Chapter 4
Options For Cardiopulmonary Support

Assuming that the patient's condition dictates prompt restoration of circulation and breathing (and thus, tissue perfusion), several options are possible:

1) External closed chest cardiac compression and positive pressure ventilation of the lungs (conventional cardiopulmonary resuscitation or "C-CPR");

2) Simultaneous compression-ventilation cardiopulmonary resuscitation (SCV-CPR)

3) High impulse cardiopulmonary resuscitation (HI-CPR).

4) Open chest cardiopulmonary resuscitation (OC-CPR).

5) Direct access of the patient's circulation and complete circulatory and respiratory support employing a blood pump and oxygenator (artificial lung).

C-CPR

C-CPR has the advantage of being immediately applicable and requiring little formal training or equipment to implement. The disadvantage is that C-CPR, performed manually (with the hands) or mechanically (with a heart-lung resuscitator (HLR)) can, even under the best of conditions, deliver only 1/4 to 1/3rd of the normal cardiac output. In a clinical setting, where a patient has experienced slow pre-cardiac-arrest hypoxia with multisystem organ failure, often superimposed on the ravages of the aging process, C-CPR is unlikely to even begin to meet the circulatory and respiratory requirements of the patient. In cases where advanced atherosclerosis is present, a much higher blood pressure will be required to adequately perfuse the tissues than the 40 mmHg to 50 mmHg that C-CPR is capable of delivering (under the most optimum circumstances). The presence of fluid in the lungs (pulmonary edema) and the consumption of lung space (gas exchange surface) by a tumor also act to reduce the effectiveness of C-CPR.

SCV-CPR

An alternative to C-CPR is simultaneous compression-ventilation CPR, a technique investigated in the late 1970's. SCV-CPR works via use of a heart-lung resuscitator to raise the total intrathoracic pressure by simultaneously ventilating the patient at a very high airway pressure (100 cm of water) and compressing the chest. It uses a lower rate of compressions (typically 40/min.), but delivers more cardiac output per stroke. SCV-CPR was very effective at raising total cardiac output and in particular at improving cerebral blood flow. Unfortunately, due to the high intrathoracic pressures it generated, it was even less effective at generating *cardiac* blood flow than C-CPR. The result of clinical trials with SCV-CPR was that there were fewer patients resuscitated, but those who were resuscitated experienced fewer neurological deficits (presumably as a result of better cerebral perfusion).

However, low cardiac blood flows do not present a problem for cryonic transport operations in that our objective is not cardiac resuscitation and resumption of spontaneous circulation and breathing, but rather adequate support of the brain. SCV-CPR is thus a viable option for use during transport of cryonic suspension patients.

HI-CPR

High impulse CPR relies on a relatively new approach to delivering force to the patient's chest in order to move blood. By tailoring the wave-form of the shock-wave delivered to the chest during the compression phase of CPR, it is possible to compress the heart *selectively*, simulating more closely its natural method of operation. By using a square wave form of great intensity (the plunger on the HLR strikes the chest at approximately 200 psi.), it is possible to avoid the high overall intra-thoracic pressures experienced with C-CPR or SCV-CPR *while still* obtaining good cardiac output. Early research indicates that HI-CPR is capable of delivering mean arterial pressures (MAPs) of between 70 and 80 mmHG, as contrasted with MAPs of 40 mmHg or less with C-CPR.

Unfortunately, HI-CPR machines are costly and are unlikely to be widely deployed into the field for some years to come.

OC-CPR

By far the most effective method of CPR is open chest CPR, wherein the patient's chest is opened and the heart is directly compressed by squeezing it in the operator's hand. OC-CPR is capable of delivering MAPs in the range of 80 to 90 mmHg and a cardiac output approaching 60% of resting normal.

There are, however, a number of drawbacks to OC-CPR. First of all, it is an invasive procedure requiring moderate surgical skill which does not lend itself to use in the field by Transport Technicians with modest training. Secondly, there are no mechanical devices currently available to carry out OC-CPR, and thus operator fatigue is a limiting factor. An added consideration is the logistics of trying to externally cool and move a patient being given OC-CPR by an operator!

Extracorporeally Supported Transport Versus HLR Supported Transport

The use of a mechanical blood pump and artificial lung (oxygenator) allows for complete control of blood flow rate (the equivalent of "cardiac output") and sidesteps any pulmonary pathology by completely eliminating the need for the patient's own lungs to provide gas exchange. Unfortunately, since cryonics procedures cannot be started on a patient until legal death has been pronounced, it is not possible to begin such extracorporeal (i.e., blood pump/oxygenator) support immediately at the time of clinical or legal death. Accessing the patient's circulatory system for extracorporeal support is a fairly sophisticated surgical procedure which requires, under optimum conditions, 15 to 30 minutes. Extracorporeal support also requires a team of at least two and preferably

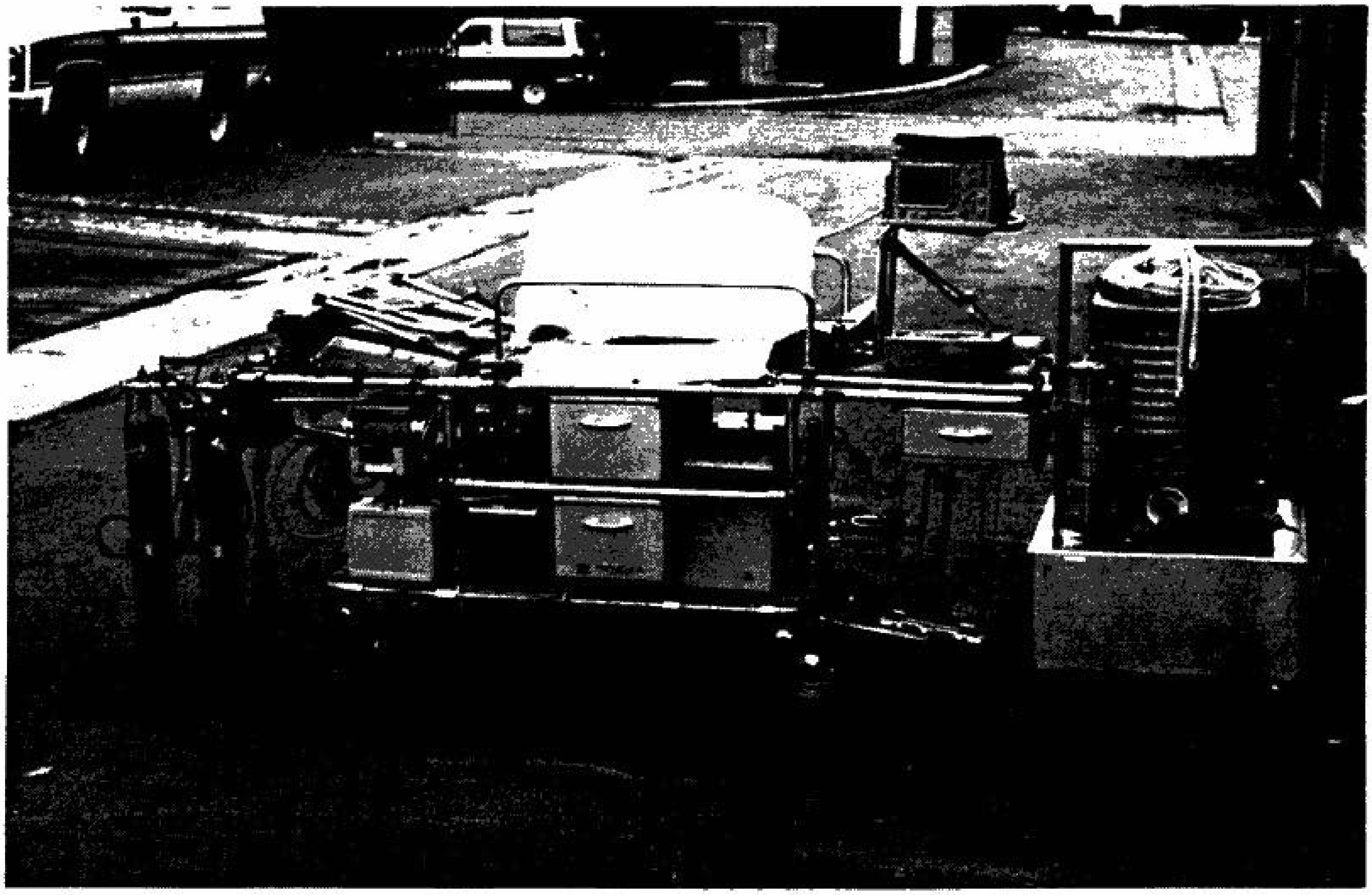


Figure 4-1: *Mobile Advanced Life Support Cart.*

three highly trained people as well as the use of sophisticated and costly equipment. Even under the best of circumstances, where such personnel and equipment are readily available, a period of circulatory support employing cardiopulmonary resuscitation will be necessary.

Initiation Of Cardiopulmonary Resuscitation (CPR)

Basic Cardiac Life Support

The details of manual CPR and the protocol for applying it is covered in course material elsewhere (i.e., in the Basic Cardiac Life Support (BCLS) Manual) and thus will be treated only briefly here. Application of the techniques discussed below presumes that the patient has been pronounced legally dead by a physician.

1) Position the patient. To perform adequate CPR, the patient must be face up on a firm surface. If the patient does not have a backboard in place and is on a mattress, quickly place the backboard of the heart-lung resuscitator (HLR) under the Patient's arms, with the patient's shoulders at the upper end of the shoulder lift and the patient's head extended down into the cup of the handle.

2) Open the airway. Clear the pharynx with a finger to remove vomitus, particles of

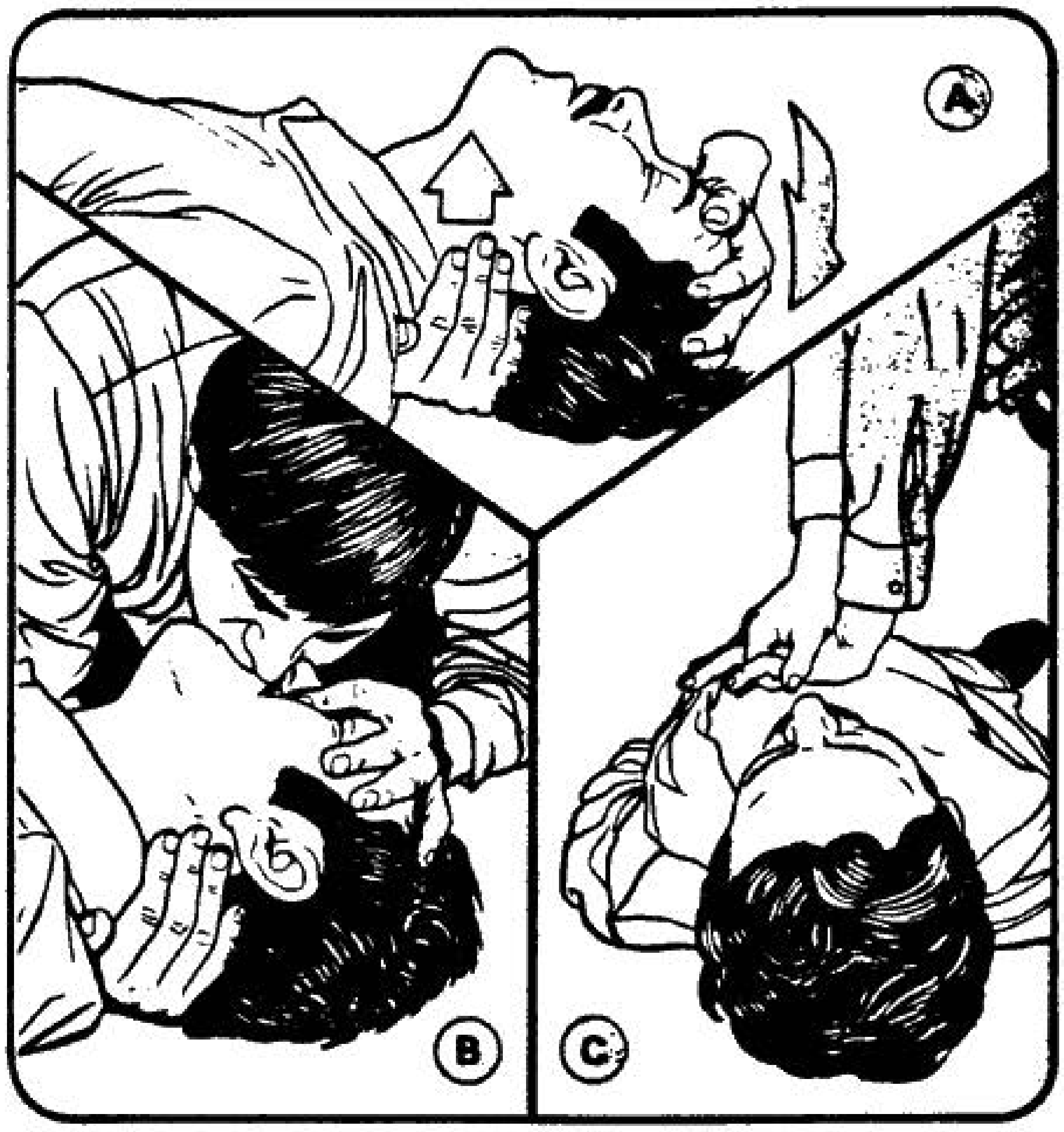


Figure 4-2: *Key elements of basic life support: (A)irway, (B)reathing, (C)irculation.*

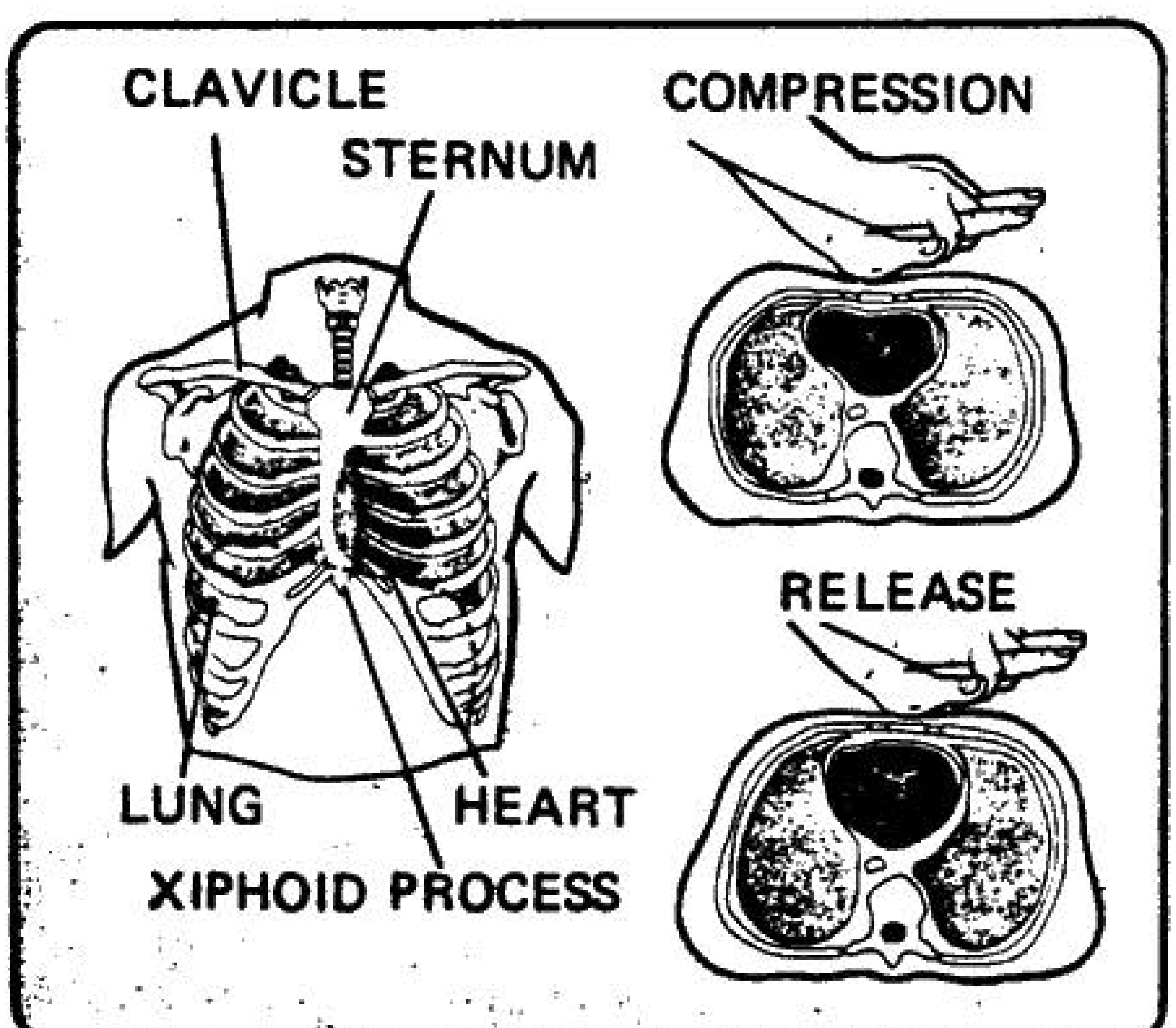
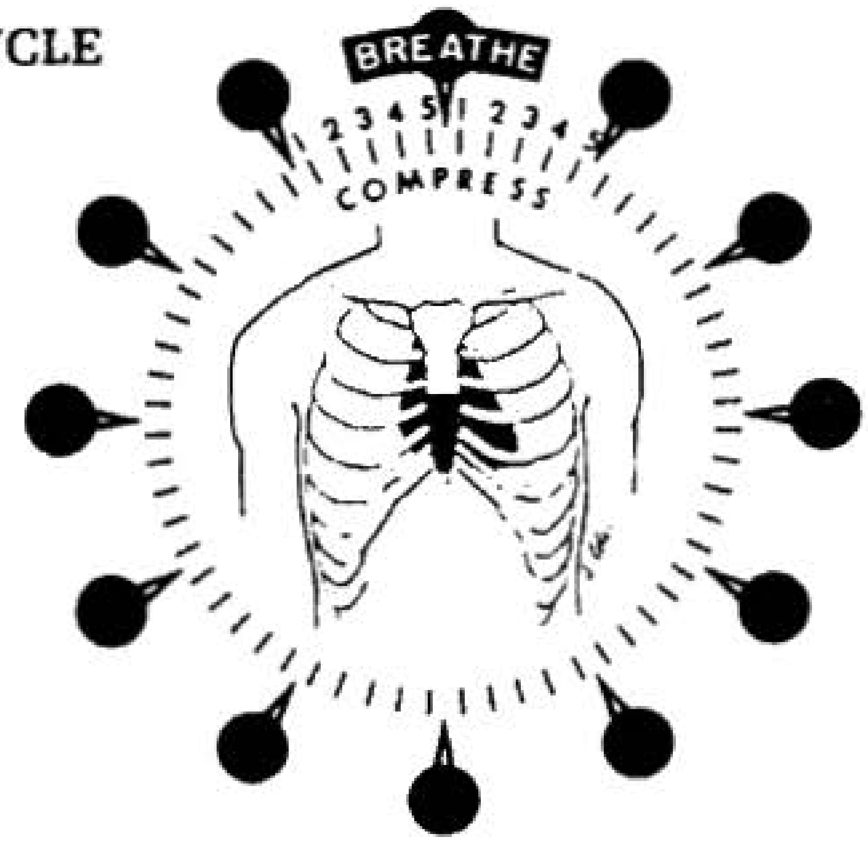


Figure 4-3: *CPR: compression of the sternum transiently raises the intrathoracic pressure and forces the heart to pump blood.*

CYCLE



CYCLE = 5 Compressions / 1 Breath — Repeat 16 to 20 times per minute.

"INTERPOSE" BREATH BETWEEN EACH 5 COMPRESSIONS

"HEAD TILT" / MOUTH-TO-MOUTH RESUSCITATION

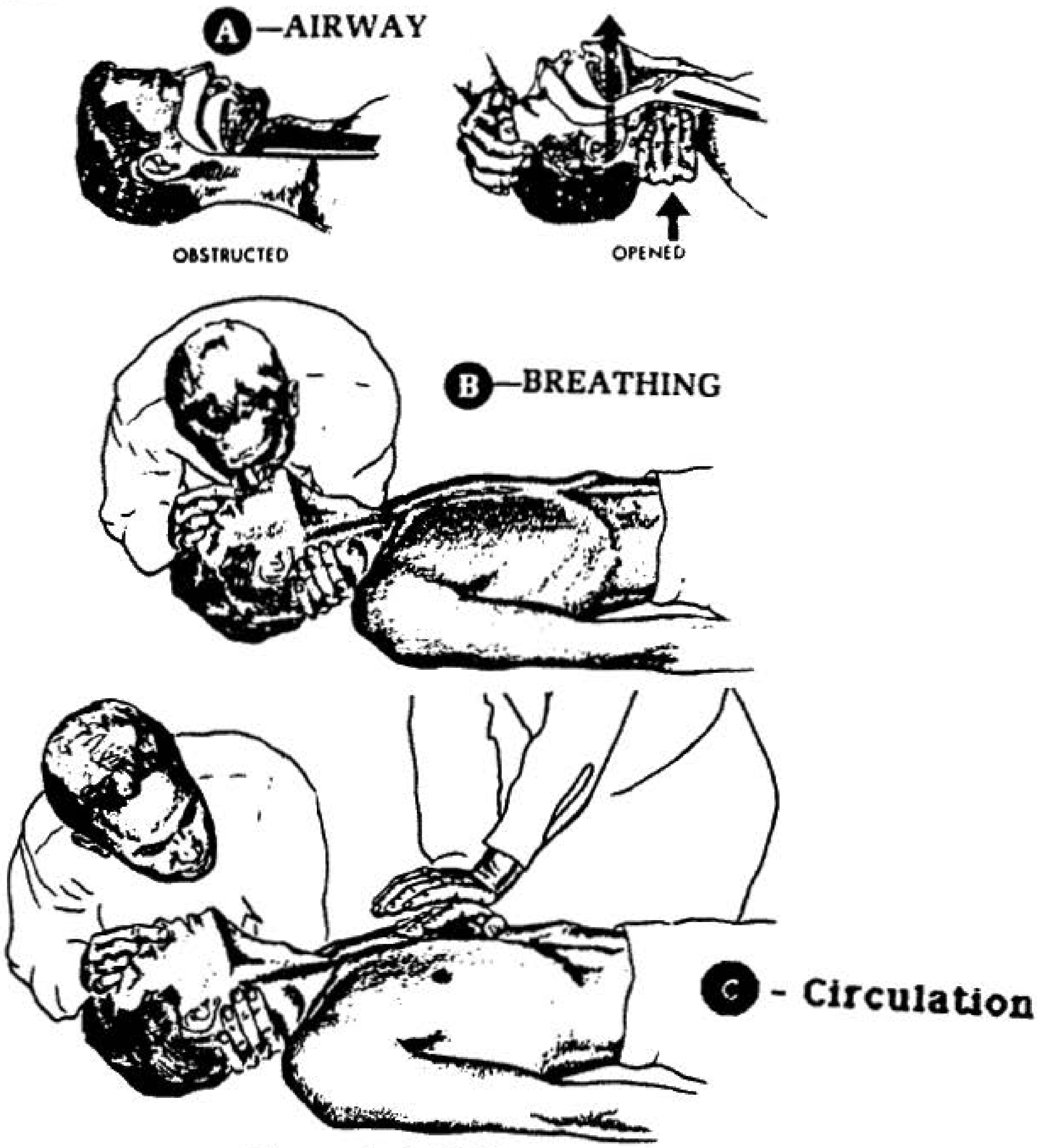


Figure 4-4: *CPR.*

food, or dentures. Hyperextend the head if the patient is not on the backboard of the HLR.

3) Using mouth-to-mouth or a bag-valve mask device (or an endotracheal tube, if one is already in place), inflate the lungs with one large breath (if mouth-to-mouth technique is used, pinch the patient' s nostrils closed).

4) Begin external chest compression (cardiac massage). Place the heel of one hand two fingers breadth above the tip of the breast bone (xiphoid process). The other hand is placed atop the first with the fingers held off the chest wall. With elbows locked, depress the lower sternum 1½ in. to 2 in. (3.8 cm. to 5 cm). The time of compression should equal the time of expansion.

5) Single-operator CPR should proceed with 15 compressions followed by two ventilations at a rate of 80 to 100 compressions per minute (15 compressions should take 9 to 11 seconds).

6) Two-operator CPR should proceed with one operator beginning chest compressions at a rate of 80 to 100 per minute and the second operator interposing a breath on the upstroke of every fifth compression. The two operators should be on opposite sides of the patient as this will allow frequent switches from ventilation to chest compression in order to minimize operator fatigue.

7) As soon as possible, adjuncts for airway management, ventilation, and cardiac compression--as discussed elsewhere in this manual--should be applied.

Techniques For Artificial Ventilation

Bag-Valve Mask

Obviously, manual chest compression and ventilation should begin as soon as legal death is declared. Chest compression should be at a rate of 60 to 80 compressions per minute. Ventilation should be carried out initially using a bag-valve-mask or bag-valve-endotracheal tube with 100% oxygen. The bag valve device consists of a rubber bladder with one-way valves at its openings. The valves allow air to enter the bag from the atmosphere and/or from an oxygen source and allow it to exit the bag only through a fitting which is attached to a mask or endotracheal tube.

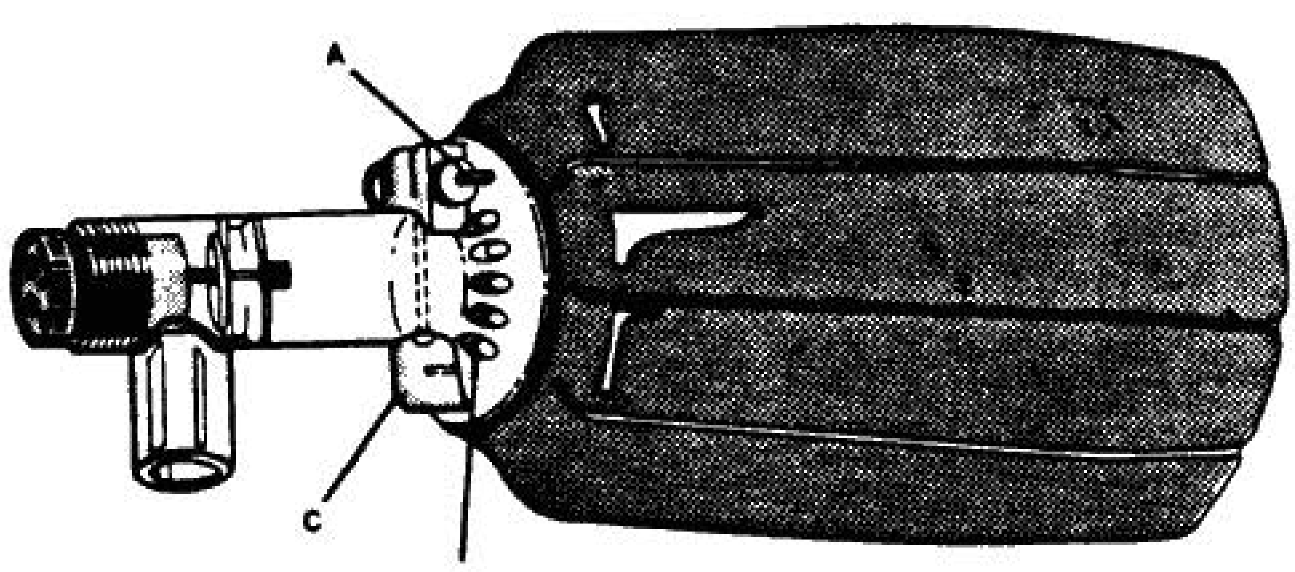


Figure 4-5: *Bag-valve device; (A) gas intake valve, (B) air intake valve, and (c) pressure limiting assembly (blow-off valve).*

The operation of the bag-valve mask is simple to understand. When the bag is squeezed, air is delivered to the patient through a one-way valve. The air inlet to the bag is closed during delivery. When the hand squeeze on the bag is released, a passive exhalation occurs. Thus air from the patient's lungs can't re-enter the bag. Instead, it passes through an exhalation valve into the atmosphere. While the patient is exhaling, air from the atmosphere and/or oxygen source refills the bag.

If the patient is *not* intubated (does not have a tube present in the trachea) at the time resuscitation begins, ventilation should commence using a bag-valve mask and CPR should continue for at least three minutes and preferably for five minutes before endotracheal intubation is undertaken. This should be done so that the flow of oxygenated blood to the tissues can be restored as quickly as possible. While the bag-valve mask technique is not nearly as efficient at providing ventilation as endotracheal intubation, it is effective and it can be applied immediately. Once a reasonable level of tissue oxygenation has been restored, it is then appropriate to proceed to more efficient means of ventilation.

Hazards Of Bag-Valve Mask

While the mask is a very quick way of beginning ventilation, it suffers from a number of drawbacks. Because the tongue and throat relax in unconsciousness, is is easy for the airway to become closed off. This can be circumvented to some extent by hyperextending the neck and inserting an oropharyngeal airway. However, these maneuvers do not completely ameliorate the problem of decreased airway diameter due to obstruction by the tongue and epiglottis.

Another problem with the bag-valve mask approach is that it allows some of the air being delivered to the lungs to enter the stomach. The lungs are designed to inflate as a result of *negative* or "sucking" pressure in the upper airway due to downward motion of the diaphragm and expansion of the chest wall.

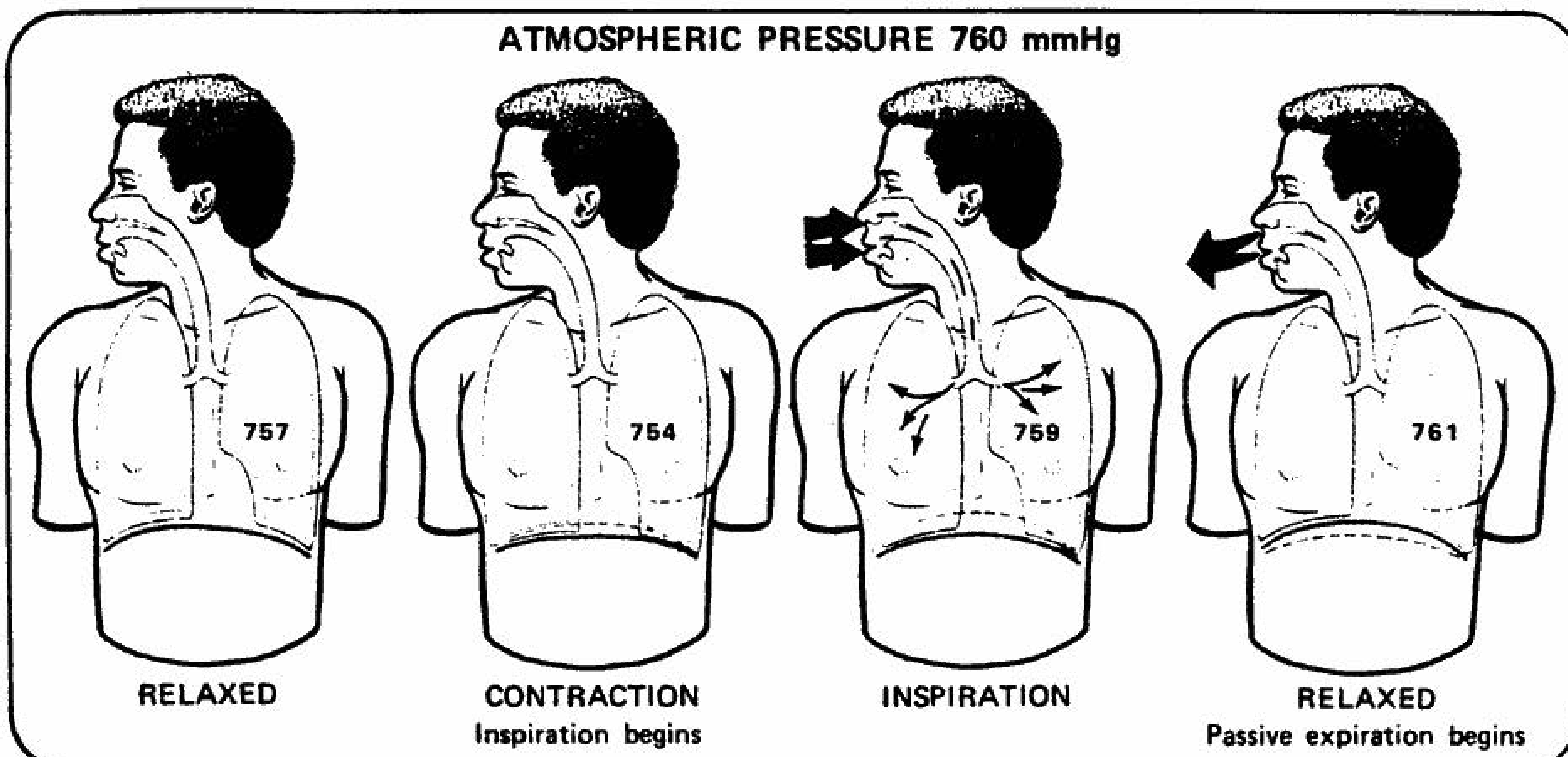


Figure 4-6: *Changes in volume of the chest cavity due to movement of the diaphragm and expansion of the chest wall produce intrapulmonary pressure changes which are responsible for inspiration and expiration.*

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If the oropharyngeal airway is not inserted properly, it may push the tongue backward into the posterior pharynx, creating or aggravating the problem of upper airway obstruction. As the oropharyngeal airway touches the back of the tongue and the posterior pharynx, it can stimulate vomiting. It should be noted that even with the use of this airway, hyperextension of the neck and proper head position are still required to obtain adequate ventilation.

Once the airway has been placed, the mask, attached to the bag-valve assembly, is positioned over the nose and mouth, and positive pressure ventilation is begun. Ventilation should be induced at a rate of 16 to 20 inflations per minute, using oxygen (the bag has an inlet for oxygen) if available, at an oxygen flow rate of 8-10 liters per minute (LPM).

Endotracheal Intubation

Because of the problems associated with the respiratory support methods previously mentioned, it is desirable to deliver oxygen directly to the lungs and to seal off the pathway of gas delivery from the possibility of aspiration of vomitus, oral secretions, or debris. The most effective approach to achieving this objective is to introduce a tube of suitable diameter into the trachea and inflate a sealing cuff which anchors the tube in the trachea and prevents debris from flowing around it and entering the lungs. This procedure is *endotracheal intubation* (or, tracheal intubation).

Technique Of Endotracheal Intubation

Endotracheal intubation is a fairly straightforward technique, but it does require some practice. In some patients, due to anatomy or the limited skill of the rescuer, intubation may prove too time-consuming, or be impossible to achieve. In such situations a third alternative, the esophageal gastric tube airway (EGTA), which will be discussed later, may be used.

Assemble the equipment required to carry out intubation. These consist of a selection of endotracheal tubes in the correct size range (7.0 to 8.5 cm), a laryngoscope, a 10 cc syringe to inflate the cuff, suction apparatus, and bag-valve device.

Endotracheal intubation consists of using a special tool--a laryngoscope--to access and visualize the critical structures of the upper airway. It consists of a blade (straight or curved) with a light bulb at the tip and a handle (which contains the batteries). The blade must be attached to the handle by inserting the U-shaped indentation on the back of the blade onto a small bar at the end of the handle. After the indentation is aligned with the bar, the blade is pressed forward to lock it in place. Then the blade is elevated until it is at a right angle to the handle. The light should then go on. If it does not, the fault may lie either with the bulb or the batteries.

The mouth should be examined for dentures, plates, or other removable dental work which could come loose or break off during attempted intubation and fall into the airway and obstruct it. Quickly remove such dental work before attempting laryngoscopy and intubation.

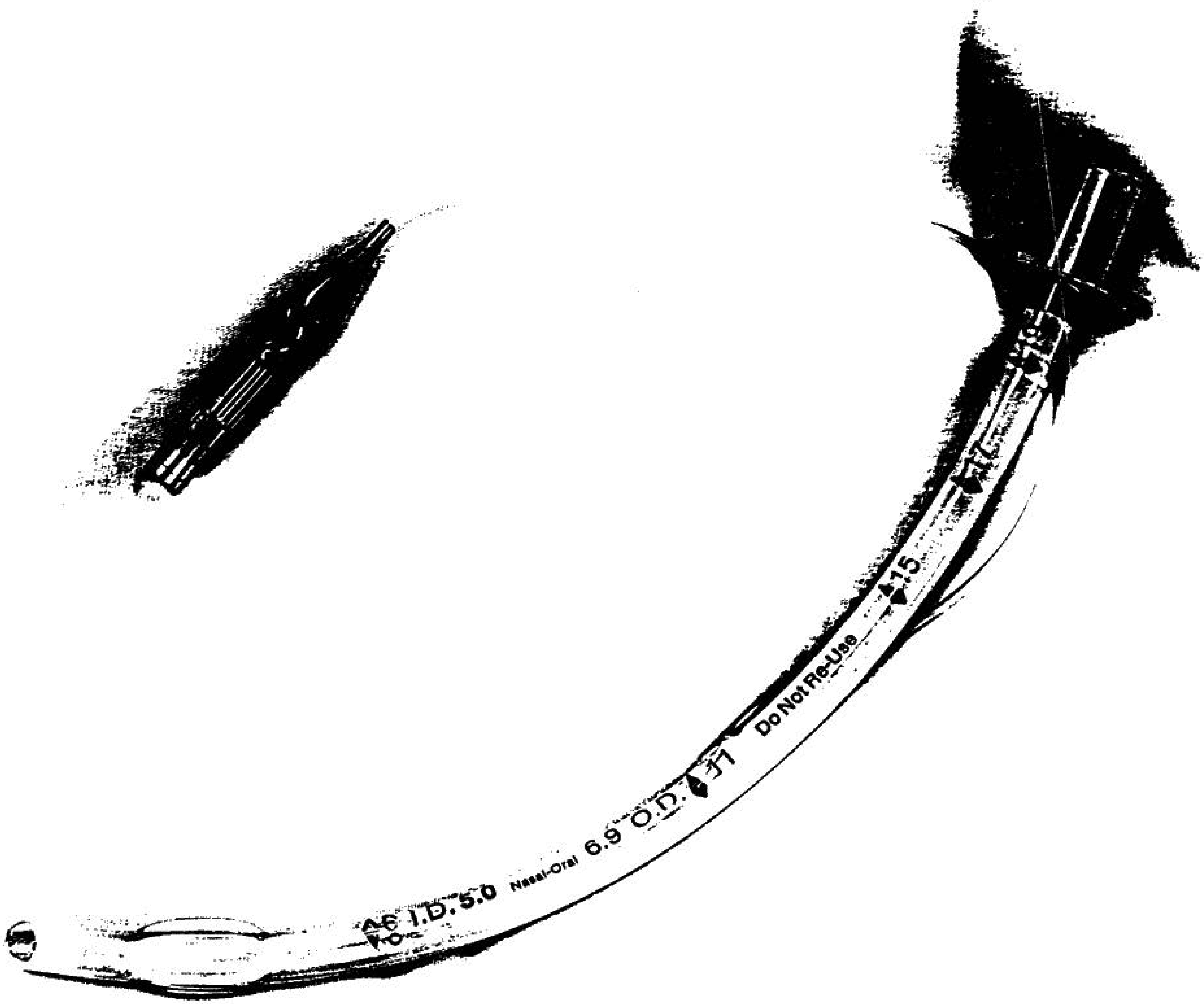

Figure 4-9: *Endotracheal Tube: Full size.*

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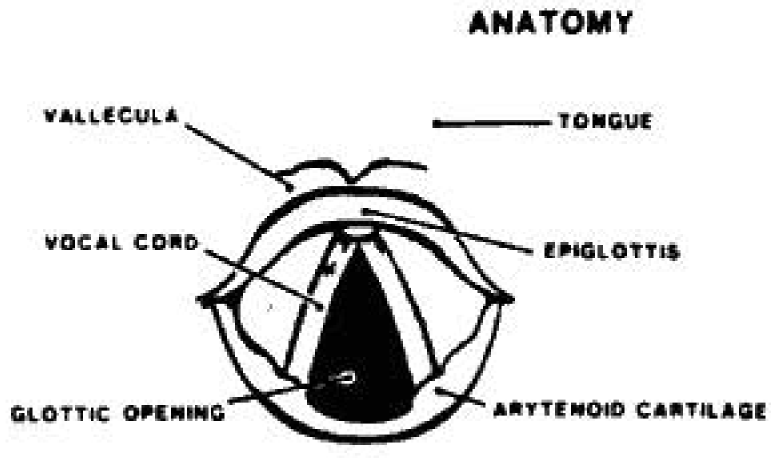

Figure 4-12: *These anatomic structures must clearly be visible prior to any attempted intubation.*

Laryngoscope blades are available curved or straight. It is the policy of Alcor to provide only straight blades and to train personnel in the use of straight blades exclusively. It has been our experience that one of the most common reasons for failure to visualize critical airway structures is the use of a too short curved blade. The straight blade should be inserted below the epiglottis. Traction is then exerted upward on the handle of the laryngoscope, displacing the base of the tongue and the epiglottis toward the front of the mouth and exposing the glottal opening. The handle must not be used with a "prying" motion, and the upper teeth must never be used as a fulcrum, lest they break off and fall into and obstruct the airway or a bronchus!

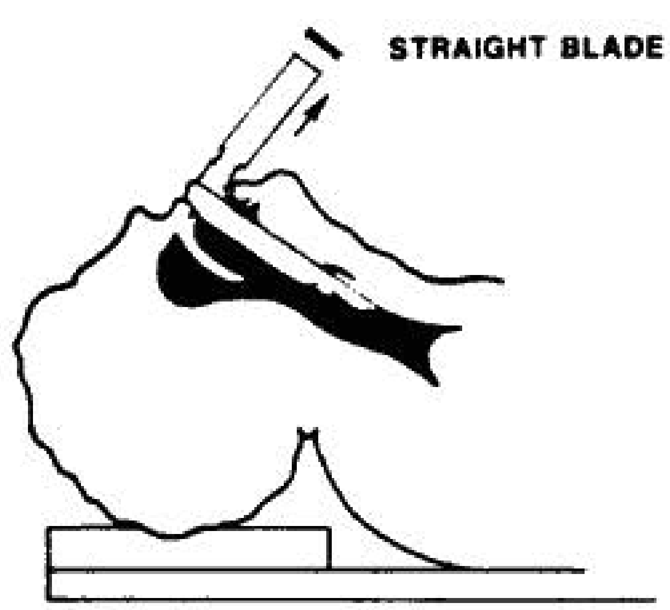

Figure 4-13: *Laryngoscopic technique with the straight blade: the epiglottis is elevated anteriorly to expose the glottal opening.*

Force must be exerted "downward" only; i.e., push the tongue further down into the mouth and retract the vallecula directly upwards, toward the end of the laryngoscope handle.

Each blade has a flange containing the bulb on its left side. If the handle is held in the right hand, it will interfere with visualization of the larynx and passage of the tube into the trachea. *Therefore, the laryngoscope must be held in the left hand.*

After positioning the patient's head, insert the blade to the right of the midline. Next, elevate and move the tongue to the left so that the blade is in the midline, clearing the tongue out of the way. As the blade is advanced, the epiglottis, the vocal chords, and several cartilages come into view. Pass the tube between the vocal chords anterior to the arytenoid cartilages. Insert the tip of the blade under the epiglottis, then elevate the handle to expose the glottis. If the blade has been advanced too far, pull it back until the epiglottis comes into view, then place the blade in the vallecula and elevate the handle to expose the glottis. With the laryngoscope held in the left hand, work with the right hand from the right corner of the mouth to insert the tube into the trachea. Remember, the trachea is above the esophagus (the opening you will most likely see first). The larynx is under the epiglottis and is quite difficult to see completely in many people.

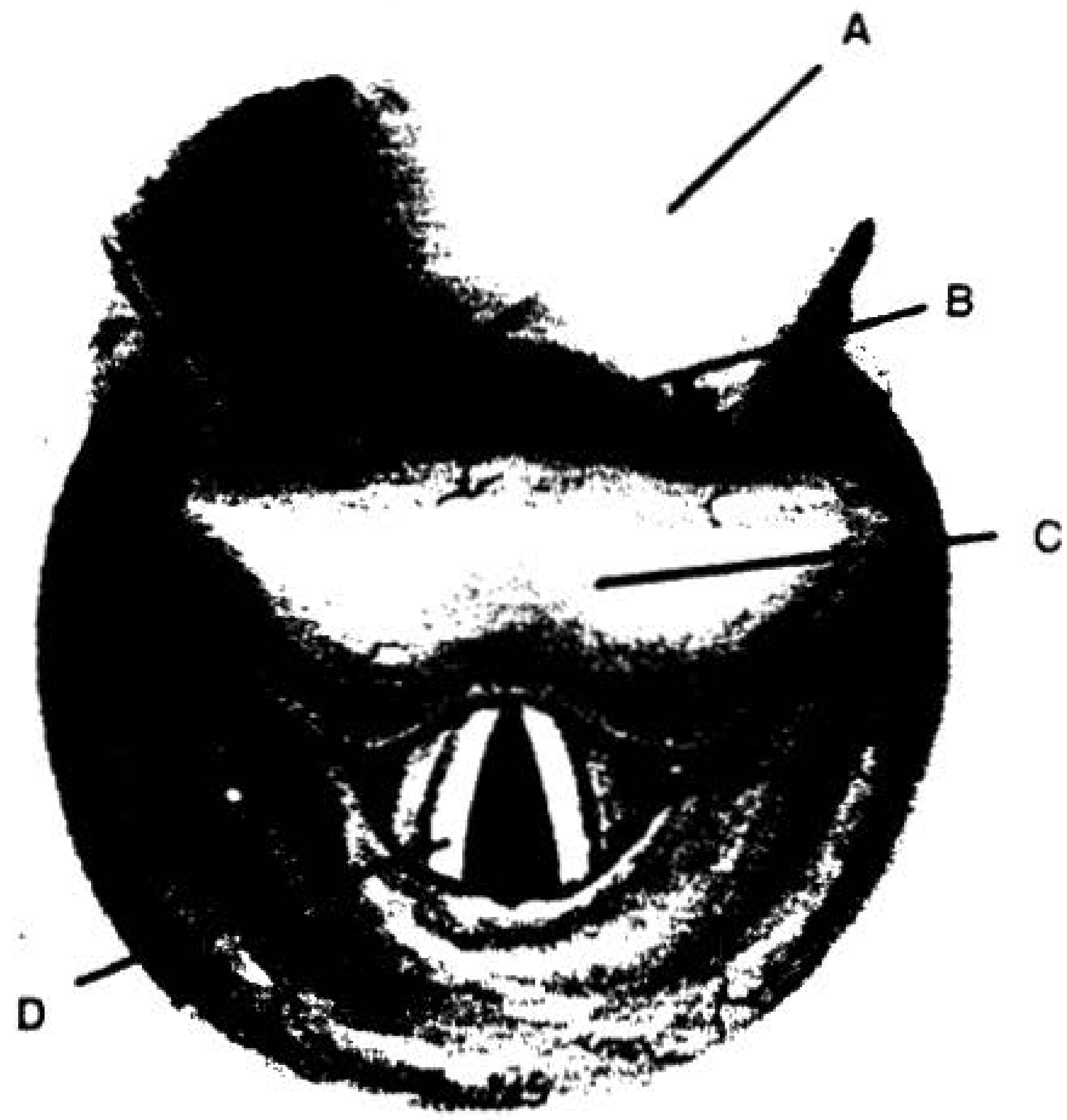

Figure 4-14: *View of the hypopharynx during laryngoscopy for intubation: (A) Laryngoscope blade; (B) vallecula; (C) epiglottis; (D) vocal chords.*

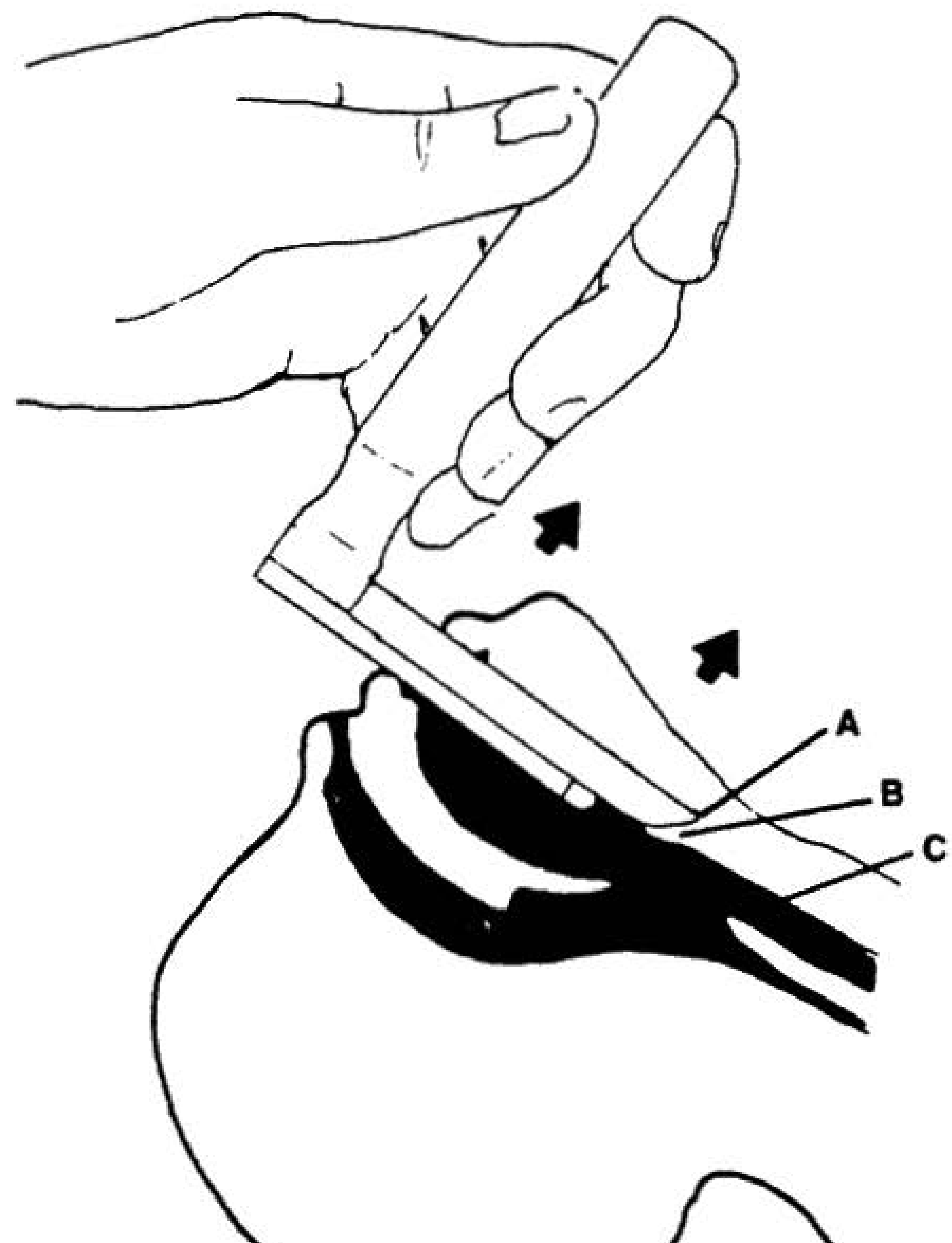

Figure 4-15: *Laryngoscope correctly positioned in the vallecula (A). A pushing motion as indicated by the arrows allows visualization of the epiglottis, glottal opening, and vocal cords.*

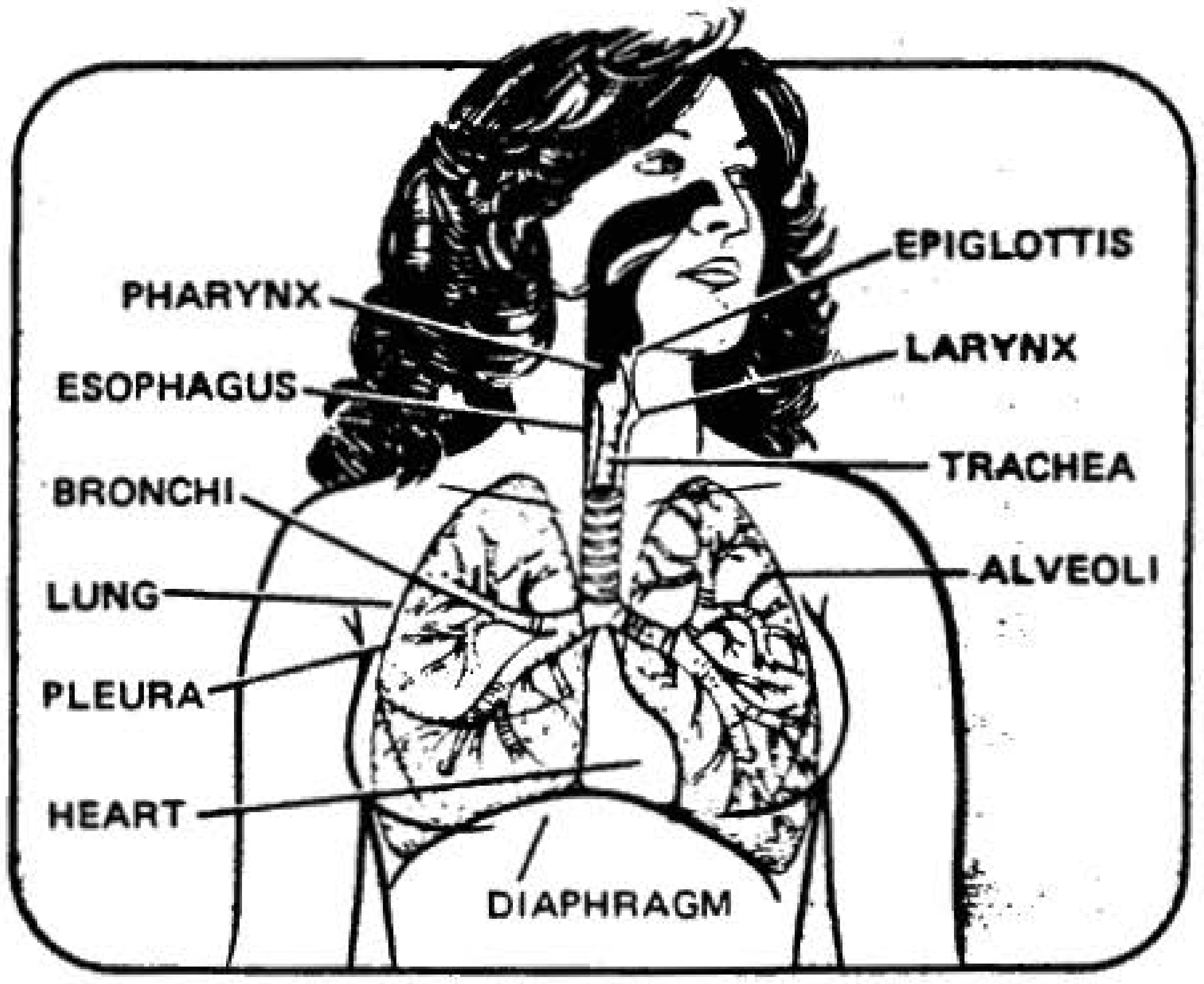

Figure 4-16: *Basic anatomy of the respiratory system.*

A very helpful procedure in endotracheal intubation of suspension patients--with its attendant risk of regurgitation and aspiration of gastric contents--is the application of firm pressure over the cricoid cartilage (adam's apple) in order to occlude the upper end of the esophagus (Sellick maneuver). An assistant applies firm backward pressure to the cricoid until intubation has been completed and the endotracheal tube cuff inflated.

The main advantage to tracheal intubation is the complete control gained over the airway. As was previously pointed out, this protects the airway from aspiration of foreign material and allows for delivery of 100% oxygen to the lungs, using intermittent positive pressure. It also eliminates the problem of gastric distention and associated reduced lung expansion.

A final advantage, which has not been discussed yet, is that tracheal intubation allows for suctioning or removal of secretions and mucus from the trachea and the bronchial tree. Such secretions are frequently a serious problem in patients who have had a long agonal (dying) course, and can be a serious barrier to effective ventilation.

Hazards Of Endotracheal Intubation

One of the major hazards of tracheal intubation is accidental intubation of the esophagus resulting in zero delivery of oxygen to the lungs. For this reason, it is absolutely essential to *immediately* auscultate the chest (listen to it with a stethoscope) and observe the chest for expansion when ventilation is carried out. The epigastric area (abdomen just below the tip of the sternum) may be auscultated after tracheal intubation and after chest auscultation to determine that the tube is in the trachea and not in the esophagus. If chest breath sounds are not heard, and gurgling *is* heard over the epigastric area, remove the tube, ventilate and oxygenate the patient with the bag-valve mask, and reattempt tracheal intubation.

It is also possible to pass the tube into a bronchus, resulting in ventilation of one lung only. Therefore, it is always necessary to make sure that the breath sounds are equal on both sides of the chest, assuming both lungs are normal (if one lung is invaded with a tumor or otherwise afflicted with an obstructive respiratory disease, breath sounds will be correspondingly diminished or absent on that side).

It is important to emphasize once again that no attempt should be made to intubate the patient before the patient has been ventilated by some other means. Because tracheal intubation requires 15 to 30 seconds, and because the patient is not being ventilated during this interval, hypoxia will become increasingly severe. Therefore, ventilation should be performed by some other means (mouth-to-mouth, mouth-to-mask, or bag-valve mask) before tracheal intubation is attempted.

Figure 4-17: *Securing An Endotracheal Tube: Three Methods.*

Before taping the tube in place, make sure the patient's face is clean, dry, and free of beard stubble. If possible, suction his mouth and dry off the tube just before taping. After taping, always check for bilateral breath sounds to ensure the tube hasn't been displaced by manipulation.

1 Cut two 2" (5-cm) strips and two 15" (38-cm) strips of 1" cloth adhesive tape. Then, cut a 13" (33-cm) slit in one end of each 15" strip (see illustration below).

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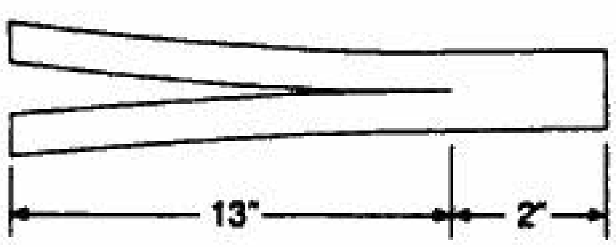


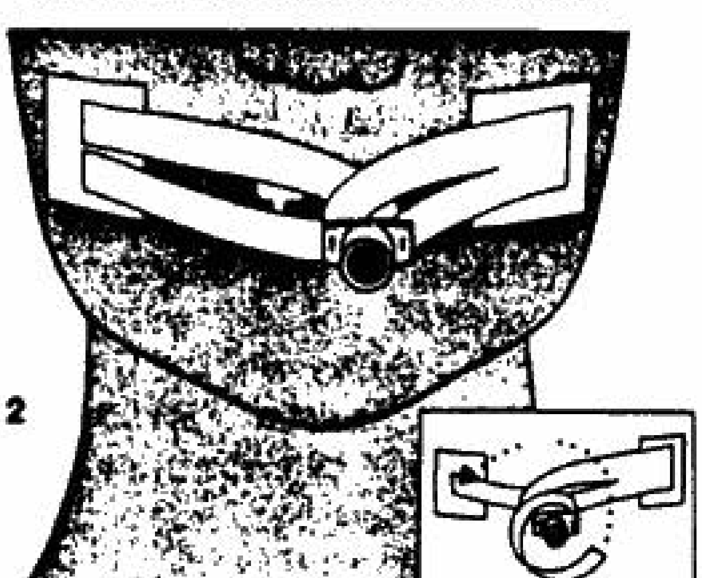
Apply benzoin to the patient's cheeks.* Place the 2" strips on his cheeks, creating a new surface on which to anchor the tape securing the endotracheal tube. *When frequent retaping is necessary, this helps preserve the patient's skin's integrity.* If the patient's skin is excoriated or at risk, you can use OP-Site to protect the skin.

Apply benzoin to the tape on the patient's face and to the part of the tube where you will be applying the tape.

On the side of the mouth where the tube will be anchored, place the unslit end of a 15" strip of tape on top of the tape on the patient's cheek. Just before taping, check the reference mark on the tube to ensure correct placement.

Wrap the top half of the tape around the tube twice, pulling the tape as tightly as possible. Then, directing the tape over the patient's upper lip, place the end of the tape on the patient's other cheek. Cut off any excess tape.

Use the lower half of the tape to secure an oral airway, if necessary (see illustration below). Or, twist the lower half of the tape around the tube twice and attach it to the original cheek (see illustration below). *Taping in opposite directions places equal traction on the tube.*



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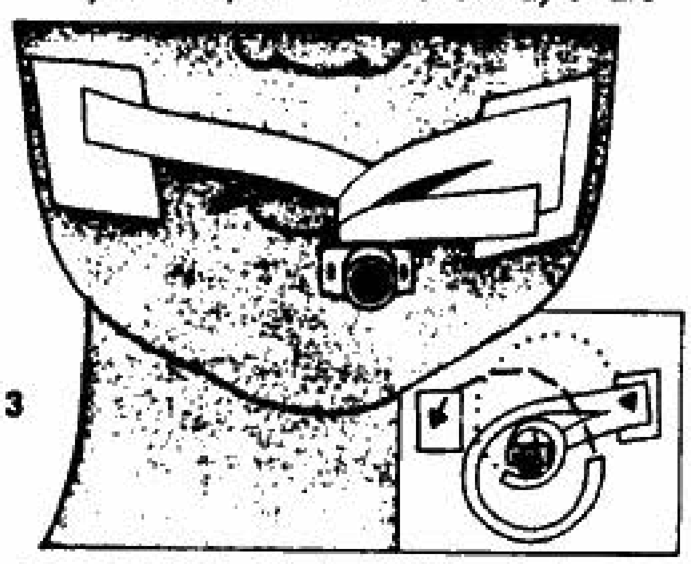

If you've taped in an oral airway or are concerned about tube stability, apply the other 15" strip of tape in the same manner as the first, starting on the other side of the patient's face. If the tape around the tube is too bulky, use only the upper part of the tape and cut off the lower part. If copious oral secretions are present, seal the tape by cutting a 1" (2.5-cm) piece of paper tape, coating it with benzoin, and placing the paper tape over the adhesive tape.

2 Cut one piece of 1" cloth adhesive tape long enough to wrap around the patient's head and overlap in front. Then, cut an 8" (20-cm) piece of tape and center it on the longer piece, sticky sides together. Next, cut a 5" (12.5-cm) slit in each end (see illustration above).

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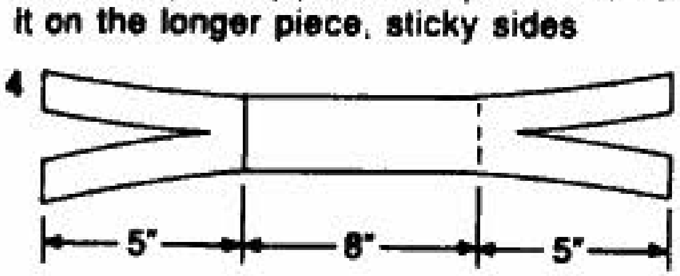
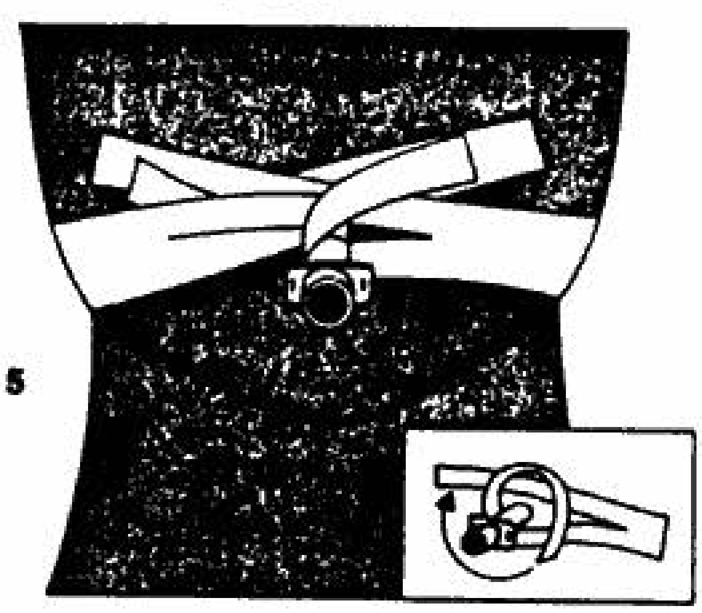


Apply benzoin to the patient's cheeks and under his nose.*



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Place the top half of one end of the tape under the patient's nose and wrap the lower half around the endotracheal tube. Place the lower half of the other end of the tape under the patient's nose and wrap the top half around the tube (see illustration above).

3 Cut a tracheostomy tie in two pieces (one a few inches longer than the other), and cut two 6" (15-cm) pieces of 1" cloth adhesive tape. Then, cut a 2" slit in one end of both pieces of tape. Fold the other end of the tape so the sticky sides are together and cut a small hole in it (see illustration below).

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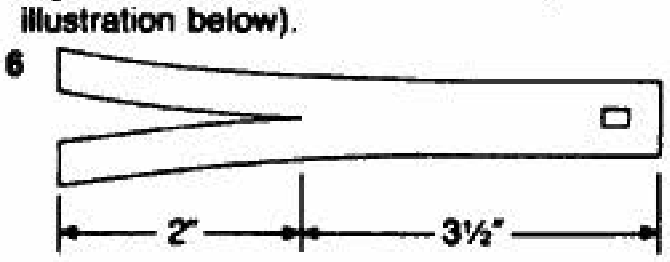

Apply benzoin to the part of the endotracheal tube that will be taped.

Wrap the slit ends of each piece of tape around the tube—one piece on each side. To secure the tape, overlap it.

Apply the free ends of the tape to both sides of the patient's face. Then, insert the tracheostomy ties through the holes on the ends of the tape and knot the ties (see illustration above).

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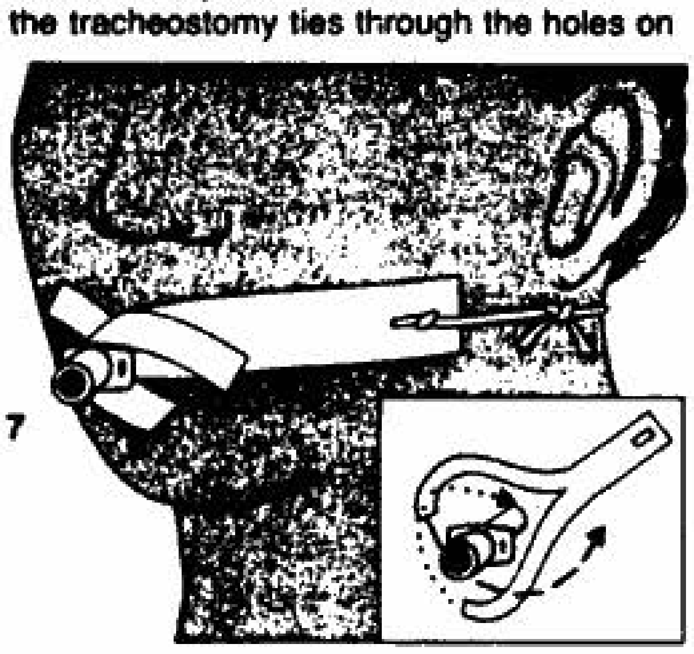


Bring the longer tie behind the patient's neck and tie it to the shorter tie at one side of his neck. *Knotting the ties on the side prevents the patient from lying on the knot and getting a pressure sore.*

***Don't spray benzoin directly on the patient's face, because its vapors can be irritating if inhaled and can be harmful to the eyes.**

With a standard 15 mm connector on the end of the endotracheal tube, it is possible to attach the tube to a bag-valve device or to the mechanical respirator on the HLR. Most adult tracheas can easily accommodate a tube size of 8 mm (internal diameter); therefore, this should be the first choice for an average size adult. For children, the outside diameter of the correct-sized tube is usually equal to the size of the patient's little finger.

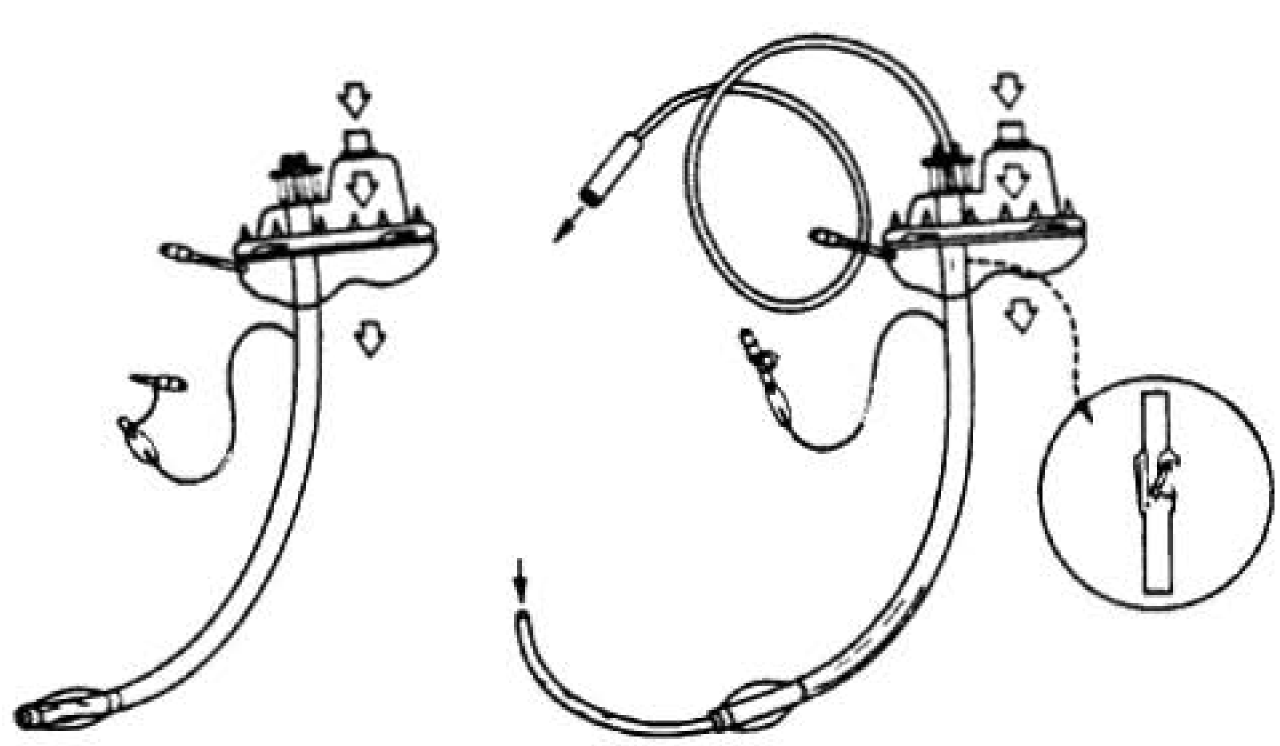
For adults, the cuff is inflated with just enough air to effect an airtight seal when positive pressure is applied to the tube. The volume required will be variable, but is generally in the range of 5-10 ml. For children up to 8 years of age, do not use a cuff. Children over 8 years may require up to 5 ml of cuff air volume.

As the patient cools, it will be important to repeatedly check the endotracheal tube cuff for patency of seal. Reduction of the patient's core temperature will cause the air in the endotracheal tube balloon to cool, and thus to contract, resulting in loss of seal and escape of air from the lungs around the balloon. Loss of balloon patency may be noted by the presence of a "hissing" or "gurgling" sound during ventilation which disappears when the cuff balloon is further inflated.

Without question, endotracheal intubation is the ideal procedure for protection of the lungs from aspiration of gastric contents and for adequate oxygenation and maximum lung expansion. However, the technique requires a fair amount of practice, and in a field situation, with tense, anxious, and relatively inexperienced personnel, it may be impossible to achieve in a safe and timely fashion.

Esophageal Gastric Tube Airway (EGTA)

An alternative to endotracheal intubation is the use of the Esophageal Gastric Tube Airway (EGTA). The EGTA is a tube (obturator) approximately 37 cm in length which is open at the top and bottom and which connects to a specially designed mask through which ventilation takes place. Insert the lower end of the obturator into the esophagus. An inflatable cuff is located just above the lower end. The upper end must be inserted into a specially designed face mask which can accommodate this tube.



ESOPHAGEAL GASTRIC TUBE AIRWAY

Figure 4-18: *The esophageal gastric tube airway (EGTA): The stomach may be decompressed by passage of a gastric tube, and antacid may be administered to buffer gastric hydrochloric acid.*

In order to insert this airway into the esophagus, grasp the lower jaw with the thumb and forefinger and pull forward (tongue-jaw lift), while blindly inserting the tube into the mouth and pharynx. With the tube in the midline, following the natural curvature of the pharynx in most cases, it will pass directly into the esophagus. This maneuver is usually facilitated by flexing the head forward.

INSERTION OF ESOPHAGEAL AIRWAY

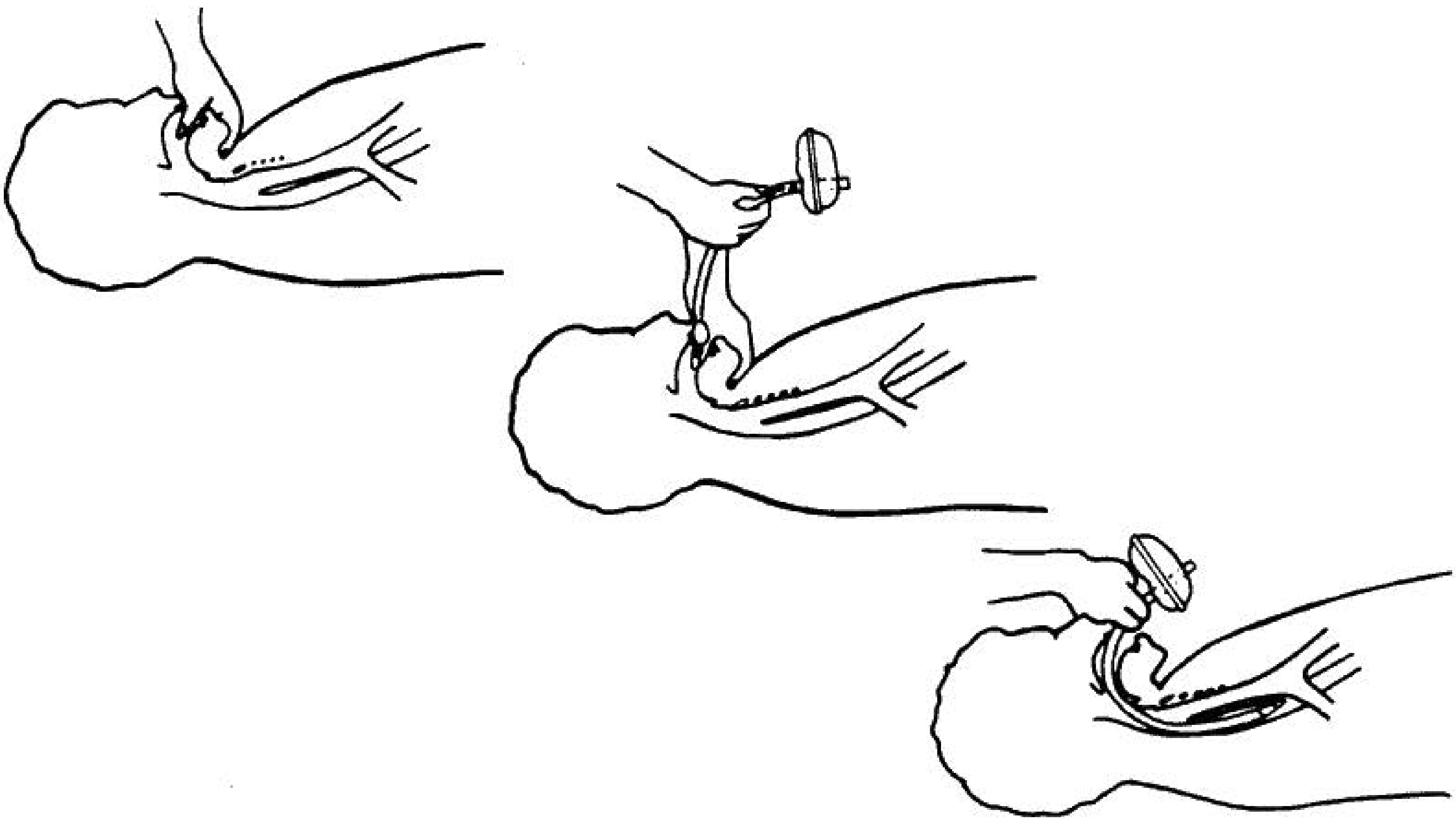


Figure 4-19: *Procedure for introducing the EGTA: Introduce the obturator into the esophagus by elevating the tongue and jaw from one corner of the mouth with one hand, with the head and neck flexed forward.*

Advance the tube until the mask is seated on the face. When this is accomplished, the cuff will be below the carina of the trachea. If the cuff is above the level of the carina it may, when inflated, compress the posterior membranous portion of the trachea and cause airway obstruction.

FINAL POSITION OF ESOPHAGEAL AIRWAY AND MASK

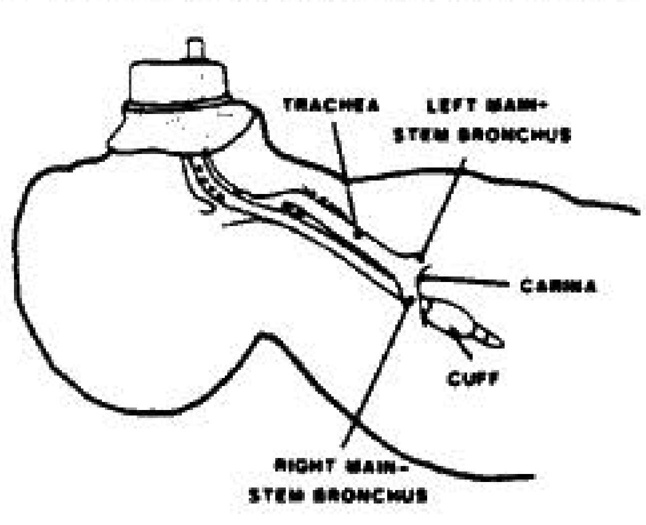


Figure 4-20: *Cutaway showing proper placement of the EGTA.*

Because there is always the possibility that the tube may become lodged in the trachea, the next step is to blow into the airway (via the *separate* airway opening on the mask) using the bag-valve device and check for chest expansion. With the airway properly positioned, air will flow through the mask, into the pharynx, through the trachea, and into the lungs. Air will not be able to move out the mouth and nose because they will be sealed off with the mask. Some air may move into the stomach before the cuff on the EGTA is inflated, but most of it will enter the trachea. The cuff should not be inflated before this point because it will cost precious seconds if the obturator has to be deflated and repositioned. Also, there is the hazard of tracheal rupture due to inflation of the large-diameter cuff balloon should the obturator inadvertently have been placed in the trachea.

ESOPHAGEAL AIRWAYS

The **esophageal gastric tube airway** consists of an inflatable face mask and an esophageal tube. The transparent face mask has two ports: a lower port for insertion of an esophageal tube and an upper port for ventilation. The inside of the mask is soft and pliable; it molds to the patient's face and makes a tight seal, preventing air loss.

The proximal end of the esophageal tube has a one-way, nonrefluxing valve that blocks the esophagus. This valve prevents air from entering the stomach, thus reducing the risk of abdominal distention and aspiration. The distal end of the tube has an inflatable cuff that rests in the esophagus just below the tracheal bifurcation, preventing pressure on the noncartilaginous back of the tracheal wall.

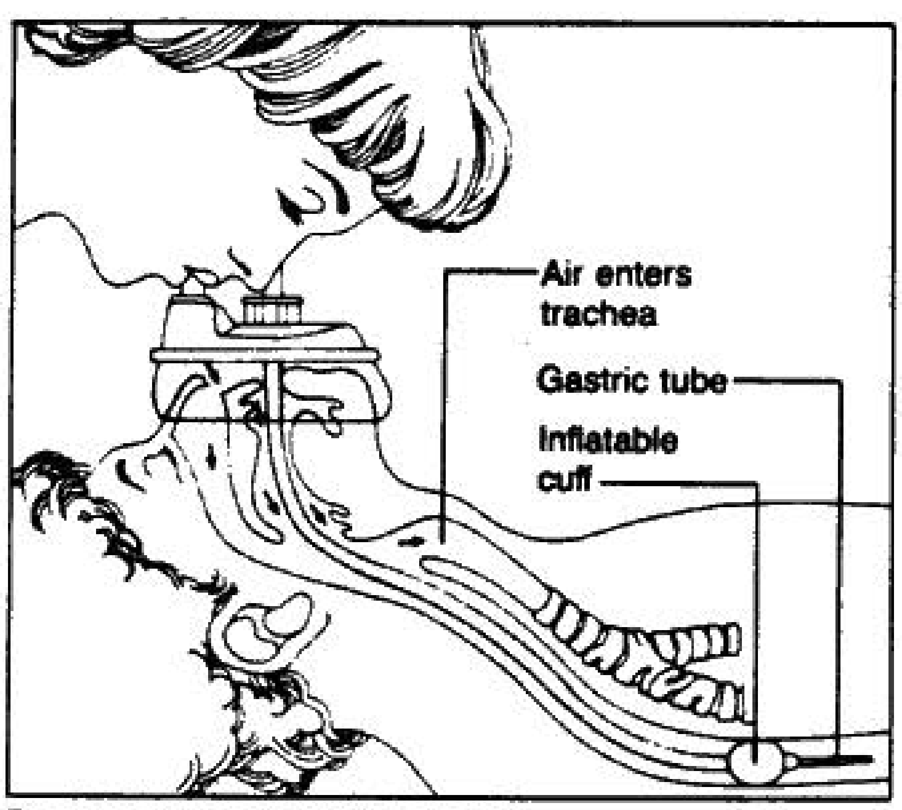
During ventilation, air is blown into the upper port in the mask and, with the esophagus blocked, enters the trachea and lungs. (See top illustration.)

A gastric (Levin) tube can be used to suction stomach contents before extubation. It's inserted through the mask's lower port into the esophageal tube, then through a small hole in the end of the tube.

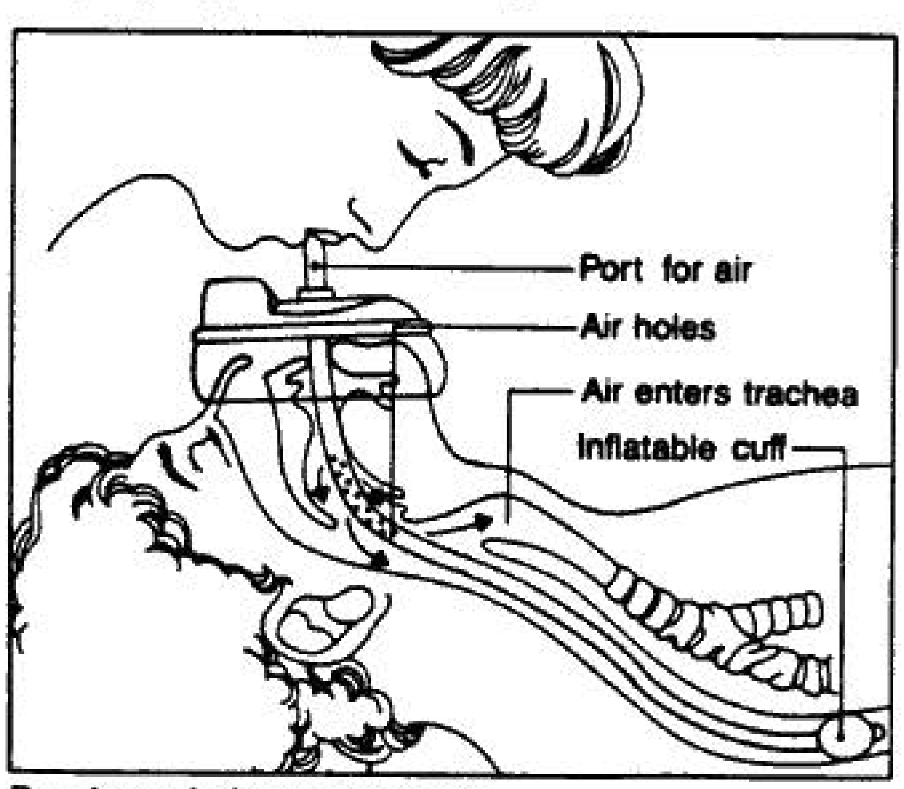
The **esophageal obturator airway** consists of an adjustable, inflatable, transparent face mask with a single port, attached by a snap lock to a blind esophageal tube.

When properly inflated, the transparent mask prevents air from escaping through the nose and mouth. (See bottom illustration.)

The esophageal tube has 16 holes at its proximal end through which air or oxygen, blown into the port of the mask, is transferred to the trachea. The tube's distal end is closed and circled by an inflatable cuff. When the cuff is inflated, it occludes the esophagus, preventing air from entering the stomach and acting as a barrier against vomitus and involuntary aspiration.



Esophageal gastric tube airway



Esophageal obturator airway

Figure 4-21: *Esophageal airways.*

If the chest rises, the tube is in the esophagus and the cuff may be inflated. The lateral lung field should then be auscultated. A maximum volume of 30 ml of air should be used to inflate the cuff. If the chest does not rise, the airway is not in the esophagus and may be in the trachea. A quick check for correct placement of the EGTA consists of auscultating the epigastric area after the cuff is inflated and applying positive pressure to the EGTA. If the tube is improperly placed in the trachea, chest breath sounds will not be heard and auscultation over the epigastric area will disclose gurgling sounds as air bubbles into the stomach. Remove the airway immediately and continue ventilation bag-valve mask.

With the face mask properly fitted over the face and the cuff inflated, air may be introduced into the airway with a bag-valve device or mechanical respirator.

Hazards Of The EGTA

Possible hazards associated with the use of the EGTA include laceration and rupture of the esophagus. The esophageal airway may enter the trachea instead of the esophagus; air would then enter the stomach rather than the lungs. For this reason, proper ventilation of the lungs must always be verified with the use of a stethoscope as soon as possible. Important considerations in the use of the EGTA are: (1) Use the tongue-jaw lift with one hand, while inserting the obturator with the other hand; (2) Never use force during the insertion of the tube. If there is difficulty in advancing the tube, withdraw it slightly, improve the jaw angle, and then readvance the tube; (3) Keep the tube in the midline.

As with the oropharyngeal airway, the EGTA can cause vomiting. It must not be used in children under the age of 16, or in cases of known esophageal disease (where use could result in esophageal rupture and/or massive bleeding).

If an endotracheal tube is to be passed (i.e., endotracheal intubation attempted) or the mouth or pharynx is to be suctioned, the mask of the EGTA must be removed. This may be done by squeezing together the plastic prongs of the tube where they project through the mask. Then the intubation or suctioning procedure may be performed.

It is possible (though not easy) to accomplish tracheal intubation with the obturator in place. After the mask has been removed, perform laryngoscopy and pass the endotracheal tube. Ventilation is then carried out through the endotracheal tube. Remove the esophageal tube (obturator) after its cuff is deflated.

Because the EGTA obturator is open at both ends, a gastric tube can be passed to decompress the stomach if it has filled with air during bag-valve mask resuscitation. The gastric tube may also be used to administer antacid to prevent erosion or ulceration of the gastric mucosa by hydrochloric acid during deep hypothermia.

Suctioning The Airway

A frequent complication in artificial ventilation common to all of the approaches outlined above is airway obstruction secondary to accumulation of oral and/or pulmonary secretions or vomitus. Most hospitals and mortuaries will have suction equipment available. Included in Alcor field kits are suction catheters and suction tubing which may be attached to an electrically powered suction device, hospital wall suction, or water-powered mortuary suction.

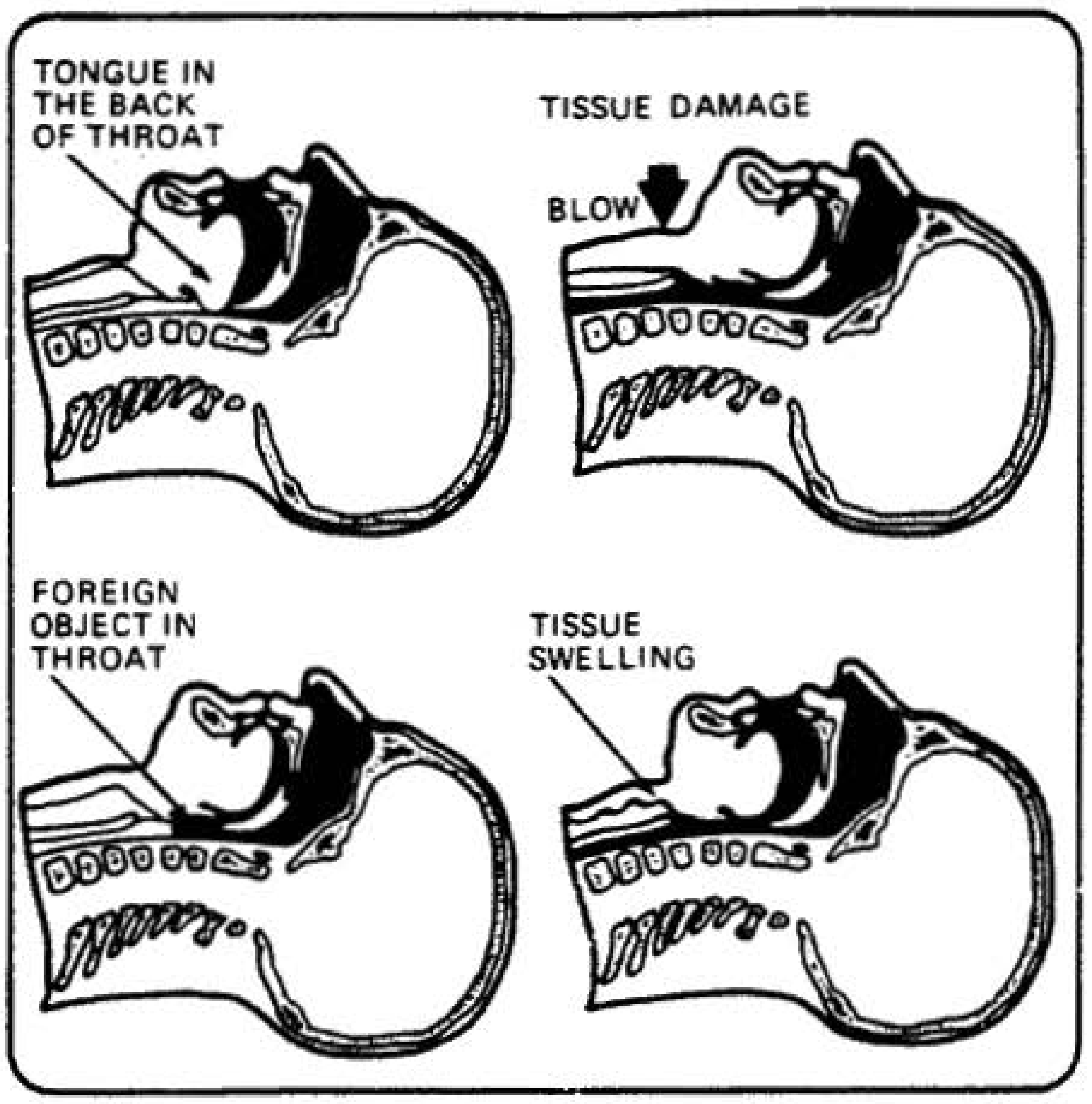


Figure 4-22: *Four common causes of airway obstruction which may be encountered in the transport of cryonic suspension patients.*

A suction catheter is a flexible or semirigid plastic tube with perforations in the tube wall at one end, and a rigid plastic fitting (connector) at the opposite end for coupling to the suction line (which in turn attaches to the suction apparatus or wall suction outlet). The suction catheter may then be passed into the pharynx to suck out mucus, vomitus, or other liquid or semi-liquid debris; or alternatively, if the patient has been intubated, the catheter may be passed down the endotracheal tube and into the bronchial tree to remove deep pulmonary secretions.

The indications for suctioning are airway obstruction or poor pulmonary compliance during ventilation when other causes of airway obstruction (such as improper head position) have been ruled out, and/or the presence of gurgling sounds or a "wet sound" to inspiration or exhalation.

Both lung fields should be auscultated periodically during resuscitation to determine when and if bronchial suctioning (if an endotracheal tube is in place) needs to be carried out. Reduced breath sounds, the presence of rattling sounds or wheezing (rhonchi), or sonorous or gurgling sounds (rales) is an indication for immediate suctioning of the endotracheal tube and bronchi.

While it will not be possible to carry out deep suctioning of a patient who does not have an endotracheal tube in place, you should auscultate the lung fields periodically and note the presence of rhonchi, rales, or any diminution of breath sounds. Notations about respiratory status such as these are important because they bear on the adequacy of gas exchange, and thus of CPR and the transport effort as a whole.

Suctioning of the pharynx is simple and straightforward, consisting of introducing the suction catheter into the pharynx and aspirating fluid, particulate matter, or secretions that are visible. Suctioning of the lungs through the endotracheal tube requires the use of a clean suction catheter and the use of clean--preferably gloved--

hands (use sterile examination gloves) to pass the catheter into the endotracheal tube and down to the bronchial tree. Normally, in a clinical setting, suction of the endotracheal tube is a sterile procedure. However, because of time and skill limits, this is not required for suspension patients, unless the technician is thoroughly familiar with the technique for sterile manipulation of the catheter. However, good, commonsense techniques of cleanliness and care are in order in handling of the catheter for endotracheal suction.

Suction catheters used for endotracheal suctioning will frequently become coated with or obstructed by thick pulmonary secretions. For this reason, it may be necessary to rinse the catheter by suctioning some saline, Ringer's solution, or tap water through the catheter, using a clean Zip-Loc bag as the reservoir for the solution. It is wise to rinse the catheter after use and place it in a plastic bag for reuse during transport, should the patient require additional suctioning.

Do not suction the patient for more than 15 seconds at a time. Remember: whenever suctioning is being carried out, the patient is not being ventilated. If repeated suctioning is required, due to rapid accumulation of secretions, space episodes of suctioning by at least five minutes.