled syringe is inserted through the cricothyroid membrane in the midline with 30^0 and 45^0 caudal angle. This angle reduces chances of vocal cord injury and the incidence of cannula kinking. The cannula is advanced with continuous aspiration. Position of needle in trachea is confirmed by aspiration of air for continuous aspiration. The Ravussin™ 13 G cannula and other such cannula designed for elective trans-tracheal jet ventilation are available. They are less likely to kink compared to an intravenous cannula, and also have wings and tape for securing them around the neck. The patient can be ventilated with using jet ventilation.

The needle cricothryiodotomy set can be custom made with 14 gauge intravenous cannula connected to a 2 mL syringe and universal connector of ET tube (Figure 3) and the patient can be ventilated with a resuscitator bag using low tidal volume delivery. This is an inferior technique and less likely to be successful and should be used only when jet ventilation is unavailable.

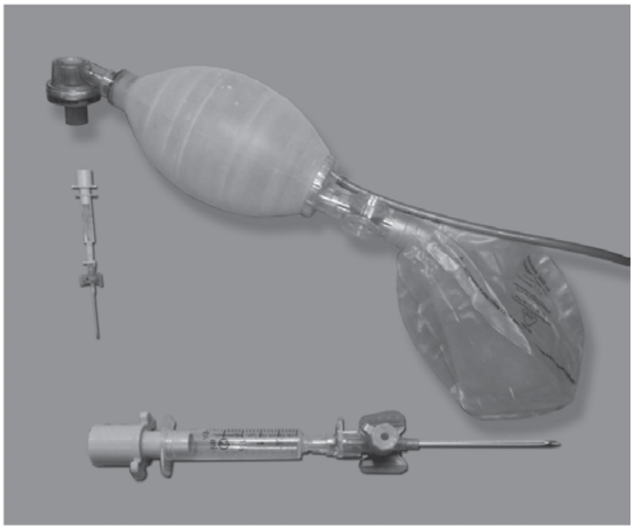

Figure 3: Custom made needle cricothryiodotomy set (A 14 gauge intravenous cannula connected to a 2 mL syringe and universal connector of an ET tube with a resuscitator bag for ventilation)

Narrow-bore cannula cricothyroidotomy require high pressure (jet) for ventilation carrying significant risk of barotrauma. High-pressure ventilation devices may not be available in all ICUs. Chances of failure[9] are high because of kinking, malposition, or displacement even with specially designed cannulae, like Ravussin™

The previous DAS guidelines[22] in 2004 included cannula techniques to promote earlier intervention since anaesthetists are much more familiar with handling cannulae than scalpels. Narrow-bore cannula techniques work well in the elective setting. In CICO situation, their limitations are requirement of a high-pressure source for ventilation, risk of barotraumas, failure because of kinking, malposition, or displacement of the cannula. High-pressure oxygenation through a narrow-bore cannula is associated with serious morbidity.

In 4th National Audit Project (NAP 4) audit[1]; narrow bore cannulae and jet ventilation had high failure rate (63%) due to various reason like misplacement, misuse and device failure like detachment of the cannula or kinking. Wide bore cannula cricothyroidotomy had lesser failure rate (43%). Surgical cricothyroidotomy was successful in all three cases in which it was first choice. Hence the current DAS Guidelines[9] recommend surgical cricothyroidotomy as a preferred method.

2. Wide-bore (≥4mm) cannula

They have advantage of larger lumen of tube with a standard 15 mm connector for conventional ventilation via resuscitation bag or ventilator circuit. It can be kept for longer time unlike small bore. They don't require high pressure oxygen source and jet ventilation. The incision required is relatively smaller compared with surgical tracheostomy,

There are many commercially available sets for performing wide-bore (≥4mm) cannula cricothyroidotomy. Technique can be either Seldinger technique (cuffed Cook Melker®) or catheter/tube over needle technique (e.g. VBM Quicktrach® 2, Portex PCK®)

Anaesthetists and intensivists might be very familiar and more comfortable using Seldinger technique than a surgical cricothyroidotomy. However, these techniques require fine motor control, making them less suited to stressful situations. The evidence[23] suggests that a surgical cricothyroidotomy is both faster and more reliable.

Procedure: Landmark identification and stabilization is similar to surgical cricothyroidotomy. A transverse incision is taken over the inferior border of cricothyroid membrane. Further procedure is similar to Narrow-bore cannula cricothyroidotomy. The position of needle in trachea is confirmed by aspiration of air for continuous aspiration. There is a slight variation in further technique depending on the method adopted.

Seldinger technique:

After conformation of needle in trachea, guidewire is advanced followed by dilator and tube. (e.g. Cook®)

Catheter or tube over needle technique[24]*:*

In catheter over needle technique e.g.Quicktrach®, incision is not required and cannula is advanced further in trachea similar to insertion of IV cannula. A slight variation of catheter over needle technique; the tube-over-needle design Potex PCK® Kit incorporates a stiff, blunt cannula on a spring loaded varess needle which confirms entry of the needle in the trachea and also any subsequent contact with the posterior tracheal wall. The device requires a two cm. skin incision on cricothyroid membrane before insertion.

The tube cuff is inflated to achieve good seal for ventilation and to prevent aspiration.

Comparison of cuffed cricothyroidotomy devices

In a porcine model[25], insersion time of Quicktrach® was fastest (52seconds) compared with Surgical (59 seconds), Melker® (92 seconds), and PCK®. (181 seconds). Melker® scored best in terms of success rate within 300 seconds (100%) compared with Surgical (95%) and Quicktrach® (95%). PCK® had very low success rate (60%) and high incidence of posterior tracheal wall trauma.In an artifical neck model[26], ventilation was achieved fastest using the surgical technique (34 seconds), faster with Minitrach® II and the Quicktrach® (48 seconds for both) and slower with Melker® kit (126 seconds). In this cross over study, in spite of faster ventilation in the surgical method, the Quicktrach® and Minitrach® II were preferred choice (first or second preference) by the majority of operators (78% and 70% respectively).

In a study in cadaveric porcine model[27] comparing percutaneous device (PCK®) and the bougie-assisted surgical technique (BACT) for emergency cricothyrotomy done by ambulance anaesthesiologists, PCK® had lower success rates (60%) compared with BACT (95%). There was also a higher incidence of tracheal injury with PCK® (60%) with no such incidence reported in BACT.

Oxygenation and Ventilation following cricothyroidotomy

1. High Pressure Jet Ventilation

With needle or narrow-bore (<4 mm) cannula cricothyroidotomy, high pressure jet ventilation is needed for oxygen to overcome resistance offered by small lumen of catheter.[21] However, the risk of barotrauma is increased especially in upper airway obstruction which must be relieved to allow adequate egress of air during exhalation. Proper rise of the chest during inspiration and also equally important, fall during expiration must be monitored with each breath to avoid barotrauma.

Jet ventilation should be avoided in children below age 8 years.[18] A four bar oxygen flowmeter with y connector should be used instead.

Figure 4: VBM® Manujet III for jet ventilation having a pressure regulator and a pressure gauge

Some authors suggest insertion of one more cricothyroidomy cannula for expiration. However this is an oversimplification of the problem with no scientific basis.[21, 28] Actually one needs a 16 such canulae to be inserted for effective exhalation, as it takes 32 s for passive exhalation of 500 ml is through a 2 mm ID orifice. Manujet injector for jet ventilation with variable working pressure[4] is shown in Figure 4.

One needs to acknowledge that effective ventilation (elimination of CO_2) becomes inferior with narrow-bore (<4 mm) cannula. Hence CO_2 accumulates. Nevertheless it can tide over the crisis by saving the patient from hypoxia. It is a temporary method that should be used as a bridge to a definitive airway.

Ventrain® device for CO_2 removal

Ventrain is a novel ventilation device designed to provide adequate ventilation through a narrow-bore catheter (2 mm). Active expiration is achieved by expiratory ventilation assistance (EVA) which is based on principle of optimizing balance between the Venturi effect and jet entrainment. Expiration time is shortened, minimizing air trapping enabling an inspiratory expiratory (I: E) ratio of 1:1 compared with conventional jet ventilation which require I/E of 1:4 or 1:3. Hence it can deliver up to seven litres of minute volume and provides connection for capnometry.

Mechanics of Jet Ventilation during Inspiration

400 kPa (pipeline) pressures is required to produce a flow of 500 ml/s through a 16 G cannula. A jet injector (400 kPa/58 PSI/4 BAR) provides 800 ml/s. oxygen flow meter has similar pressure range. when set to 15 l/min, it gives flow of 400 ml/s. Oxygen flush from an anaesthetic machine (32 kPa/4.6 PSI) gives 200 ml/s. Anaesthetic circuit with a bag (6 kPa) provides only 80 ml/s. Ideally, a jet injector at 200-400 kPa (29-58 PSI) should be used with an inspiratory phase of 1 s duration with a period of at least 4 s for exhalation. Venturi effect with entrainment of air can reduce FIO_2 to 50%. A four bar oxygen flow meter with Y-connecter is recommended as alternative to jet ventilation in child aged 1-8 yrs.[18]

Expiration while using jet ventilation

Exhalation is passive and occurs only slowly through a small cannula. Time for passive exhalation of 500 ml is 32 s through a 2 mm ID orifice, 8 s through a 3 mm orifice and only 4 s through a 4 mm orifice.[28] Exhalation can also occurs through the larynx and upper airway and ultimately through the mouth, when a non cuffed cannula or tube is used. In such cases capnography cannot be utilized for confirming or for guiding ventilation.

If the airway is obstructed due to oedema or laryngospasm, tongue fall or any anatomical problem, overinflation of the lungs can easily occur with resulting barotrauma. Hence monitoring of proper rise and fall of the chest with each breath is of paramount importance. Some authors recommend insertion of oral and nasal airway and sometimes laryngoscope blade to aid expiration.

To summarize, with needle cricothyroidotomy, it is easy to ventilate with closed glottis. However there are chances of barotraumas because expiration does not occur through closed glottis. If the glottis is open, expiration is not an issue but inspiration is not possible and only jet can ventilate such patient. In practice glottis might be partly open or closed so chest rise and fall must be monitored with each breath.

2. **Conventional ventilation**

   Cannula of needle cricothyroidotomy is connected to 2 mL syringe with piston removed. Other end of syringe can accept a 15 mm. airway adapter from a 7.5 mm. ID ET tube, which can be connected to a bag-valve oxygen source (Figure 3). Due to high resistance and lower pressures generated by bag ventilation and oxygenation is far inferior compared to jet ventilation. Through a 14 G cannula it can deliver 80 ml tidal volume with closed Glottis and 0 ml with open Glottis.[21] This technique can be employed to needle cricothyroidotomy in infants with some success. [19] Cuffed cricothyroidotomy tubes have larger lumens (ID 4-6mm). They are definitive airways. Effective oxygenation and ventilation can be achieved by regular bag-valve oxygen source.

Complications of Cricothyroidotomy

They can be differentiated into early and late.

◆ Early[16]

- Posterior tracheal wall and Esophageal injury
- Subcutaneous emphysema
- Tracheal bleeding

◆ Late

- Subglottic stenosis
- Injury to tracheal and laryngeal cartilage.

Though cricothyroidotomy is not without complications, one must outweigh these against the risk of not performing a cricothyroidotomy, which can potentially lead to hypoxic brain damage cardiac arrest leading to death unless the situation is rapidly resolved.

Cricothyroidotomy tube can be left in place for up to 72 hours. If airway access is needed for more than 72 hours, it should be converted to a tracheostomy.[16]

Subglottic stenosis is a very specific complication of cricothyroidotomy historically highlighted by Chevalier Jackson. However benefit of establishment of oxygenation in CICO situation outweighs risk of this complication.

Choice of cricothyroidotomy technique:

A comparison of surgical, wide and narrow bore canula cricithyroidotomy techniques is given in Table 2. National Airway Project 4 (NAP4) audit[1] has observed preference of Anaesthetists for cannula techniques over surgical technique for rescue of airway. However, these techniques, especially the narrow bore cricothyroidotomy were associated with a higher failure rate. Surgical cricothyroidotomy had consistently high success rate but not necessarily with good patient outcome. Most international airway various societies[9-12] have recommended either surgical or cannula techniques for FONA. Further research is warranted in this area before strong recommendations can be made for one technique over the other.

Table 2: Comparison of Various Cricothyroidotomy Techniques

Features for comparison		**Narrow bore (<4mm) cannula** (needle)	**Wide-bore (≥4mm) cannula** (commercial kits)	**Surgical cricothyroidotomy**
Technique	Availability of equipments	Readily available	Need to be procured	Can be made available
	Ease of technique	Easiest	Easier	Moderate difficulty
	Familiarity of technique	Very Familiar	Quite familiar	Generally unfamiliar
Success Rate		Failure due to blockage, kinking	Fair success rate	Excellent success rate
Duration		Very short term	Long term (72 hours)	Long term (72 hours)
Ventilation	Inspiration	Needs jet ventilation	Similar to conventional ventilation through ET/ tracheostomy tube	Similar to conventional ventilation through ET/ tracheostomy tube
	Expiration	Delayed expiration with chances of barotrauma. (with the possible exception of devices like Ventrain®)		

Training in FONA

Surgical cricothyroidotomy may be considered as the gold standard. This technique is recommended in most airway algorithms. However, one needs to practice this procedure regularly to master it. Anaesthetists and intensivists may very rarely ever perform this procedure on a patient in their lifetime. Thus in a panic life and death situation of CICO, they may not be confident enough to perform this procedure, unless they have practiced it on manikins and simulation based courses testing both technical and non technical skills.

The NAP4 report findings revealed that surgical cricothyroidotomy was almost universally successful as compared cricothyroidotomy with needle cricothyroidotomy (66% failure rate). [1]Nevertheless, other valid techniques for FONA may continue to be learnt and performed depending on the skill and availability in the institute, while attempts should be made by all to learn surgical cricothyroidotomy. Everyone involved in airway management should be should be familiar with the cricothyroidotomy procedure with repeated training at regular intervals to ensure skill retention[9].

Human factors

Human factors play significant role in occurrence of adverse outcomes in difficult airway situation[9]. Berlin et al[29] have reported 'The Notorious Five' attitudes for avation industry. Greenland et al[30] have commented about possibility of these attitudes playing role in CICO situation, These attitudes are listed below.

1. Anti-Authority: "Don't tell me."
2. Impulsivity: "Do it quickly."
3. Invulnerability: "It won't happen to me
4. Macho: "I can do it." I'll show them
5. Resignation: "What's the use?"

The behavioural aspects of airway rescue are not studied well. Delay in decision-making and skill-fade over a period of time are likely to have a more significant impact on outcome than the choice of device [1].The NAP4 report had highlighted a number of problems at various levels which can lead to failed airway. Firstly, there can be a delay in decision to go for cricothyroidotomy (due to various reasons). There can be knowledge gaps such as not everyone understands how available equipment for oxygenation works or there can be system failures due to non availability of specific equipment. And lastly there can be technical failures as not everyone is well versed with insertion of cannula in the airway especially in emergent situation. Following further analysis, Flin et al [31], identified median of 4.5 (range 1–10) human factors per case reported to NAP 4. The most common factors in descending order were related to lack of situation leading to failures to anticipate, wrong decision followed by job factors like task difficulty, staffing, time pressure and also personal factors like tiredness, hunger and stress.

An important lesson learnt from the NAP4 report is that dissemination of guidelines and a professional willingness to follow them is not enough to prevent serious complications of airway management. Even the best airway team may still struggle in crisis situation with flawed systems. One need to also acknowledge that management of difficult airway is complex and cannot be clubbed into a single algorithm.

Fixation errors impair decision-making abilities of clinicians due to overload of information. One may have observed clinicians missing the big picture and getting fixated on a particular task, for example multiple failed attempts tracheal intubation leading to life threatening hypoxemia.

Simulation can play very important role in rehearsal of this life threatening and relatively rare situation of CICO. Few societies like Australian and New Zealand College of Anaesthetists mandate participation in such training during continuing professional development. Simulation can also help in training and development of clinicians to deal with CICO by improving their non-technical skills like leadership, communication, and team coordination.

Conclusion:

Any airway management in ICU is considered as difficult and high risk and one must be prepared and trained to handle a CICO situation at all times. Proper planning for difficult airway and its communication in the team before airway management of every patient is of utmost importance. Emergency cricothyroidotomy and not tracheostomy, is the technique of choice in CICO situations with increasing hypoxemia. Considering the life saving potential of this technique, every anaesthesiologist, intensivist, or any other physician dealing with airway management in practice should be well versed with this procedure. Remember: *"Good preparation does not always lead to success but lack of preparation guarantees failure"*.

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