INFRAGLOTTIC INVASIVE AIRWAYS

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Percutaneous, invasive, surgical, cricothyrotomy, tracheostomy, mini-tracheostomy, cricothyrodotomy, cricothyrostomy, rail-road, Seldinger, dilatational, retrograde.

Summary:

Alternative means of airway management by airways to regular endotracheal intubation can be divided into two broad categories:

1) Cricothyrotomy and
2) Tracheostomy.

These can be assessed either percutaneously with less invasiveness or surgically. Here techniques, indications, contraindications, advantages and complications of these procedures are discussed.

Introduction:

In the vast majority of instances, anesthesiologists manage to control and maintain the airway by endotracheal intubation. However despite extensive training and skills, every anesthesiologist occasionally encounters an airway that cannot be managed by endotracheal intubation.

During control of the airway three scenarios can be there:

1) airway can be easily controlled by mask ventilation and endotracheal intubation
2) airway can be maintained by mask ventilation but can not be intubated
3) airway can not be maintained by either mask ventilation or intubation.

This third condition is called as 'Can Not Intubate / Can Not Ventilate' (CNI / CNV). This is a real nightmare to any anesthesiologist. To manage such situations, American Society of Anesthesiologists (ASA) has devised certain guidelines. This algorithm is updated in 2003 and is given here.

Infraglottic invasive airway techniques are used in emergency as well as in elective situations. They are advocated when the non-invasive techniques like LMA or Combitube fails or can not be used. From the time of airway management by endotracheal intubation is practiced, alternative means of airway access by invasive techniques are tried. During CNI / CNV situation, these techniques gain more value.

Situations where Infra Glottic Invasive Airways (IGIA) are practiced:

1) in difficult airway patients (CNI / CNV)
2) when endotracheal intubation is contraindicated

3) in continuation of ET intubation (as in ICU patients)
4) when endotracheal intubation is contraindicated
5) in emergency airway access

In many hospitals, the anesthesiologist is called up to manage the airways of critically ill patients in other departments like ICU or war. So these techniques should be in the armamentarium of any anesthesiologist to control the airway successfully.

In emergency conditions, when the airway should be controlled without any time to loss, the following procedures are now internationally accepted (in order):

1) Needle cricothyrotomy
2) Percutaneous cricothyrotomy
3) Surgical cricothyrotomy
4) Surgical tracheostomy

History:

3000 years ago, airways were maintained by invasive procedures in Egypt and India. 1300 years ago, Spanish person *Vesalius* tried control of airway of a noble man by tracheal stabbing and ventilation of lungs by reed. He can be considered as the first man to do CPR.

Until 1970, due to the influence of *Chavelier Jackson*, who advocated surgical tracheostomy procedure and discouraged percutaneous techniques, cricothyrotomy and percutaneous tracheostomy were not practiced widely. After 1970, these techniques were popularised and the advent of fiberoptic endoscopy they become safe also.

Techniques:

Though there are many infraglottic airway procedures, a simple classification here is followed for the ease of understanding:

1) Percutaneous jet ventilation (through needle)
2) Retrograde intubation
3) Percutaneous cricothyrotomy
4) Surgical cricothyrotomy
5) Percutaneous tracheostomy
6) Surgical tracheostomy

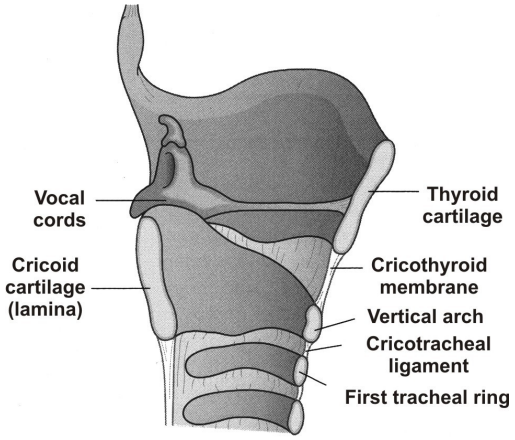
Before seeing various techniques let us see some common features like anatomy, physiology and anaesthesia.

Anatomy:

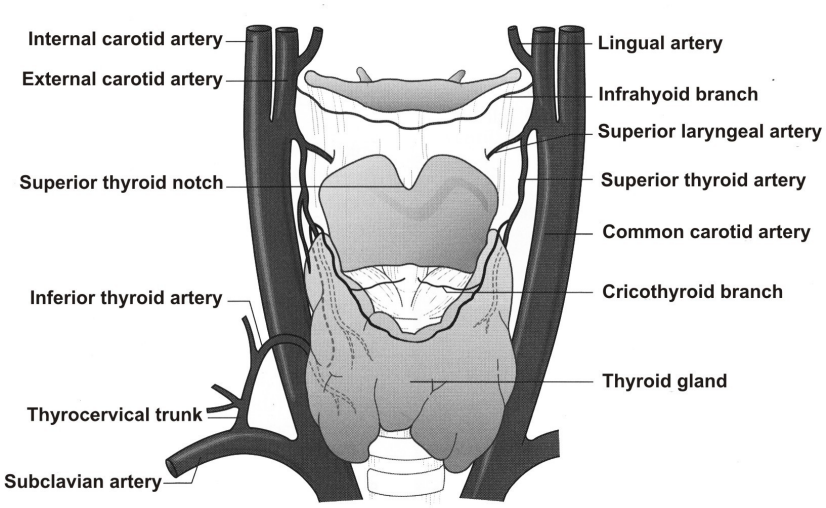
Before we see the various procedures, it is important to note the basic anatomical features and their variations.

The thyroid cartilage is prominent in the middle (especially in males). Above it, connecting this with hyoid bone is thyro hyoid membrane. The vocal cards are behind the thyroid cartilage.

The cricoid cartilage is situated below the thyroid cartilage and is in the shape of signet ring. This is the only cartilage covered posteriorly. The flat part (lamina) is in the posterior part. Since this is just below the skin, it can be easily palpated even in obese patients.



Anatomy of the cricoid cartilage



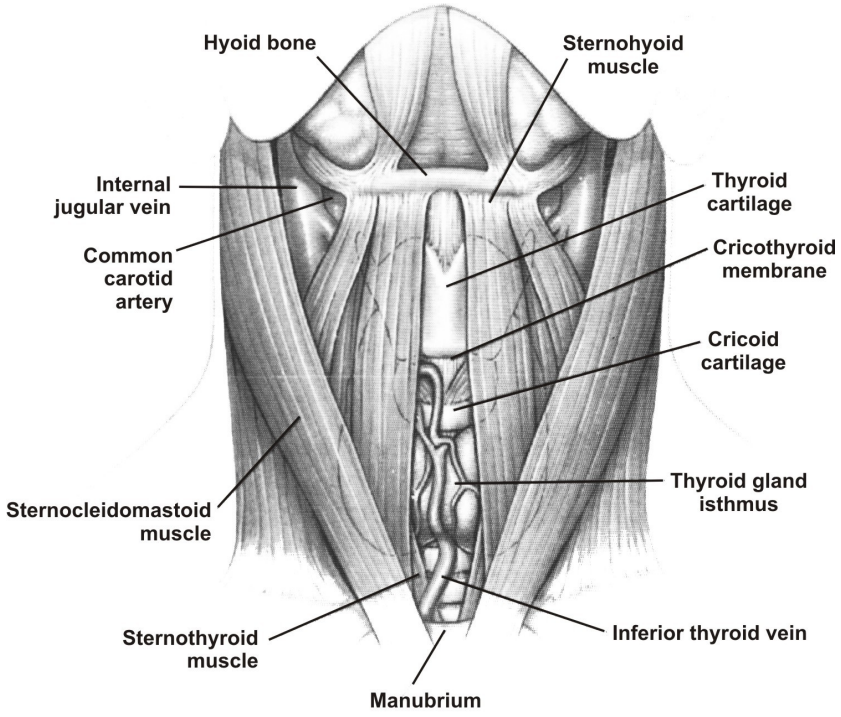
Vascular anatomy above and below the cricoid cartilage

In between cricoid cartilage and thyroid cartilage, there is cricothyroid membrane (CTM). This membrane is 1 cm in height and 2 cm in width. Central part of this membrane is thick and triangular in shape (conus elasticus) with apex near cricoid cartilage.

The important feature of this CTM is that, it does not calcify with age like other cartilages. So this can be pierced even in old age.

There may be cricothyroid artery and superior thyroid artery above the cricoid cartilage. In some cases, the cricothyroid arteries anastamose in midline at the upper part of CTM. So it is safer to pierce the CTM at its inferior part.

Below the cricoid cartilage, there are tracheal rings. In front of 1st to 4th tracheal rings, the isthmus of thyroid gland situated. The anterior branches of the superior thyroid artery run along the upper border of the thyroid isthmus to anastomose in the middle. In this part, the arteries are prominent. In 10% of patients, an unpaired thyroid ima artery ascends ventral to the trachea to anastomose at the level of isthmus.



Anatomic landmarks of the neck

The high innominate artery sometimes lies over the lower tracheal rings and obstruct the access of trachea.

Physiology:

During airway access, sympathetic responses occur. To facilitate the viewing of the cartilages better, patient is positioned supine sniffing position with the neck hyperextended.

Anaesthesia:

This procedure is done usually in critically ill patients or whose airway is already compromised by repeated manipulation. So, topical anaesthetic agents like lidocaine is used for nerve blocks along with some IV sedation.

IV sedation is usually accomplished by Propofol / Fentanyl / Midazolam as per the performing anesthesiologist's choice or patients status.

Topical infiltration of 1 % lidocaine (with epinephrine) at the incision site along with Superior laryngeal nerve block and Glossopharyngeal nerve block will make the procedure comfortable for the patient as well as the anesthesiologist.

I. PERCUTANEOUS JET VENTILATION:

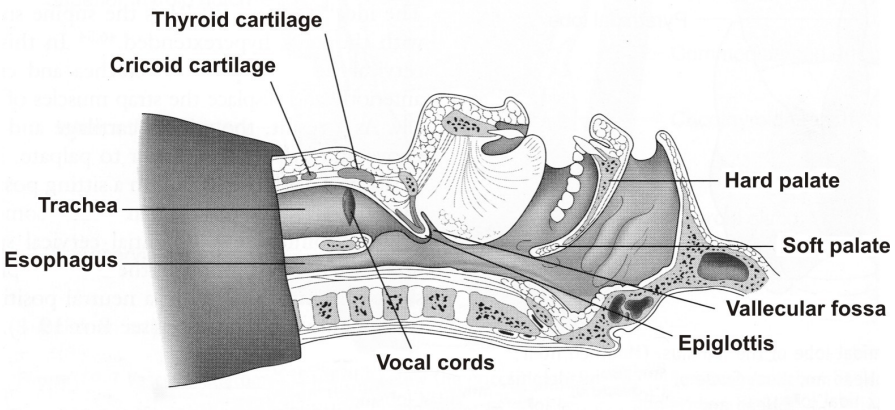
This procedure is also called as 'Trans Tracheal Jet Ventilation' (TTJV).

TTJV is used in:

1) CNV / CNI situations
2) for surgeries in upper airways, when the airway is share by surgeon and anesthesiologist or when the airway is not accessible.
3) as an interim procedure till the ET tube is placed.

Procedure:

With a large bore needle the CTM is pierced at its lower end. Usually 12 to 16 G needle is used for this. Air is aspirated to make sure the placement of needle tip. Pressurised O_2 source is connected to the needle and ventilation is given.



Midsagittal view of the head and neck

Due to Venturi principle, the surrounding air is also sucked in and inflation of lungs occur. Exhalation is by elastic recoil of the lungs.

As the exhalation depends on the patency of airway, this procedure is contra indicated in obstructed airway. Important complications are barotrauma and inadequate ventilation.

II. RETROGRADE INTUBATION:

This is a misnomer. Actually, this procedure is **translaryngeal guided intubation**. It was popularized when a British anesthesiologist *Waters* used this in 1963 for the Nigerian patients who were having cancrum oris with limited mouth opening.

Contrary to the belief it is done faster with average time of 90 – 120 seconds. Usual upper airway anaesthesia with some IV sedation is given.

Indications:

1) CNV / CNI condition
2) upper airway trauma

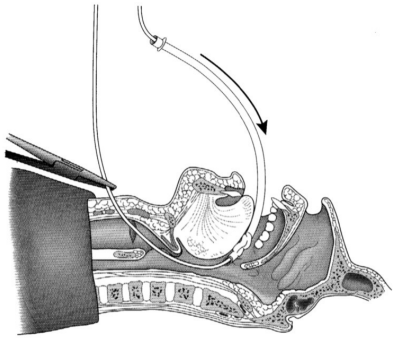
3) bleeding and secretions in the upper airway with makes the visibility of vocal cord difficult

Contraindications:

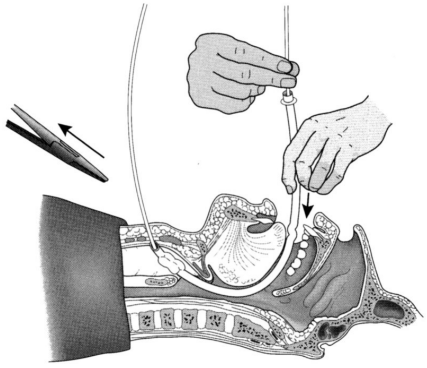
1) unfavourable anatomy (obesity, enlarged thyroid)
2) laryngotracheal diseases
3) coagulopathy
4) infection

Technique:

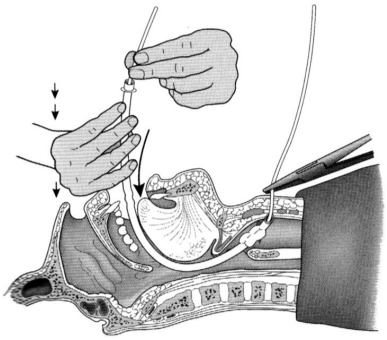
CTM or cricotracheal ligament or airway at tracheal rings is pierced with an epidural needle. Placement of needle tip is confirmed by aspiration and epidural catheter is guided into the airway which is identified in the oral cavity and the same is pulled through the oral cavity.



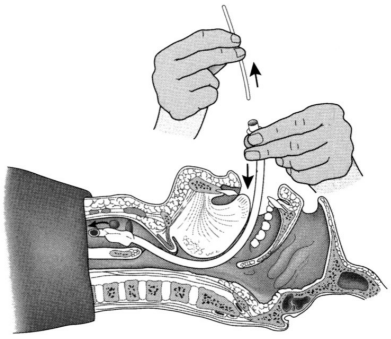
Thread a well- lubricated endotracheal tube (ET)



Have an assistant remove hemostat



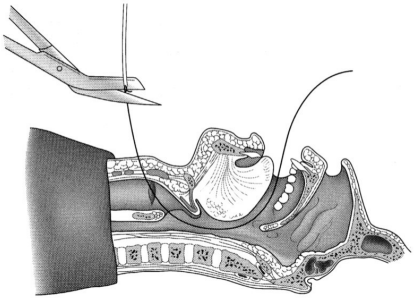
When the encotracheal tube



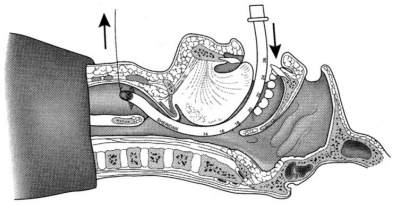
Simultaneously remove epidural catheter as you advance the endotracheal tube

Now through the catheter the Murphy's eye or the end of the ET tube is guided so as the ET tube is guided into the trachea.

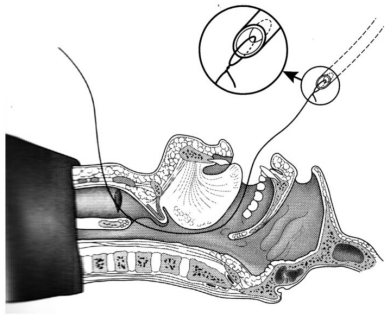
In **'Silk Pullthrough technique'** the epidural catheter is used to track down the silk which is brought out through the neck. Now the ET tube is pulled into the trachea. In this technique silk is maintained in the trachea so as reintubation if necessary becomes easier.



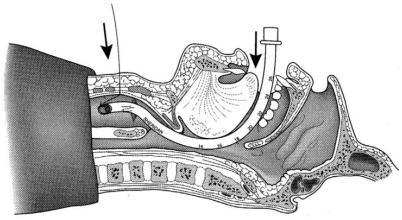
Pull the epidural catheter caudad



Simultaneously pull the silk caudad



Tie the suture to the Murphy eye as shown



Release the suture, and with the opposite hand advance the endotracheal tube

This retrograde intubation procedure is practiced even in peadiatric patients with the help of fiberoptic scope.

Complications:

1) esophageal perforation
2) hemoptysis
3) hematoma
4) edema
5) laryngospasm
6) infection, tracheitis
7) tracheal fistula
8) vocal cord damage
9) subcutaneous emphysema

III. PERCUTANEOUS CRICOTHYROTOMY:

Cricothyrotomy can be defined as a technique for providing an opening in the space between the anterior inferior border of the thyroid cartilage and the anterior superior border of the cricoid cartilage for the purpose of gaining access to the airway.

Cricothyrotomy is also called in medical literature as coniotomy, crico thyroidotomy, cricothyrostomy, intercricothyrotomy, minitracheostomy and percutaneous dilatational tracheostomy.

It is a safer and fast technique used in emergencies. Ideally speaking, Trans Tracheal Jet Ventilation, Retrograde intubation are also cricothyrotomies.

Indications:

1) failed intubation
2) head and neck trauma
3) acute respiratory obstruction
4) alternative to tracheostomy

It is done as an emergency procedure

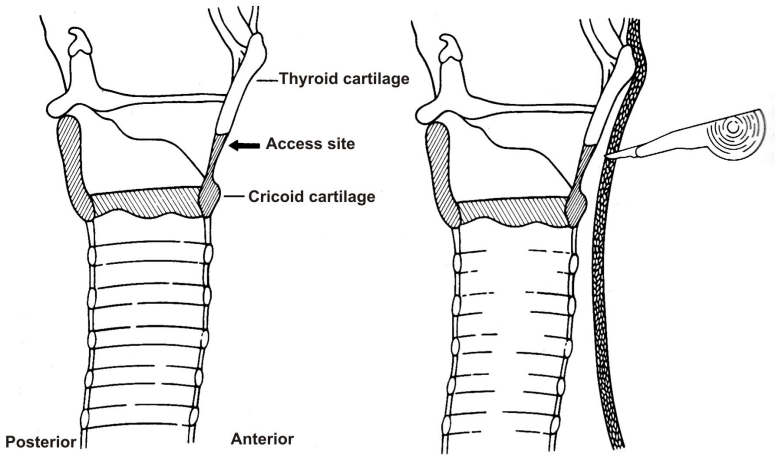
1) during transport of patients
2) in the prehospital scenario
3) in the emergency department
4) in ICU
5) in OT

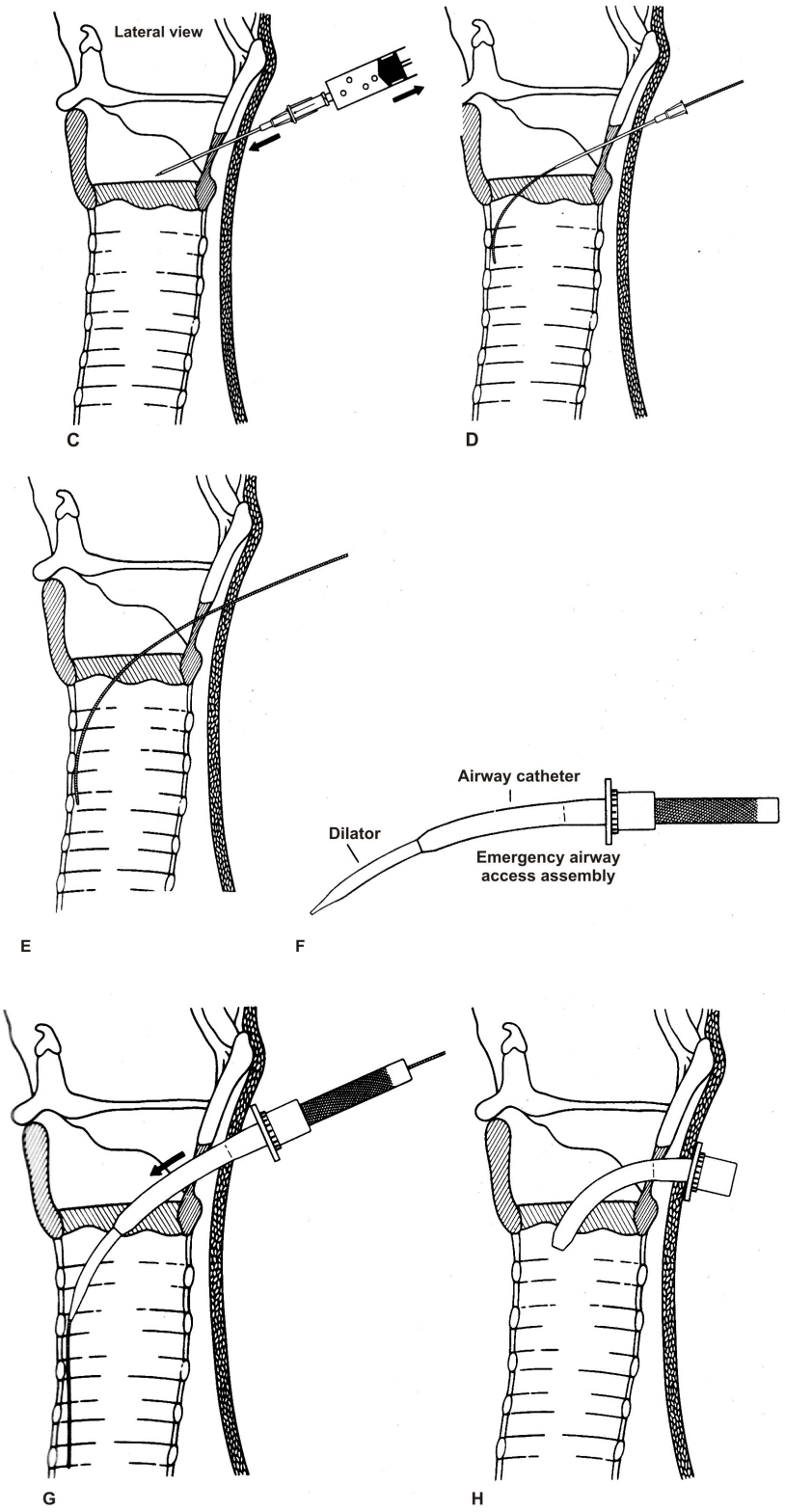
Contraindications:

1) intubated patients (> 3 days) - subglottic stenosis
2) infants and children (< 10 years) - narrow airway
3) preexisting laryngeal disease
5) bleeding disorders

Techniques:

Percutaneous cricothyrotomy is done by piercing the CTM membrane at its lower part with a wide bore needle. After confirmation of the position of tip, a guidewire is inserted. Railing through the guidewire, serial dilators are inserted to dilate the pathway and finally the ET tube or tracheostomy tube is inserted.





There are many techniques followed internationally:

1) Melker percutaneous dilational cricothyrotomy device (see figure)

2) Pertrach percutaneous dilational cricothyrotomy device (guidewire and dilator are in a single unit)
3) Nutrake percutaneous dilational cricothyrotomy device
4) Portex and Melker Military (without guidewire)

Complications:

Early:

1) asphyxia
2) hemorrhage
3) improper or unsuccessful tube placement
4) subcutaneous emphysema
5) pneumothorax
6) esophageal / mediastinal perforation
7) vocal cord injury

Late:

1) tracheal / subglottic stenosis
2) TE fistula
3) infection
10) tracheomalacia

IV. PERCUTANEOUS TRACHEOSTOMY:

This is almost like percutaneous cricothyrotomy, except the entry point. The needle here is inserted in between the tracheal rings (usually between 2nd and 3rd or 3rd and 4th).

Yet there are some basic differences between two procedures:

Sl. No.	Cricothyrotomy	Tracheostomy
1.	Used in emergencies	Not usually used in emergencies
2.	Usually a temporary airway access	Long term maintenance of airway
3.	Fiberoptic view is not necessary	Recommended
4.	LA / Sedation less required	Adequate analgesia is needed
5.	Done only in adults	In paediatrics also
6.	Less complications	Needs more expertise
7.	Ideal in obese patients, huge thyroid, innominate artery patients	Ideal for upper airway masses
8.	Speed and simplicity	Time consuming

Now it is recommended to use fiberoptic viewing of trachea during the entire procedure to increase the safety.

Indications:

1) usually done in ICU patients for

a. continuation of airway maintenance
b. weaning from ventilator
c. obstruction in airway
d. tracheal toileting

2) in children – elective and emergency

a. continuation of airway maintenance
b. weaning from ventilator
c. obstruction in airway
d. tracheal toileting

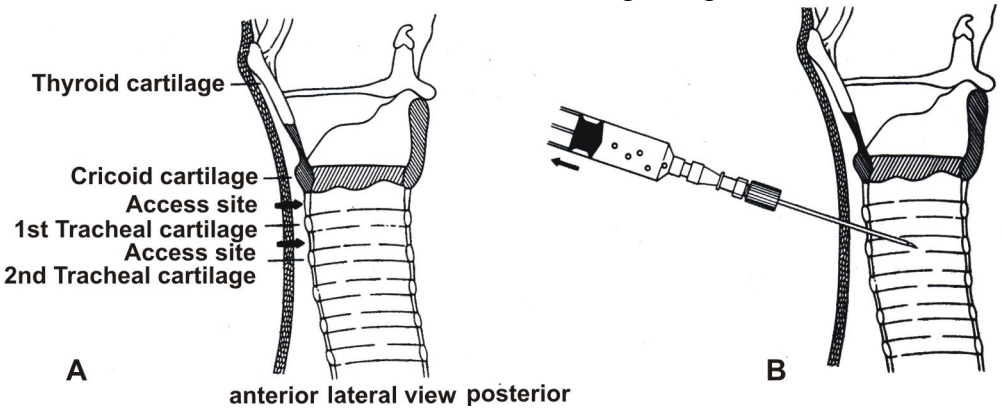
Contraindications:

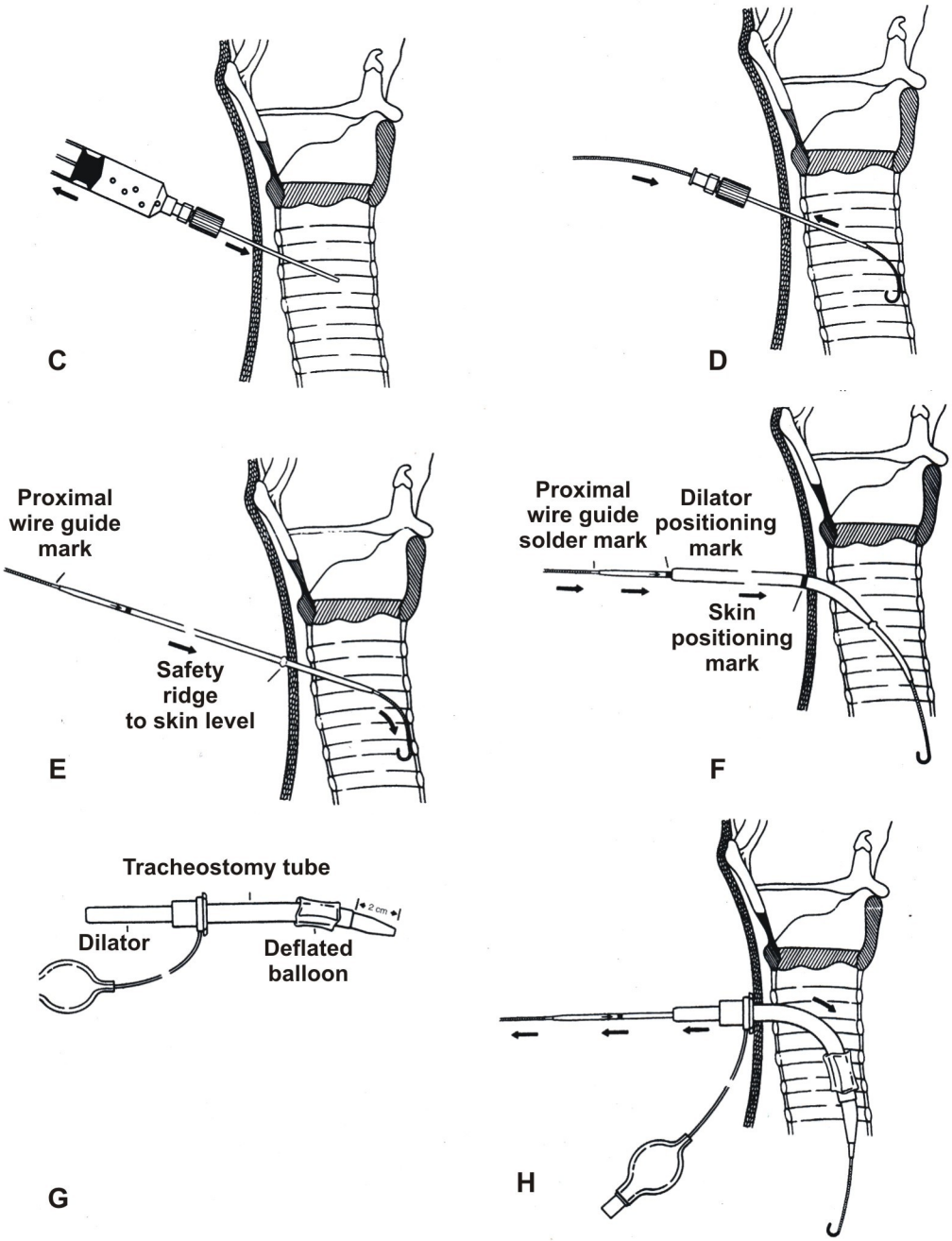
1) midline neck mass (including thyroid)
2) high innominate artery
3) inability to palpate cricoid and trachea
4) unprotected airway
5) with PEEP > 20 cmH_2O
6) coagulopathy
7) non availability of fiberoptic bronchoscope

Technique:

After the skin is infiltrated with 1 % lidocaine, an horizontal incision (vertical incision also allowed) is made. Now the bronchoscope is advanced to view the trachea below vocal cords. Then an introducer needle is inserted in the lower most part of trachea under vision. After confirming, a guide wire is inserted. Now the needle is removed and the port is dilated either with serial dilators or a single dilator (horn like). After adequate dilation, the tracheostomy tube is inserted.

Newer variation of Cook dilator set (of Ciaglia technique) is currently practiced more worldwide. The single dilator in this set has soft tip (to prevent soft tissue injury) with hydrophilic coating. It can dilate upto size 8. The set also contains a 17 G introducer needle, 14 Fr. introducer dilator and 12 Fr. guiding catheter.





Complications:

<u>Early:</u>

1) hemorrhage
2) subcutaneous
3) pneumothorax
4) recurrent laryngeal nerve injury

<u>Late:</u>

1) infection
2) TE fistula

3) granuloma
4) laryngotracheal stenosis

V. SURGICAL CRICOTHYROTOMY:

Also called as 'open cricothyrotomy'. Instead of introducing a needle through CTM membrane, an incision is made to introduce dilator and then ET tube or tracheostomy tube.

In 'No-drop technique', vertical skin incision is made followed by horizontal incision of CTM. In 'Rapid four step technique', horizontal incisions are made in skin and CTM.

Indications:

1) trauma patients – to secure airway faster
2) airway obstruction due to

a. trauma
b. FB
c. stenosis
d. mass

Contraindications:

1) in children
2) laryngeal fracture

VI. SURGICAL TRACHEOSTOMY:

This is the technique popularized by Chevalier Jackson who condemned high tracheostomy (cricothyrotomy).

This technique is:

- faster,
- safer and
- definite.

It is refereed as gold standard to compare other airway access procedures.

The limitations are:

- it needs a surgeon to perform,
- it requires an operating room (becomes expensive)
- it requires an anesthesiologist to be with the patient

Maintenance of airway:

After securing the airway, it is tied behind the neck with some strap. ET cuff should be adequately inflated so as to prevent the seepage of secretions into the lungs. High volume low pressure cuffs are preferred because they prevent ischemic damage to the tracheal mucosa. It is important to apply suction frequently to maintain airway patency.

Indications for suctioning:

1) visible secretions in the tracheostomy tube
2) audible gurgling
3) coarse or diminished breath sounds
4) increased airway pressure
5) unexplained decrease in O_2 saturation.

Conclusion:

As the anesthesiologist is viewed as the ultimate saviour when the patient's life is depending on airway maintenance, every anesthesiologist should have knowledge and experience in these life saving procedures. Many disasters will be prevented if we are well versed in such techniques.

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