Advanced Airway: Integrating with the Basics

Objectives

After reading this article, you will be able to:

1. Describe the anatomy and physiology of the human airway, and the respiratory system.
2. List the indications of airway management in the trauma and medical patient.
3. Explain the importance of basic airway management in the ALS setting.
4. Discuss the implementation of airway management and ventilation with adjuncts in accordance with the 2010 AHA Recommendations.

Case Study

During an evening of indoor rock climbing, a 22-year-old female reaches the top of a 30-foot climb, making a concerted effort to complete the last part of the climb. She immediately becomes unconscious for unknown reasons. She slumps backward and hangs in "rag-doll" fashion in her harness on the rope. After a moment of disbelief and calling to her to "stop fooling around," the woman's partner finally lowers her down to the ground. Getting her to the ground and released from her ropes takes approximately two minutes from the time she became unconscious.

The woman is placed on her back while her partner shouts for help from nearby climbers. Several climbers come running, although none knows what to do other than to call 911. An off-duty paramedic at the climbing gym is alerted to the situation and immediately responds to the incident. On arrival, the medic notes that the woman is severely cyanotic and is unresponsive, and she is not showing any signs of life. The paramedic confirms that 911 has been notified and calls for someone to retrieve the automated external defibrillator (AED). Emergency dispatch confirms that an ambulance will take 10 minutes to reach the gym. The paramedic on scene is in his own jurisdiction, so he instructs his climbing partner, an EMT-B, to get the medical kit from his private vehicle, which is parked three minutes away from the gym.

Donning the latex gloves that he always carries with him, the paramedic determines that the patient has a palpable pulse. Bystanders and the patient's climbing partner assure the paramedic that she did not fall but simply became unconscious on the rope. With that information, the paramedic uses the head-tilt/chin-lift procedure to open the patient's airway. The paramedic visualizes the inside of the patient's mouth and does not see any obstructions.

Within a few seconds of the paramedic opening the patient's airway, she begins to have some agonal respirations. After two minutes of artificial respirations using a one-way mouth-to-mouth valve, the patient has decidedly "pinked up" but has not resumed adequate spontaneous respiration. The patient remains unconscious, with a respiratory rate of 6 bpm. Her pulse, although present, is rapid, thready, and weak.

The paramedic continues mouth-to-mask respirations, checking the pulse every two minutes. During the second cycle, the patient begins to regurgitate. The paramedic moves the patient into a lateral recumbent position to clear the vomitus. The kit arrives during the middle of the third cycle of respirations. The paramedic instructs his friend to assemble the bag-valve-mask (BVM), and at the end of the third cycle of respirations, instructs him to begin bagging the patient.

Several minutes later, the ambulance arrives and the paramedics onboard confirm that they received the update and that medical direction is pending. The ambulance crew takes over basic life support and attaches an ECG. The ambulance's paramedic assembles the laryngoscope and prepares the ET tube. At the end of the fourth cycle, the ambulance paramedic, who is now in position to intubate, inserts the tube using standard procedure. Fortunately, the victim has no gag reflex; however, the paramedic has difficulty visualizing the vocal cords. Cognisant that the victim is apneic, the paramedic withdraws the ET tube after 10 seconds and has his partner resume BVM ventilations for an additional minute.

The paramedic reattempts intubation and is successful the second time around. The ET tube is attached to the BVM

and ventilations are continued. The ET position is verified and is secured in place. The patient is transferred to the ambulance, making sure that the ET tube is not dislodged, and is transported to the hospital.

The patient's partner informs the paramedic that she has a history of cardiac arrhythmias and this is not the first time an incident like this has occurred, although she usually recovered spontaneously.

Introduction to the Respiratory System

Breathing is the process whereby air is moved into and out of the lungs. The mechanics of breathing involve volume and, subsequently, pressure changes in the thoracic cavity. As the diaphragm contracts, it moves out of the chest cavity as it straightens out. This action increases the volume of the thoracic cavity. Accompanying the diaphragm, the ribs pull the sternum forward, which also increases the volume of the thoracic cavity. The lungs themselves adhere to the chest walls via the surface tension between the membranes of the visceral and parietal pleura, and expand during the process of inspiration.[1]

According to Boyle's law, an increase in volume will result in a decrease of pressure. This decrease in pressure (relative to ambient pressure) will cause ambient air to enter the body to fill up the space and equalize the pressure. Once the pressure has equalized, air has entered the lungs. The diaphragm and intercostals then relax, which reverses the process, causing a decrease in the volume of the lungs and an increase in the pressure of the chest cavity. This pressure forces the carbon dioxide-rich air to be expelled into the atmosphere.[2]

In a healthy patient, air first enters the nose, travels through the pharynx and the larynx, and then down the trachea. The trachea then splits into the left and right primary bronchi, also known as the right and left mainstem bronchus. As the bronchi branch deeper into the lungs, their diameter becomes smaller until they become bronchioles. The bronchioles eventually lead into the alveoli, which is where gas exchange takes place.[3]

Inhalation allows the alveoli to receive a fresh supply of oxygen. This, in turn, allows for the gaseous exchange between the pulmonary blood and the alveoli to occur. Once the gaseous exchange at the alveoli is complete, the freshly oxygenated blood is carried from the lungs back to the heart, first entering the left atrium, moving through the bicuspid valve into the left ventricle, and is then pumped out of the heart through the aortic semilunar valve. After leaving the heart, the blood is circulated via the arterial blood vessels to the brain and the rest of the body.[4]

As the blood travels away from the heart, the blood vessels continually decrease in diameter. The arteries eventually become capillaries, which is where gas exchange between the blood and cells takes place. Cellular respiration occurs when the oxygen is "off-loaded" into the cell and the carbon dioxide waste, as well as other wastes, is "picked-up."[5]

Once cellular respiration is completed, the blood then carries the carbon dioxide back to the right atrium of the heart via the veins. The blood moves from the right atrium through the tricuspid valve into the right ventricle. The right ventricle then pumps the blood through the pulmonary semilunar valve into the pulmonary artery and back to the lungs where the entire process repeats.[6]

Upper Airway

Nose

The interior of the nose provides important natural protection of the lungs by warming and filtering air before it enters the lungs. The nose is separated into the left and right nasal cavities by the nasal septum and is lined with mucous membranes that are highly vascular. Care must be taken when entering the nose to insert adjuncts to ensure that no physical damage is caused to the inside of the nose.[7, 8]

Oral Cavity

The oral cavity acts as a part of the digestive system[9] and the respiratory system. Air can enter the airway through the nose or mouth. The oral cavity plays an important role in airway management, as it allows medical personnel direct access to the trachea via the pharynx and the larynx. It is generally easier to "tube" a patient through the mouth, as one can better visualize the vocal cords. Foreign body airway obstructions generally enter the airway through the oral cavity.[10]

Pharynx

The pharynx, commonly called the throat, is a muscular passageway that is approximately five inches long in adults.[11] The pharynx extends from the nasal cavity to the larynx. The pharynx is subdivided into the superior nasopharynx, the oropharynx, and the inferior laryngopharynx. The oropharynx and the laryngopharynx accommodate the passage of

both air and food. Food travels from the mouth through the oropharynx and the laryngopharynx to the point of the larynx.[12]

Epiglottis

The epiglottis is one of the most important airway landmarks when advanced airway management is needed.[13] Medical personnel should be able to identify it easily by both sight and touch. The epiglottis protects the larynx by the mechanism described in the following section.[14]

Larynx

The larynx, also known as the voice box, has three major roles. First, it is the pathway for air to travel to and from the lungs from the pharynx. Second, it protects and provides support to the trachea. The larynx offers protection by preventing solids and liquids from entering the trachea by forcing the epiglottis over the opening of the larynx when a person swallows. Should a solid or liquid manage to bypass the epiglottis and enter the laryngopharynx, the protective sphincter in the larynx will close and prevent the solid or liquid from entering the trachea.[15, 16] Third, the larynx plays an important part in speech.[17]

The larynx is comprised of its encasing cartilages. The thyroid cartilage, better known as the Adam's apple, is the largest cartilage. The Adam's apple is usually visible only in adult males.[18] The epiglottis's function is to protect the larynx from anything other than air. When a person swallows, the larynx is pulled superiorly, and the epiglottis moves inferiorly and closes off the larynx. If a solid or liquid manages to enter the larynx, a strong cough reflex is triggered to ensure that the object is expelled before it enters the lungs. It is important to note that unconscious people do not have this reflex and therefore cannot protect their own airway. Because they do not have this reflex, the implementation of proper airway management to ensure that aspiration does not occur in these individuals is of utmost importance.[19]

Trachea

The trachea, commonly called the windpipe, is approximately four inches long in adults,[20] extending from the larynx to the level of the fifth thoracic vertebra. The trachea is kept rigid with c-shaped, hyaline cartilage rings. This rigidity is required to keep the trachea open during the air pressure changes of inspiration. The rings are open on the posterior side of the trachea to allow the esophagus to expand when large pieces of food are swallowed. If the trachea becomes obstructed, there is no other natural way for air to enter the lungs, and the condition becomes immediately life threatening.[21, 22]

Obstructions of the Upper Airway

Airway obstructions can be caused by any of the following:

- Foreign bodies (e.g., pieces of food or small objects)
- Trauma (e.g., a crushed trachea)
- Medical conditions (e.g., anaphylaxis, asthma, or infection)
- The body's own parts, such as the tongue and epiglottis

A general classification of obstructions will be discussed in the following sections.

Mild Airway Obstruction[23]

Partial obstruction with good air exchange: The obstruction has reduced the diameter of the airway to less than normal but is still allowing sufficient air to travel to the lungs. Examples include small pieces of food caught in the larynx or a mild infection that has caused the airways to swell. It is important to note that patients with this kind of obstruction still require immediate medical care, as the obstruction could move, causing either a full airway obstruction or diminished air exchange to less than that which is required to support life.

Severe Airway Obstruction[24]

Partial obstruction with poor air exchange: The obstruction has reduced the diameter of the airway to significantly less than normal. Although some air is able to travel past the obstruction to the lungs, the amount of air able to do so is insufficient for normal respiration. The patient will become increasingly hypoxic and will most likely die without immediate medical care.

Full obstruction with no air exchange: The obstruction of the airway is complete and no air is able to travel past the obstruction to the lungs. This is a true medical emergency, as the patient will die within minutes if the obstruction is not removed.

Types of Obstructions

Foreign Body

A foreign body airway obstruction (FBAO) is caused when any object, such as small bits of food (candy, gum, meat), toys, buttons, and coins, inadvertently enters the airway and subsequently causes an obstruction. Meat is the most common FBAO.[25] The object may be inhaled, in which case the epiglottis does not close the airway and the object travels straight into the trachea. The object, such as food, might be too large to swallow and may become stuck in the pharynx.

Teeth

Broken or dislodged teeth may cause an airway obstruction. Teeth can be damaged from traumatic or iatrogenic reasons. Traumatic reasons include blunt trauma to the face, which can dislodge or shatter teeth. Iatrogenic reasons, or reasons caused by medical personnel, include damage to the teeth due to improper techniques, such as levering the laryngoscope off the teeth.[26, 27]

Dentures

Patients with loose dentures can also create challenges for airway management. There are two schools of thought on the placement of dentures during airway management. Modern-day dentures are generally well fixed into place and should be left in place, as they provide rigidity to the mouth during bag-valve or mouth-to-mouth respirations. Others think that the removal of dentures provides a wider opening in which to manage the airway. Always follow local training and protocols.

Tongue

The tongue is a muscle that is anchored to the hyoid bone and styloid processes of the skull. With an unconscious patient in a supine, or "looking-up," position, or with a patient who has lost muscular control of the tongue, the relaxed tongue will fall back and obstruct the airway.[28] There are numerous easily implemented techniques to mitigate this, all of which are discussed in the following sections.

The tongue can also swell due to injury or illness to the extent that it will occlude the airway. There are numerous reported cases of post-operative swelling[29] caused by a number of iatrogenic reasons, some relating to poor intubation technique. When it comes to the human body, if one injures something, it will swell.[30] The tongue can also swell from illness or allergic reaction, as discussed below.

Epiglottis

As with the tongue, when an unconscious patient is lying supine, the epiglottis will droop backward and may obstruct the airway. Repositioning the patient into the lateral position is the easiest way to remedy this, although care and special techniques to protect the c-spine must be implemented with trauma victims suspected of a c-spine injury.

Epiglottitis is caused by a severe bacterial infection of the epiglottis, which can cause an airway obstruction. Up until children became regularly vaccinated against the haemophilus influenza type b bacterium, children aged two to five were most commonly affected. These days, cases in children are rare. Adults most often get epiglottitis from Streptococcus pneumonia (among other things).[31, 32]

Allergies, Hypersensitivities, and Anaphylaxis

An allergen is any substance that the immune system in some people will act against in order to protect the body. Examples of allergens include animal protein and fur, bacteria, viruses, various chemicals, dust, pollen, drugs, foods (shellfish, nuts, etc.), plants, perfume, and smoke. Allergies and hypersensitivities are abnormal and are powerful immune responses to an allergen. However, allergies can cause severe enough reactions that immediate medical attention is required, especially allergies that involve the inflammation and swelling of the airways.

Anaphylaxis and the more severe allergic reactions have an onset of seconds to minutes after exposure to an allergen. In rare cases, the reaction can occur after a number of hours. Without treatment, anaphylaxis can lead to death in

minutes.[33, 34]

Crush Injuries to the Upper Airway

The trachea maintains rigidity with c-shaped cartilage rings. These rings prevent the trachea from collapsing upon inspiration due to the negative pressure created inside the trachea. If trauma to the trachea is sufficient enough to damage the cartilage, the trachea may collapse, causing an airway obstruction.[35]

Inflammation

Inflammation of the upper and lower airways may be caused by a number of reasons, such as allergies, infections, or injuries. If the inflammation is significant, the airway may become obstructed by the swollen tissue inside the airway itself.

Laryngospasm

Irritation or stimulation of the vocal cords can cause the vocal cords to spasm, which will close the glottis.[36] Air will not be allowed in, although the patient may still expire air. The spasm usually lasts one to two minutes and is generally benign, although near fatal cases have been reported.[37]

Other Types of Obstruction

A variety of other medical causes of upper airway obstruction includes abscesses, cancer, croup, vocal cord problems, and tracheomalacia (a weakness and floppiness of the tracheal walls that cause the trachea to collapse during respiration).

Lower Airway

Primary Bronchi[38]

The distal end of the trachea divides into the left and right primary bronchi, which contain c-shaped cartilage rings for rigidity. The division occurs at the level of the angle of Louis, which is just inferior to the jugular notch. The bronchi run obliquely to where they enter the lung on their respective sides. The right bronchus is straighter, wider, and shorter than the left bronchus, which is why foreign objects are more likely to become lodged in the right bronchus. This is relevant to the medical provider, as improper placement of an endotracheal tube will most often result in the tube entering the right bronchus if it is inserted too far into the trachea. In addition, the bronchi, apart from being passageways for air, further warm and humidify the air.

Secondary and Tertiary Bronchi[39, 40]

The secondary bronchi are the first subdivisions of the primary bronchi. There are two left secondary bronchi and three right secondary bronchi. The secondary bronchi are the passageways to each of their respective lobes of the lung. The secondary bronchi also contain cartilage, although less than the primary bronchi. The amount of cartilage decreases as the bronchi get smaller in diameter. The secondary bronchi further divide into the tertiary bronchi, of which there are ten on the right and nine on the left. The tertiary bronchi continue into the lobules of the lungs.

Bronchioles[41, 42]

The bronchi subdivide several times until the diameter is reduced to about 1 mm or less in adults.[43] At this point, the bronchi become the bronchioles. Bronchioles do not have cartilage, so their rigidity is controlled by muscles. These muscles are sensitive to hormones such as epinephrine, and the contraction of the muscles significantly changes the resistance to airflow. Bronchioles further subdivide into terminal bronchioles, and then into respiratory bronchioles.

Alveoli[44, 45]

Each respiratory bronchiole divides into alveolar ducts, which lead into the alveoli. The alveoli are tiny, grapelike clusters of air sacs and are the main sites of respiratory gas exchange. The alveoli make up most of the lung tissue, and each person has approximately 300 million of them. The alveoli are comprised of a single layer of epithelial cells and elasticated fibers called stroma, which allow the alveoli to expand and contract during respiration. Oxygen/carbon dioxide exchange takes place in the alveoli, which are surrounded by blood capillaries. The respiratory membrane that separates the blood capillaries has air on one side and blood on the other, and gas exchange occurs by simple

diffusion. Finally, the alveoli are interconnected by alveolar pores, which allow alternate routes when the bronchioles have been obstructed by various means (e.g., mucus, disease, etc.).

Indications of Airway Management

Any patient, conscious or not, who cannot maintain or protect his or her own airway requires airway management. The guideline that the lack of a gag reflex is a reliable indicator for airway management is not valid, as up to one-third of healthy people do not have a gag reflex.[46]

Regardless of whether a patient is considered trauma or medical, the following should be considered general indications for airway management:

- Patient unable to maintain his or her own airway for any reason
- Cardiac arrest
- Unresponsive or unconscious patient
- Respiratory insufficiency (e.g., less than 8 bpm)
- Increasing respiratory distress (e.g., vital signs deteriorating, cyanosis worsening)
- Respiratory arrest
- Possibility of the airway being lost at a later stage (e.g., swelling of the larynx/tongue/epiglottis)
- Universal choking sign (i.e., patient has hands on his or her own throat)

Trauma Patient

Airway management for trauma patients should be a priority, as they often will have food or drink in their stomachs, and given the stress and anxiety caused by the trauma, they may vomit or aspirate, even if they are fully conscious. Depending on the nature of the injury (e.g., head trauma), there may be bleeding and foreign objects such as loose teeth in the nasopharynx and the oropharynx, and medical providers should always ensure that they look inside the patient's mouth for any obstructions. Trauma patients are also often immobilized to protect the cervical spine. If properly done, immobilization will render the patient completely unable to move or to protect his or her own airway in the event of vomiting. In such a case, communication with a conscious patient or close observation of an unconscious patient is critical to ensure aspiration does not occur.

Patients who have been subjected to blunt trauma, especially above the level of the clavicles, should be suspected of having a neck injury. If the patient has a head injury with a Glasgow Coma Score (GCS) of less than 9, the risk of a neck injury increases four-fold. A head injury is a neck injury until proven otherwise. A neck injury may or may not affect the patency of the airway.[47, 48]

Assessment

A patient who is conscious, alert, and capable of coherent conversation, and who is not immobilized, is most likely able to maintain his or her own airway. A patient's condition may deteriorate at any given time and should constantly be reassessed. There are also instances, such as in the case of inhalation burn patients, where airway management should be implemented immediately.

In addition to the indications listed above, trauma patients in the following categories require airway management:

- Apneic
- GCS less than 8 (e.g., traumatic brain injury (TBI))
- Sustained seizures (e.g., status epilepticus)
- Trauma to the mid-face resulting in instability
- Injuries to the airway (e.g., inhalation burns, extrinsic injuries such as blunt or penetrating trauma)
- Large flail segments
- High risk of aspiration (e.g., immobilized patient, head injury, intoxication, etc.)

The procedure to use in securing the patient's airway is dictated by the condition of the patient. Airway is one of the first priorities (the A in CAB), but consideration must be given to the condition of the cervical spine as well. The use of the head-tilt/chin-lift method as a measure to open an airway should be excluded from the options of a patient with a suspected cervical spine injury. Specifics of airway opening techniques will be discussed in detail in subsequent sections.

Other factors that will determine which airway method can be used include the cooperation of the patient, the patient's specific anatomy (e.g., deviated septum), the nature of the trauma, the availability of equipment, and the experience and training of the person managing the airway.[49]

Medical Patient

Medical patients can offer as many complications regarding airway management as trauma patients do. Patients who are morbidly obese or have airway abscesses, cancer, or other growths in the airway can create challenges.

Assessment

In addition to the indications listed above, medical patients in the following categories require airway management:

- Airway occlusion from any disease that is causing the patient to become hypoxic
- Any non-traumatic brain injury (e.g., a cerebrovascular accident (CVA)) resulting in the patient becoming combative or having a GCS of less than 9
- Drug overdose patients who are not responsive to naloxone or flumazenil, where the patient has a reduced level of consciousness

Importance of Basic Airway Management

Without an open airway, the patient will become increasingly hypoxic and, in most instances, will die within ten minutes.[50] This renders all other care and procedures moot if this cannot be accomplished.

The major issues are that we've come to associate airway management with the ET tube and in some cases we're killing patients because of this fixation. We need to look past any one device or skill and look at patient outcomes. – Dr Braude[51]

Advanced airway techniques and management are designed to extend basic airway management. In other words, if basic airway management is neglected, complications such as acidosis and high levels of carbon dioxide can severely complicate treatment later on, regardless of whether the advanced airway maneuver was successful. In addition, as the patient becomes more unstable, the stress of the care provider increases, as does the chance of error. There are, of course, instances where only advanced airway management will work, such as a cricothyroidotomy in the case of a full airway obstruction that does not yield to the normal choking-relief techniques, but these cases tend to be the exception.

In the case study, the paramedic was presented with a critical patient and he did not have any advanced equipment with him. In that situation, the victim had already been unconscious and was most likely not breathing for two minutes before the arrival of the paramedic. Although an ALS kit was available, it was still six minutes away. If basic airway management had not been implemented during those six minutes, the victim most likely would have died or would have suffered irreversible brain death.

Being caught off-duty is not the only instance when ALS might be required to use basic airway management only. Equipment failure, equipment and consumables shortages, multiple casualties (but not multiple ALS), and problematic airways are some additional situations. Regardless of the advanced technique being used, there should always be a backup plan if that technique is unsuccessful.

Two things come to mind: 'ETI tunnel vision' (the mistaken idea that ETI is the best and only way to manage the airway) and lack of adequate educational resources for ETI education—a big problem in some areas. – Dr Wang[52]

Regardless of the advanced technique being used, most protocols clearly state that the patient must be ventilated with a BVM before and in-between advanced airway attempts. (In the case of surgical or needle airway interventions, it is usually the case that the airway is severely obstructed and ventilations are not possible until the airway is established using these methods). The only way to accomplish this is with proper basic airway management and ventilation, which both require continuous practice.[53]

A patient who requires advanced airway management will most likely be hypoxic. These patients are far more susceptible to oxygen deprivation than a healthy individual. This hypoxia is worsened every second it takes to attempt to intubate a patient. In cases of cardiac arrest, attempts to intubate should not interrupt chest compression for more than 10 seconds, and the patient should be thoroughly oxygenated between attempts.[54]

Suctioning is another practice that is sometimes neglected. Suctioning is vital to clearing an airway and protecting it from blood and gastric contents. Intubating into an airway through a pharynx that is contaminated with blood and gastric contents increases the chance of pneumonia and lung infections at a later state. Care and consideration should always be given to the patient's long-term recovery, provided the short-term care is not unduly compromised.

Implementation of Airway Management and Ventilation: ECC 2010 Guidelines

Airway Equipment

The following is a list of equipment needed to implement airway management and ventilation. All equipment should be properly stored, inspected, used, and maintained according to the manufacturers' guidelines and local standard operating procedures (SOPs).

Personal Protection Equipment (PPE)

- Eye protection is essential when intubating a patient or dealing with trauma patients. The close proximity to the patient's face can easily result in bodily fluids getting in the eyes.
- Gloves should be used on all patients, regardless of the situation.
- Aprons and facemasks are additional forms of protection that should be used, according to personal choice or local protocol.

Spinal Immobilization with Head-restraint Device (Trauma Patients)

- Trauma (and sometimes medical) patients require spinal immobilization, as well as the appropriate head-restraint device, to limit movement of the cervical spine.
- C-spine collars are used in conjunction with spinal immobilization equipment to maintain a patient's neck in a specific position, to encourage the patient not to move, and to maintain the neck in the most natural position possible.

Airway Kit (O2, Suction, Etc.)

- A full, functioning, and portable oxygen cylinder, with the appropriate regulator and valve key, is essential. In addition to the portable cylinder, there should be larger cylinders in the vehicle to provide sufficient oxygen for the journey to definitive medical care.
- Manual and electrical suction devices should be included in the kit. Manual devices should always be available in the event that the electrical device fails. Electrical suction devices should be well maintained and charged.
- Various types of airways devices, such as oropharyngeal, nasopharyngeal, and endotracheal tubes, and blind insertion airway devices, each of which are discussed under their respective headings below, should be made available.

Opening an Airway[55, 56, 57]

If the airway cannot be effectively opened, resuscitation efforts will ultimately fail. Often, the most effective life-saving procedure is simply opening an airway, using the techniques mentioned below, to allow spontaneous respiration to begin. Airway management should always progress from the least invasive procedure first.

Head-Tilt/Chin-Lift (HTCL)

This is the preferred method of manual airway management when there is no suspicion of traumatic injury to either the head or the neck. By performing the HTCL method correctly, one can move the hyoid bone anteriorly. Since both the tongue and the epiglottis are attached to the hyoid bone, this action will prevent them from "flopping back" and the airway will become unobstructed.

Procedure:

- Tilt the forehead of the patient backward by gently pushing with the palm of one hand.
- Use the fingers of the other hand to lift the jaw anteriorly. The fingers should be placed under the bony part of the lower jaw, just under the patient's chin.
- Once the HTCL is complete, this is usually an opportune moment to look into the patient's mouth to visualize any obstructions in the mouth.

Precautions:

- Do not attempt on a patient who is responsive.
- Do not hyperextend the patient's head.
- Do not use the thumb to grip the jaw when lifting the chin.
- Do not press into the soft tissue under the chin, as this may occlude the airway.

Jaw Thrust

This method is used when there is suspicion of injury to the c-spine. The jaw thrust method involves lifting the jaw anteriorly and moving the head backward. The main difference between the HTCL and the jaw thrust methods is that the jaw thrust gives additional displacement to the mandible. This action, as with the HTCL, will bring the tongue and the epiglottis forward to open the airway.

Procedure:

- Kneel at the head of the patient, with knees in line with the patient's shoulders.
- With elbows firmly on the ground or other surface on which the patient is lying, place hands on each side of the patient's head. Palms should be resting more or less on the zygomas (cheekbones).
- Place fingers under the angle of the patient's jaw, with thumbs on the mandible.
- Lift the jaw forward with the fingers and tilt the head back.
- Use the thumbs to open the lips if the mouth closes.

Precautions:

- Do not attempt on a patient who is responsive.
- Do not hyperextend the patient's head.
- Do not lean on the patient's face.

Modified Jaw Thrust

This method is the preferred manual method of opening an airway when there is suspicion of injury to the c-spine.

Procedure:

- Stabilize the patient's head.
- Immobilize the patient's neck.
- Follow the steps for the jaw thrust method above, with the exception that the head-tilt portion is not used.

Precautions:

- Do not attempt on a patient who is responsive.
- Do not hyperextend the patient's head.
- Do not lean on the patient's face.

Maintaining an Airway

Once an airway is opened, it needs to remain open. This section describes the available techniques to ensure that a patient continues to have a patent airway.

Recovery Position[58]

This is a multi-faceted procedure in that it can be used to protect an airway. This technique is used mostly on patients who are not intubated and have normal breathing and circulation. By placing the patient on his or her left side, gravity pulls the jaw, tongue, and epiglottis forward, opening the airway. Gravity will also cause any fluids to run out of the mouth, not into the airway. The recovery position is contraindicated in patients with suspected neck/spine injuries.

Regardless of whether a patient is considered medical or trauma, care should always be taken to avoid excess movement of the neck. Typically, the left-lateral recumbent position is preferred, as this position takes the weight off the organs and the vena cava; however, the priority is opening the airway and either position can be used.

Procedure:

The following procedure describes a "log roll" performed by two rescuers to move the patient into the recovery position. Each step is dependent on the injuries of the patient. There is no one correct way of performing this procedure and good judgement should prevail.

- From the supine position, one rescuer (the "first rescuer") will maintain control of the c-spine. This first rescuer should be kneeling at the patient's head, taking care not to kneel into any bodily fluids. The first rescuer will then support the patient's head using both hands, taking care not to block the ears of a conscious patient so that the he or she can hear any commands given.
- The first rescuer is in charge, giving all the commands to move the patient.

- Position (at least) one rescuer (the "second rescuer") on the side of the patient that the rescuer is rolling toward (i.e., if the rescuer is rolling the patient onto the patient's left side, then the rescuer should be on the patient's left side).
- The second rescuer should ensure that there are no objects in the patient's pockets that will cause pressure points or injuries if the patient is rolled onto them.
- The second rescuer will cross the farthest leg of the patient over the nearest leg (e.g., the right leg over the left leg if rolling onto the patient's left side.
- The second rescuer will then move the patient's nearest arm above the patient's head. The farthest arm of the patient is brought across the chest of the patient.
- The second rescuer will then place one arm on the patient's shoulder and the other on the patient's hip. Generally, it is not advisable to grab clothing, with the exception of belts, as clothing can rip and cause loss of control of the procedure.
- The first rescuer will then ask if everyone is ready. Once affirmative responses have been received from all participating in the procedure, the first rescuer gives a predetermined count and everyone rolls the patient as a unit into the recovery position.
- The first rescuer maintains control of the c-spine, if necessary.

Precautions:

- All rescuers must work as a team, with the first rescuer in charge.
- Make sure all the rescuers know in which direction the patient is being rolled.
- The patient must not be rolled onto any sharp or hard objects.
- Rescuers must maintain a firm grip on the patient during the procedure.

Suctioning[59, 60]

The airway must remain clear of obstructions (e.g., foreign objects, blood, mucus, saliva, and other secretions). Although turning a patient onto his or her side or doing a finger sweep where indicated can clear the airway of these obstructions, it is generally not an efficient means of keeping an airway clear. Suction devices provide an expedient way of clearing these obstructions, with a minimal interruption of ventilations and usually no interruption of chest compressions. Due to the many factors that cause aspiration, all patients are at risk and suctioning equipment should always be ready.[61]

Suction Catheters

There are two main types of suction catheters: soft (whistle tip) and rigid (tonsil tip, or Yankauer). Soft-tip catheters are used for endotracheal and nasopharyngeal airway suctioning. Rigid catheters are used to clear the oral cavity and the oropharynx of blood, mucus, and foreign obstructions.

Hand-powered Suction Equipment

There are many different makes and models of hand-powered suctioning equipment. Hand-powered units are generally small and portable. Rescuers should become proficient with the equipment at their disposal, and ensure that the equipment is set up and used according to the manufacturer's instructions.

Procedure:

- Assemble the suction unit according to the manufacturer's instructions.
- Select the appropriate catheter: soft tip for nasal suctioning, or soft or rigid catheter for oral suctioning.
- Set the suction pressure to between -80 mmHg and -120 mmHg, accordingly.
- Operate the device to test that it is functioning. Often, rescuers will place the suction tip against a gloved hand to make sure it is "sucking."
- Measure the length of the suction catheter against the patient's exterior landmarks (i.e., from the tip of the patient's nose to the earlobe, about five inches, for oral suctioning, or from the top of the patient's nose to the earlobe, and then down to the Adam's apple). Mark the length of the catheter to be inserted with a gloved hand.
- Insert the suction tube for the appropriate length.
- Once the suction tube is inserted, activate the suction and slowly withdraw the tube.
- Repeat as required.

Precautions:

- In addition to removing fluids and solids, suction devices also remove air. Do not suction a patient for more than

10 seconds at a time.
- Once suctioning is complete, and the airway is cleared, reoxygenate the patient.
- ALWAYS keep the suction device and oxygen together.

Battery-powered Suction Equipment

As with hand-powered suctioning equipment, battery-powered units are also available in a wide variety of makes and models. Battery-powered units are generally heavier and more complicated to use than hand-powered units are. Rescuers must become proficient with the operation of the devices available to them. Manufacturers' instructions and guidelines must be followed.

Procedure:

The procedure for operating a battery-powered suction unit is the same as for the hand-powered unit.

Precautions:

- The precautions for hand-powered units are also applicable to battery-powered units.
- Battery-powered units more easily malfunction than hand-powered units do.
- Batteries can run dry, even when not being used; always ensure that the units are properly charged.
- Always carry a hand-powered suction unit as a backup.

Basic Adjuncts[62, 63]

To use a basic adjunct, the patient should not have a gag reflex, as vomiting or gagging can be induced when an airway is inserted.

Oropharyngeal Airways (OP Airways)

These are designed to be inserted into the mouth to prevent the tongue from pressing against the posterior pharyngeal wall and obstructing the airway. OP airways are indicated in any patient with a reduced level of consciousness and without a gag reflex. If a patient is able to tolerate an OP airway, the patient should be considered for endotracheal intubation, as the protective reflexes required to protect the airway from aspiration are no longer present. OP airways are also effective in preventing patients from biting down on endotracheal tubes.

Procedure:

- Select the appropriate-size airway. The general measurement is from the corner of the mouth to the angle of the jaw or the ear lobe.
- Open the airway using one of the following procedures:
    - Scissor maneuver: Use the non-dominant hand to open the mouth, using the thumb and forefinger to push the upper and lower jaw in opposite directions.
    - Jaw lift: Place two fingers under the bony part of the chin; lift the jaw away from the patient.
    - Tongue blade: Gently insert the tongue blade into the mouth and depress the tongue.
- Clear the mouth and pharynx of all fluids and foreign objects.
- Gently insert the OP airway without pressing on the tongue. The airway should be inserted at 90 degrees to the tongue, or upside down. Rotate the airway into the proper position (airway opening facing inferior) once the airway clears the tongue.
    - The preferred method is to use a tongue blade to bring the tongue anterior and inferior, providing direct vision of the airway.

Precautions:

- If gagging occurs, immediately remove the airway and suction as necessary. Reattempt with a nasopharyngeal airway.
- Take care not to press the tongue back into the pharynx.
- Do not allow the tongue or lips to catch between the teeth and airway.
- Selecting the correct-size airway is imperative, as an airway too long or too short may obstruct the airway.
- OP airways do not prevent aspiration.

Nasopharyngeal Airways (NP Airways)

These are designed to be inserted into the nose to prevent the tongue and the epiglottis from falling against the posterior pharyngeal wall. Generally, nasopharyngeal airways do not cause a gag reflex. NP airways are indicated in any patient with a reduced level of consciousness who cannot maintain his or her own airway.

Procedure:

- Select the appropriate-size airway. The diameter should be approximately the same size as the patient's baby finger yet small enough to enter the nostril. The length of the NP airway should be measured from the tip of the patient's nose to the inferior tip of the earlobe.
- Generously lubricate the airway with water-based lubricant. This is important not only for ease of insertion but also for protecting the fragile nasal mucosa.
- The jaw should continually be displaced during the airway insertion using either the HTCL method or the jaw thrust method without the head tilt.
- With the bevelled edge of the airway facing the septum, insert the airway into the nostril.
- Continue to insert the airway using a gentle rotating motion to overcome any resistance, until the flange of the airway reaches the opening of the nostril.

Precautions:

- Ensure that a HTCL or jaw thrust method is done first; otherwise, the tongue may prevent the airway from positioning correctly. The airway must go under the tongue, not over the tongue.
- Be gentle inserting the airway, as the nasal mucosa can easily be damaged and cause bleeding. If bleeding does occur, leave the airway in place.
- Do not force the airway.
- If resistance becomes significant, try the other nostril.
- Use caution with NP airway intubation in patients with suspected anterior base of skull fractures, as intracranial penetration may occur.
- If gagging occurs, retreat the airway about half an inch, or remove it completely.
- NP airways that are too long may enter the esophagus; airways that are too short will not prevent the tongue from obstructing the airway.
- NP airways do not prevent aspiration.

Advanced Adjuncts[64, 65]

Endotracheal Intubation (ETI)

ET tubes were originally considered the "gold standard" of airway management; however, attempts by medical personnel who were not proficient at ETI have produced complications, such as longer than necessary interruptions to CPR or ventilations, trauma to the oropharynx, and failure to recognize that an ETI was incorrectly placed. Indications for ETI include any patient who has a threatened airway, who is in need of assisted ventilations, or who cannot be ventilated by mouth-to-mask or bag-valve-mask.

ET tubes can be inserted orally or nasally. Oral intubation is the most common method. Nasal intubation is used when oral intubation is too difficult or is not possible (e.g., patient entrapment, anaphylaxis, or spontaneous respirations).

Equipment:

- Laryngoscope handle with either a straight or curved (Miller or Macintosh, respectively) blade. Each type of blade has various advantages and can be used based on personal preference and individual circumstances.
- Correct-size ET tube. For adults, a tube 28 to 33 cm in length and 6.0 to 9.0 mm in internal diameter is appropriate.
- Malleable stylet or Gum Bougie™. This maintains the ET tube in the correct "field hockey stick" shape. The stylet should not be extended further than one to two inches before the distal end of the tube, or past the Eye of Murphy on the tube. (Follow your local guidelines.)
- Water-soluble lubricant
- 10 cc syringe
- Magill forceps, used to remove foreign objects or to guide the tube into the larynx
- ET tube holder or tape to hold the tube in place
- Suction equipment as described under "Suctioning" above
- Pulse oximeter and/or capnometer
- Optional: Bougie or tube introducer for difficult intubations

Procedure:

- Assemble and check all equipment listed under "Equipment" above.
- Adequately oxygenate the patient for 15 to 30 seconds before attempting to intubate.
- Use suction as needed.
- If the patient is a trauma patient, the neck must be stabilized and movement of the neck must be limited. It is best if an assistant stabilizes the head in cases of trauma.
- Once the ventilations stop, the person intubating must be aware that the patient is becoming increasingly hypoxic.
- If CPR is in progress, chest compressions should be interrupted for no more than 10 seconds to intubate.
- Pull down the patient's chin and slide the blade into the right side of the patient's mouth.
- Push the tongue to the left side, and slowly move the blade along the tongue until the epiglottis can be visualized. NB – the tongue must be pulled forward to lift up the epiglottis.
- Use the laryngoscope blade to move the tongue and the epiglottis up and away from the posterior pharyngeal wall in a straight line.
- With the epiglottis visualized and the glottis opening identified, advance the ET tube to two inches past the vocal cords.
- Holding the ET tube in place, remove the laryngoscope and stylet, and inflate the cuff with 10 cc of air.
- Attach a BVM or other ventilation device to the tube.
- Confirm the placement of the tube by auscultating the right and left midaxillary lines for breath sounds and, more importantly, the epigastrium for silence (breath sounds here would indicate air entering the stomach). The chest should also be observed for rise and fall with each ventilation. Additional methods of confirmation of tube placement include pulse oximetry, capnography, and esophageal detectors.
- With the placement of the ET tube confirmed, secure the tube in place and continue to ventilate and reassess the placement of the tube. Mark the position of the tube for easy reference to see if the tube is accidentally moved.
- Insert an OP airway to prevent the patient from biting down on the ET tube.

Precautions:

- Do not unnecessarily delay ventilations or CPR while attempting to intubate.
- Minimize movement of the c-spine in trauma patients.
- Do not lever the laryngoscope off the patient's teeth.
- Always protect the tube.
- Always verify placement of the tube.
- If using a stylet, make sure it does not advance past the end of the ET tube, as the stylet may damage the trachea.

Nasotracheal Intubation

Nasotracheal intubation may be your only choice in certain situations. These include patients with spinal injuries, patients who are comatose or in arrest, patients whose mouth cannot be opened, patients with oral or facial injuries, and severely obese patients.

Blind Nasotracheal Intubation

Hyperventilate the patient with 100% oxygen. Assemble and check the equipment. Lubricate the distal end of a tube. Place the patient's head in a relaxed position. If spinal injuries are suspected, maintain the head and neck in a neutral in line position. Inspect the nose, and choose the larger nostril for insertion. Insert the tube into the nostril with the flanged end of the tube along the floor of the nostril or facing the nasal septum. Gently guide the tube in an anterior to posterior direction.

As you feel the tube drop into the posterior pharynx, listen closely at the end of the tube for the patient's respiratory sounds. You will hear the sounds the loudest when the tube is proximal to the epiglottis. Next, the tube is directed toward the glottic opening. You may see "tenting up" of the skin on either side of the Adam's apple and this indicates pyriform sinus placement. Slightly withdraw the tube and rotate it to the midline to correct this problem. As the patient inhales, advance the tube rapidly into the glottic opening and continue passing it until the distal cuff is just past the vocal cords. The patient may cough, buck or strain. Gagging is a sign of esophageal placement. If correctly placed, the patient's exhaled air will be felt coming from the proximal end of the tube. Breath condensation should also fog the clear plastic tube. Hold the tube in place and inflate the distal cuff with 5-10cc of air. Recheck for proper placement by observing the chest rise, breath sounds, and absence of sounds over the epigastric area. Hyperventilate the patient with 100% oxygen and secure the tube with tape.

Nasotracheal Intubation under Direct Visualization

With the glottic opening exposed, direct the tube tip by rotating its proximal end to position it in the mid line. Advance the tube between the vocal cords and if the tube falls posteriorly and cannot be directed through the glottic opening, use Magill forceps to grasp it and direct it. While one person holds the tube and puts it into place, the other person should advance the tube.

Advantages of the NT tube is that the tube can be placed with the patient’s head immobilized, nasal intubation is more comfortable than oral intubation, the tube cannot be bitten, and tube can be easily anchored.

Disadvantages of the NT tube is that it is more difficult to perform, and more time consuming than oral intubation, it is more traumatic to patients, it causes a greater risk for infection, improper placement is more likely, and the patient must be breathing to perform blind insertion.

Contraindications include patients with a deviated septum, patients with nasal and basilar skull fractures, and patients experiencing nasal obstruction.

Size Determinations for ET tubes

- Newborn 2.5-3.5
- Infant 3.5-4.0
- Child 4.0-6.0
- Adult 7.0-9.0

In an emergency, a good standard size ET for both male and female adults is 7.5

Digital Intubation

To perform, position yourself at the patient’s left side. Assemble and prepare your equipment. Hyperventilate the patient for a minimum of two minutes with oxygen. Place a bite block in the patient's mouth to keep it open and prevent the patient from biting down on your fingers. Place your left index and middle fingers into the patient's mouth. Work your way down the throat pulling the tongue and epiglottis away from the glottic opening. Work your way until you can feel the epiglottis, it will feel like a mucous covered flap. Guide the ET tube with your right hand alongside your left index finger. Insert the tube into the glottic opening. Verify tube placement by auscultation, and inflate the cuff. Verify placement again and secure tube.

The advantages of digital intubation are no laryngoscope is needed, and it can be performed on trauma patients.

Disadvantages of digital intubation are that tube placement may be incorrect because of lack of visualization, and the rescuer can be bitten.

Extubation

Removal of the ET tube is usually not indicated in the field. However, if the patient cannot tolerate the tube, you may be advised from medical control to extubate the patient. You should hyperventilate the patient prior to extubation. To remove the tube you should do the following:

- Have suction available (the oral cavity and the area above the cuff should be suctioned prior to extubation).
- Deflate the cuff completely.
- Withdraw the tube swiftly on inspiration while ventilating the tube.
- Assess the respiratory status.
- Administer 100% oxygen and assist ventilations as needed.

Needle Cricothyrotomy

Cricothyrotomy allows you to penetrate a patient's airway by puncturing the cricoid membrane and creating an airway tube for temporary oxygenation and ventilation. You will need a 12 to 14 gauge over the needle catheter, a 5-10 ml syringe, alcohol or iodine swabs, tape, ties, pressure regulating valve, pressure gauge with a high pressure oxygen supply, high pressure tubing and regulator, and a release valve.

Place the patient in a supine position. Find the cricoid membrane. Hold the larynx using the thumb and middle finger of one hand, and while doing this insert the needle of the syringe downward at a 45-degree angle into the cricoid. Maintain negative pressure on the syringe while advancing it. When the needle is in the trachea, air will fill the syringe. If you get a blood return in the syringe, reposition the needle. Advance the catheter over the needle toward the carina and remove the syringe. Be careful not to bend the catheter while doing this. Hold the catheter hub while attaching a pediatric endotracheal tube adapter. Check for adequate ventilations by observing the rise and fall of the chest and by checking breath sounds. If breath sounds are absent, begin transtracheal jet ventilation. Remove the Pedi ET tube adapter, and connect flexible tubing to the end of the hub of the cannula to the oxygen regulator. Be sure to provide a release valve. You may do this by using a Y or T connector through a three way stop cock directly attached to the high pressure tubing. This may also be accomplished by cutting a hole in the oxygen line proving a whistle stop effect.

Complications of needle cricothyrotomy include hemorrhage at the insertion site, subcutaneous or mediastinal emphysema and it is possible to perforate the esophagus if the needle is over inserted.

Disadvantages of transtracheal jet ventilations is that due to the high pressure in ventilation, a pneumothorax may develop, TJV does not allow for suctioning and it may not provide adequate elimination of carbon dioxide.

Cricothyrotomy

To perform, clean the neck with alcohol or iodine prep pads. Locate the cricoid membrane and with a scalpel make a 2 cm incision at the cricoid membrane level (check your protocol for vertical or horizontal incision). Open the cricothyroid membrane by inserting the scalpel handle into the membrane and rotate it. Insert a 6.0 or 7.0 ET tube into the larynx. Inflate the cuff and secure the tube. Ventilate with BVM that is hooked up to an oxygen supply. Determine adequacy of ventilations by observing the chest rise and fall and by auscultation. Do not attempt removal of this adjunct in a prehospital setting.

Complications of cricothyrotomy include: hemorrhage, aspiration, possible misplacement, perforation of the esophagus, vocal cord, carotid and jugular injury, and subcutaneous emphysema.

Cricothyrotomy is contraindicated in acute laryngeal disease caused by trauma or infection.

Supraglottic Devices (SDs)

SDs are advanced airways that are available in a variety of different devices, including the laryngeal mask airway (LMA), the esophageal-tracheal combitube (ETC), and the King LT-D airway (King). All SDs are indicated when ETI has not been successful or when ETI cannot be attempted (e.g., position of the patient or a c-spine injury is present).

In general, the use of SDs requires less training and maintenance than ETI. The same general guidelines for ETI, such as pre-ventilation, suctioning, and time away from CPR, apply to SDs.

Equipment:

- Water-soluble lubricant
- 10 to 20 ml syringe
- Bag-valve-mask
- Oxygen kit
- Suctioning devices
- Stethoscope for initial placement confirmation
- Pulse oximeter or other secondary confirmation device

Conclusion

Airway management is a cornerstone of emergency medical care. Proficiency by care providers in the techniques of basic airway management is as important as proficiency in the advanced airway techniques. Advances in medical research are becoming more rapid, and it is imperative to keep abreast of the latest developments. Providers, although often trained in all of the airway techniques, should factor their personal proficiency into their decision when choosing a particular technique. An improperly placed advanced airway can be detrimental to a patient’s outcome. Often, basic airway management is neglected when sometimes that is all that is required.

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