

# **Airway Management**

**EMS Continuing Education  
Technician through Technician-Advanced Paramedic**

**Consistent with the  
National Occupational Competency Profiles  
as developed by  
Paramedic Association of Canada  
and  
“An Alternate Route to Maintenance of Licensure”  
as developed by Manitoba Health**

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## **Disclaimer**

These documents were developed for improved accessibility to standardized continuing education for all paramedics in Manitoba.

This training package is consistent with the National Occupational Competency Profiles and the core competency requirements (both mandatory and optional) as identified in “An Alternative Route to Maintenance of Licensure” (ARML). It is not the intent that this package be used as a stand-alone teaching tool. It is understood that the user has prior learning in this subject area, and that this document is strictly for supplemental continuing medical education. To this end, the Paramedic Association of Manitoba assumes no responsibility for the completeness of information contained within this package.

It is neither the intent of this package to supersede local or provincial protocols, nor to assume responsibility for patient care issues pertaining to the information found herein. Always follow local or provincial guidelines in the care and treatment of any patient.

This package can be used in conjunction with accepted models for education delivery and assessment as outlined in “An Alternative Route to Maintenance of Licensure”. Any individual paramedics wishing to use these continuing education packages to augment their ARML program should contact their local EMS Director.

This document was designed to encompass all licensed training levels in the province (Technician, Technician – Paramedic, Technician – Advanced Paramedic.). Paramedics are encouraged to read beyond their training levels. However, it is suggested that the accompanying written test only be administered at the paramedic’s current level of practice.

This package has been reviewed by the Paramedic Association of Manitoba’s Educational Subcommittee and is subject to review by physician(s) or expert(s) in the field for content.

As the industry of EMS is as dynamic as individual patient care, the profession is constantly evolving to deliver enhanced patient care through education and standards. The Paramedic Association of Manitoba would like to thank those practitioners instrumental in the creation, distribution, and maintenance of these packages. Through your efforts, our patient care improves.

This document will be amended in as timely a manner as possible to reflect changes to the National Occupational Competency Profiles, provincial protocols/Emergency Treatment Guidelines, or the Cognitive Elements outlined in the Alternate Route document.

Any comments, suggestions, errors, omissions, or questions regarding this document may be referred to [info@paramedicsofmanitoba.ca](mailto:info@paramedicsofmanitoba.ca) , attention Director of Education and Standards.

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## **Introduction:**

Establishing and maintaining an open airway is of primary concern in any patient care situation. This module deals with anatomy and physiology of the respiratory system, assessment of the airway and the respiratory system and the principles of airway management and mechanical ventilation.

### **Conventions Used in this Manual**

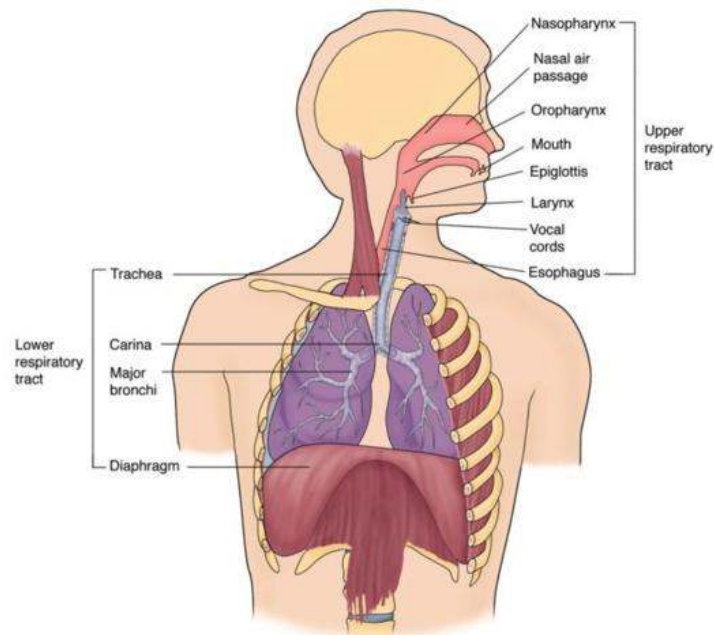
Black lettering without a border is used to denote information appropriate to the Technician Level and above.

|| Text with the single striped border on the left is information appropriate to Technician - Paramedic Level and above.

||| Text with the double striped border on the left is information appropriate to Technician – Paramedic Advanced.

## **Anatomy of the Respiratory System:**

The function of the respiratory system is two-fold: to provide the body with a constant source of oxygen, necessary for the conversion of essential nutrients into energy and to continually remove carbon dioxide and other waste products.



The respiratory system is divided into two areas: the upper airway, which extends from the nasal openings to the larynx, and the lower airway which extends from below the larynx to the alveoli.

### ***Anatomy of the Upper Airway:***

The upper airway, extending from the nose and mouth to the larynx consists of the nasal cavity, oral cavity and pharynx.

*Fig. 1-1 The upper and lower airways contain all the structures in the body that help us to breathe. The upper airway contains the nose, mouth, and throat. The lower airway consists of the larynx, trachea, main bronchi and other air passages within the lungs.*

**Nasal Cavity:** This is the superior-most portion of the airway. The lateral and superior walls of the nasal cavity are formed by the maxillary, frontal, nasal, ethmoid and the sphenoid bones. It is separated into right and left sides by the cartilaginous septum.

Air enters the nasal cavity through the external nares where it is filtered by nasal hairs. The air continues into the nasal cavity until it strikes three shelf-like bony structures called the superior, middle and inferior conchae, which cause turbulent airflow. This allows any airborne particles to be deposited on the mucous membrane. This membrane is covered with mucous and is fed by a rich blood supply resulting in the air becoming warmed, filtered and humidified. This occurs so efficiently that by the time the air reaches the lower airway, it is at body temperature (37° C), 100% humidified and virtually free of any airborne particles. Particles trapped on the mucous membrane are moved to the back of the pharynx by hair-like fibers called cilia. Air leaves the nasal cavity through the internal nares and enters the nasopharynx.

**Oral Cavity:** The oral cavity, or mouth, is defined by the cheeks, the hard and soft palates (forming the top of the oral cavity), the tongue, the gums and the teeth. The lips surround the opening of the mouth. The tongue, resting on the bottom of the oral cavity, is attached to the mandible and the hyoid bone.

**Pharynx:** The pharynx, or the throat, is a muscular tube, which extends from the back of the soft palate to the upper end of the esophagus and the trachea. It allows for both the passage of food and air. Openings into the pharynx include the Eustachian tubes, the internal nares, the mouth, the larynx and the esophagus.

The pharynx is divided into three regions: the nasopharynx, the oropharynx and the laryngopharynx. The uppermost nasopharynx extends from the back of the nasal opening to the plane of the soft palate. The oropharynx extends from the soft palate to the hyoid bone and the laryngopharynx extends from the hyoid bone to the esophagus, posteriorly, and the trachea, anteriorly. Another name for the laryngopharynx is the hypopharynx, important with regard to airway management techniques.

Due to the dual nature of the mouth and the pharynx (air and food passageway), several mechanisms are present to isolate each function. When food enters the trachea and lungs, sensitive nerves activate coughing and swallowing mechanisms as well as the gag reflex. Located anteriorly in the pharynx are the epiglottis, the laryngeal inlet and the mucous membrane covered arytenoids and cricoid cartilages of the larynx. Immediately behind the laryngopharynx are the fourth and fifth cervical vertebral bodies. The epiglottis is a leaf shaped cartilage, which prevents food from entering the respiratory tract while swallowing. It is attached to the hyoid bone and mandible by ligaments and muscles. Just above this is the vallecula, a depression between the epiglottis and the base of the tongue. On either side are recesses called the pyriform fossa.

**Larynx:** The larynx is a structure that joins the pharynx with the trachea. It consists of the thyroid cartilage, the cricoid cartilage, the upper end of the trachea, the vocal cords and the arytenoid folds (cupped tissues found posterior to the vocal cords). The walls of the larynx are supported by cartilage that prevents it from collapsing during inhalation. The main laryngeal cartilage is the thyroid cartilage (Adam's apple), which is the narrowest portion of the upper airway of an adult, due to the fact that it contains the vocal cords. Consisting of two large plates forming the anterior wall, it forms the characteristic V-shape. This cartilage is larger in males than in females. The upper portion of this cartilage is attached to the hyoid bone by the thyrohyoid membrane. The posterior portion of the thyroid cartilage is open, consisting of muscle.

The cricoid cartilage is beneath the thyroid cartilage. It forms the inferior walls of the larynx and is attached to the trachea's first ring of cartilage. This cartilage is a complete ring surrounding the esophagus and in children, is the narrowest part of the laryngeal airway. Located between the cricoid and thyroid cartilages is the cricothyroid membrane. On the rear surface of the cricoid cartilage are two pyramid-shaped arytenoid cartilages. Attached to the vocal folds and the pharyngeal walls, they are capable of opening and closing the vocal cords. True vocal cords regulate the passage of air through the larynx, controlling the production of sound. They can also close to prevent the passage of foreign bodies into the airway. This changeable space is called the glottic opening

(glottis). Passing an endotracheal tube through the glottic opening interferes with the production of sound and coughing.

Much of the larynx is lined with ciliated tissue that secretes mucous. Lined with nerve endings from the vagus nerve, it is very sensitive to irritation. Once irritated, air is inhaled, the glottis shuts tightly (trapping air in the lungs) and the abdominal and thoracic muscles contract, increasing intrathoracic pressure. The vocal cords open suddenly, allowing a burst of air to clear the lungs of any foreign particles in the form of a cough.

Because of this vagal sensitivity, stimulation of this area by a laryngoscope or endotracheal tube could cause bradycardia, hypotension and a decreased respiration rate.

## ***Anatomy of the Lower Airway***

The lower airway extends from the larynx to the alveoli. Respiratory gas exchange occurs here.

**Trachea:** Air enters the trachea, a 10-12 cm. tube connecting the larynx with the branching bronchi. Its open position is maintained by C-shaped cartilaginous rings, found along its entire length. It is lined by respiratory epithelium containing cilia and mucous-producing cells which trap any foreign material which was not filtered out in the upper airway. The cilia move these particles upward, into the mouth where they are swallowed or expelled.

**Bronchi:** The trachea divides into the right and left mainstem bronchi at the carina. The right mainstream bronchus is almost straight, while the left mainstem bronchus angles more to the left. Mainstem bronchi divide into secondary bronchi, which in turn divide into bronchioles, or small airways. After approximately 22 divisions, the bronchioles become respiratory bronchioles.

**Alveoli:** The respiratory bronchioles divide into alveolar ducts, which terminate in the alveolar sacs. The majority of gas exchange takes place in the alveoli, however, limited gas exchange does take place in the alveolar ducts and respiratory bronchioles.

Oxygen and carbon dioxide exchange takes place in the alveoli, which comprise a surface area of approximately 40 square metres. Alveoli are hollow and surrounded by a thin alveolar membrane (1-2 cells thick). The chemical surfactant is present which decreases surface tension of the alveoli, and therefore prevents collapse.

**Lung Parenchyma:** In addition to the alveoli, which are the functional units of the lung, there is present an additional lung tissue called lung parenchyma. It is this parenchyma which divides the lung into pulmonary lobes; three in the right lung (upper, middle and lower lobes) and two in the left lung (upper and lower lobes).

**Pleura:** The lungs are covered by a connective tissue called pleura. It is connected to the lung in only one place, the hilum (the point at which the bronchi enter the lungs). The pleura consists of two layers, the visceral pleura (covers the lungs and does not contain nerve tissue) and the parietal pleura (lines the thoracic cavity and does contain nerve

fibre). In the pleural space, the potential space between these two layers, is found a small amount of pleural fluid.

## **Physiology of the Respiratory System**

This section will detail the physiology of the respiratory system. An understanding of respiratory physiology is essential to providing competent advanced pre-hospital care.

### ***Respiration and Ventilation***

Respiration is defined as the exchange of gases between a living organism and its environment. Pulmonary respiration occurs in the lungs when the respiratory gases are exchanged between the alveoli and the red blood cells in the pulmonary capillaries through the capillary membranes. Cellular respiration occurs in the peripheral capillaries and is the exchange of the respiratory gases between the red blood cells and the various body tissues. Ventilation is the mechanical process whereby air is taken into and out of the lungs.

*Fig. 1-2 With diffusion, molecules of oxygen move from the alveoli into the blood, because there are fewer oxygen molecules in the blood. Similarly, molecules of carbon dioxide moves from the blood into the alveoli, because there are fewer carbon dioxide molecules in the alveoli.*

### ***Respiratory Cycle***

The lungs have no intrinsic capability to contract or expand. Pulmonary ventilation therefore depends upon changes in pressure within the thoracic cavity. The respiratory cycle requires coordinated interaction between the respiratory system, the central nervous system, and the musculoskeletal system.

The respiratory cycle begins when the lungs have achieved a normal expiration. At this point, the pressure inside the thoracic cavity is equal to atmospheric pressure. The thoracic cavity is a closed space, with the trachea as the only opening to the external environment. The size of the thoracic cavity can be made larger by contracting the diaphragm and the intercostal muscles. Contraction of the diaphragm results in its downward movement, while



contraction of the intercostal muscles results in outward expansion of the chest wall. In respiratory inadequacy, this process can be augmented by the use of accessory respiratory muscles, such as the strap muscles of the neck and the abdominal muscles. Both serve to increase the size of the thoracic cavity. The highly elastic lungs immediately assume the contour of the thoracic cavity. This is because of the negative pressure in the pleural space.

Increasing the size of the thoracic cavity decreases the intrathoracic pressure. As intrathoracic pressure decreases, air rushes into the lungs through the trachea (inspiration). When the pressure in the thoracic cavity again reaches that of atmospheric pressure, the air exchange stops. The respiratory muscles now relax, which in turn decreases the size of the chest cavity, thus increasing intrathoracic pressure. This causes air to rush out of the lungs through the trachea (expiration) until intrathoracic and atmospheric pressure are again equalized. Normal expiration is a passive process, while inspiration is an active, energy utilizing process.

### ***Pulmonary Circulation***

An intact circulatory system is also required for respiration. In fact, the amount of blood pumped to the lungs is the same as that pumped to the peripheral tissue. Body cells take oxygen from red blood cells in the arterial system and return carbon dioxide to red blood cells in the venous system. The venous system presents this deoxygenated blood to the right side of the heart. The right ventricle pumps blood into the pulmonary artery. This artery immediately divides into the right and left pulmonary arteries, each supplying the respective lung. Both branches quickly divide into smaller vessels that end in the pulmonary capillaries. The pulmonary capillaries are spread across the surface of the alveoli where the blood can pick up oxygen diffusing through the alveolar/capillary membranes. After this occurs, the pulmonary capillaries recombine into larger veins, eventually terminating in the pulmonary veins. The pulmonary veins empty this oxygenated blood into the left atrium of the heart. It is then transported, via the left ventricle, to the systemic arterial system.

The lung tissue itself receives little of its blood supply from the pulmonary arteries and veins. Instead, bronchial arteries that branch from the aorta provide most of the blood supply. Bronchial veins return blood from the lungs to the superior vena cava.

### ***Gas Exchange in the Lungs***

Gas exchange in the lungs occurs in opposite patterns to those in the periphery. Blood presented to the lungs is low in oxygen saturation and high in carbon dioxide saturation. Blood presented to the tissues is high in oxygen saturation and low in carbon dioxide saturation.

## Measurement of Oxygen and Carbon Dioxide Levels

The amount of oxygen and carbon dioxide in the blood can be determined by measuring the partial pressure of those gases. Partial pressure is pressure exerted by each of the components of a gas mixture. In other words, any partial pressure is a fractional component of the total gas mixture. Total gas pressure at sea level equals approximately 760 mm/Hg or 14.7 pounds per square inch. Since one millimetre of mercury pressure equals 1 Torr, the terms mm/Hg and Torr are interchangeable. The partial pressure can be calculated by taking the total atmospheric pressure and multiplying it by the percentage of the desired gas present. For example, to calculate the partial pressure of oxygen at normal atmospheric pressure, multiply the percentage of oxygen present in atmospheric air (21 percent) by the atmospheric pressure (760 Torr). The computation is as follows:

$$760 \text{ Torr} \times 0.21 = 159.6 \text{ Torr}$$

Our atmosphere consists of four major respiratory gases: nitrogen (N<sub>2</sub>), oxygen (O<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), and water (H<sub>2</sub>O). Although nitrogen is metabolically inert, it is necessary for the inflation of gas filled body cavities such as the chest. These four respiratory gases are present in the environment in the following partial pressures and concentrations:

<i>Gas</i>	<i>Partial Pressure</i>	<i>Concentration</i>
<i>Nitrogen</i>	<i>597.0 Torr</i>	<i>78.62%</i>
<i>Oxygen</i>	<i>159.0 Torr</i>	<i>20.84%</i>
<i>Carbon Dioxide</i>	<i>0.3 Torr</i>	<i>0.04%</i>
<i>Water</i>	<i>3.7 Torr</i>	<i>0.5%</i>
<i>TOTAL</i>	<i>760.0 Torr</i>	<i>100.00%</i>

*If you look at these same gases after the air has been taken into the alveoli, the partial pressures and concentrations are somewhat different:*

<i>Gas</i>	<i>Partial Pressure</i>	<i>Concentration</i>
<i>Nitrogen</i>	<i>569.0 Torr</i>	<i>74.9%</i>
<i>Oxygen</i>	<i>104.0 Torr</i>	<i>13.7%</i>
<i>Carbon Dioxide</i>	<i>40.0 Torr</i>	<i>5.2%</i>
<i>Water</i>	<i>47.0 Torr</i>	<i>6.2%</i>
<i>TOTAL</i>	<i>760.0 Torr</i>	<i>100.00%</i>

Since alveolar partial pressure and arterial pressure are essentially the same, normal arterial partial pressures for oxygen and carbon dioxide may be expressed as follows:

$$\text{Oxygen (PaO}_2\text{)} = 100 \text{ Torr (average} = 80 - 100\text{)}$$

$$\text{Carbon Dioxide (PaCO}_2\text{)} = 40 \text{ Torr (average} = 35\text{-}40\text{)}$$

Alveolar partial pressures are represented by the abbreviation PA (e.g., PA<sub>O2</sub>) while arterial partial pressures are represented by the abbreviation Pa (e.g., Pa<sub>O2</sub>). However, because these values are almost always the same, the arterial gases usually appear in shortened notations P<sub>O2</sub> and PC<sub>O2</sub>.

### **Diffusion**

Diffusion is the movement of a gas from an area of higher partial pressure concentration to an area of lower partial pressure concentration. Diffusion helps transfer gases between (1) the lungs and the blood and (2) the blood and the peripheral tissues. The rate of diffusion of a gas across the pulmonary membranes depends on its solubility in water. For example, carbon dioxide is 21 times more soluble in water than oxygen and readily crosses the pulmonary capillary membranes.

In the lungs, oxygen leaves the area of higher P<sub>O2</sub>, the alveoli, and enters the area of lower P<sub>O2</sub>, the arterial blood in the pulmonary capillaries. Concurrently, carbon dioxide leaves the area of higher PC<sub>O2</sub>, the arterial blood, and enters the area of lower PC<sub>O2</sub>, the alveoli. The blood returns via the pulmonary vein to the heart and then moves into the systemic circulation.

### **Oxygen Concentrations in the Blood**

Oxygen diffuses into the blood plasma, where it combines with hemoglobin. Hemoglobin approaches 100% saturation when the PA<sub>O2</sub> reaches 50-100 Torr. Each gram of saturated hemoglobin carries 1.34 millilitres of oxygen.

Oxygen saturation is the ratio comparing the actual amount of oxygen available with the oxygen-carrying capacity of the blood. This ratio is represented by the following equation:

$$\text{Oxygen Saturation} = \frac{\text{O}_2 \text{ content}}{\text{O}_2 \text{ capacity}} \times 100(\%)$$

It is important to point out that the vast majority of oxygen in the blood is carried on the hemoglobin molecule (approximately 97%). Very little oxygen is dissolved in the plasma. Since partial pressure measurements detect only the amount of oxygen dissolved in the plasma, and do not always reflect the total oxygen saturation, these measurements can be misleading. For example, a patient who has suffered carbon monoxide poisoning can not transport enough oxygen to the peripheral tissues since carbon monoxide displaces oxygen from the hemoglobin molecule. But, if an arterial blood gas sample were taken, it might reveal a normal or high PA<sub>O2</sub>. This indicates that adequate oxygen is reaching the blood, yet an inadequate amount of hemoglobin is available to transport the oxygen to the peripheral tissues.

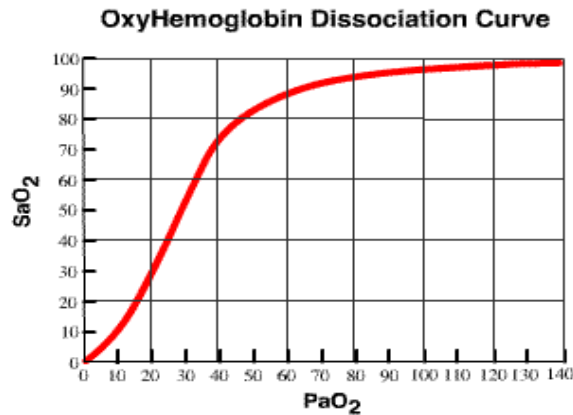


Fig. 1-3 This curve describes the relationship between available oxygen and amount of oxygen carried by hemoglobin. The horizontal axis is PaO<sub>2</sub>, or the amount of oxygen available. The vertical axis is SaO<sub>2</sub>, or the amount of hemoglobin saturated with oxygen.

Several factors can affect oxygen concentrations in the blood:

Inadequate alveolar ventilation is caused by many factors; low inspired oxygen concentration, respiratory muscle paralysis and pulmonary conditions such as emphysema, asthma and pneumothorax.

Decreased diffusion across the pulmonary membrane may be caused when diffusion distance increases or the pulmonary membrane changes - for example, when fluid enters the space between the alveolar membrane and the pulmonary capillary membrane (pulmonary edema).

Ventilation/perfusion mismatch can occur when a portion of the alveoli collapses as in atelectasis. Blood is then shunted past these collapsed alveoli without oxygenation or without removal of carbon dioxide. Also, pulmonary embolism, a blood clot in the pulmonary artery, can halt blood flow through the vessel. Consequently, a significant volume of blood is prevented from reaching the alveolar/capillary membranes where gas exchange can occur.

Oxygen derangements are corrected by increasing ventilation, administering supplemental oxygen, using intermittent positive pressure ventilation (IPPV), or by administering drugs to correct underlying problems such as pulmonary edema, asthma, and pulmonary embolism. The desired FiO<sub>2</sub> (oxygen concentration) should be selected based on the emergency being treated.

### **Carbon Dioxide Concentration in the Blood**

Carbon dioxide is transported mainly in the form of bicarbonate ( $\text{HCO}_3$ ). Approximately 66% of carbon dioxide is transported as bicarbonate, while 33% is transported combined with hemoglobin. Less than 1% is dissolved in the plasma. Carbon dioxide concentrations in the blood are influenced by several factors including increased  $\text{CO}_2$  production and/or decreased  $\text{CO}_2$  elimination. Causes of  $\text{CO}_2$  derangements include:

Increased  $\text{CO}_2$  production - This can result from several actions including:

Fever

Muscle exertion

Shivering

Metabolic process resulting in the formation of acids (metabolic acids)

Decreased  $\text{CO}_2$  elimination - This results from decreased alveolar ventilation. Common causes include:

Respiratory depression by drugs

Airway obstruction

Impairment of the respiratory muscles

Obstructive disease states such as asthma and emphysema

Increased  $\text{CO}_2$  levels (hypercarbia) are usually treated by increasing the ventilation and by correcting the underlying cause.

### **Regulation of Respiration**

Respiration falls under the control of both the voluntary and involuntary nervous systems. However, most of the body's oxygen needs are monitored by involuntary control systems - various chemical, physical, and nervous reflexes such as those noted below:

#### **Nervous Impulses from the Respiratory Centre**

The main respiratory centre lies in the medulla, located in the brain stem. Various neurons within the medulla initiate impulses that result in respiration. A rise in the frequency of these impulses results in an increase in respiratory rate. Conversely, a decrease in firing frequency results in a lowered respiratory rate. The medulla is connected to the respiratory muscles primarily via the vagus nerve. If the medulla fails to initiate respiration, an additional control centre located in the pons, called the apneustic centre, assumes respiratory control to ensure continuation of respirations. Expiration, on the other hand, is controlled by a third centre, the pneumotaxic centre, also located in the pons.

### **Microscopic Stretch Receptors**

During inspiration, the lungs become distended, activating what are known as stretch receptors. As the degree of stretch increases, these receptors fire more frequently. The impulses they send to the brain stem inhibit the medullary cells, decreasing the inspiratory stimulus. Thus, the respiratory muscles relax, allowing the elastic lungs to recoil and expel air from the body. Then, as the stretch decreases, the stretch receptors stop firing. This is referred to as the Hering-Breuer reflex; a process that prevents over expansion of the lungs.

### **Chemoreceptors**

Other involuntary controls include central chemical receptors in the medulla and peripheral chemoreceptors in the carotid bodies and in the arch of the aorta. These chemoreceptors are stimulated by decreased  $PAO_2$ , increased  $PACO_2$ , and decreased pH. (The pH scale expresses degree of acidity or alkalinity. A lower pH indicates greater acidity; a higher pH indicates greater alkalinity.) Cerebrospinal fluid (CSF) pH is the primary control of respiratory centre stimulation. A change in the CSF pH occurs very quickly in relation to arterial  $PCO_2$ . A rise in the CSF pH inhibits respiration, while a decrease in CSF pH stimulates it. Because arterial  $PCO_2$  is inversely related to pH, including CSF pH, it is seen as the normal neuroregulatory control of respirations. Any increase in the arterial  $PCO_2$  will stimulate the peripheral chemoreceptors. They will then send impulses to the brain stem to increase respirations. And, as indicated, any increase in  $PACO_2$  will decrease CSF pH, which will also stimulate the central chemoreceptors. The result will be increased respirations. Conversely, low  $PACO_2$  levels will decrease chemoreceptor stimulation, thereby effectively decreasing respiratory activity.

### **Hypoxic Drive**

The body also constantly monitors the  $PaO_2$  and the pH. In fact, hypoxemia (decreased partial pressure of oxygen in the blood) is a profound stimulus of respiration in a normal individual. People with chronic respiratory disease such as emphysema and chronic bronchitis tend to retain  $CO_2$  and therefore have a chronically elevated  $PaCO_2$ . Chemoreceptors in the periphery eventually become accustomed to this chronic condition, and the central nervous system ceases dependence upon  $PaCO_2$  to regulate respiration. These individuals have to depend on changes in  $PaO_2$  to control respiration. Such a condition is termed hypoxic drive. Respiratory stimulation is increased when  $PaO_2$  falls and inhibited when it climbs. High - volume oxygen administration to people with this condition can cause respiratory arrest. Because high - flow oxygen can quickly double or even triple the  $PaO_2$ , peripheral chemoreceptors cease to stimulate the respiratory centers, causing apnea. Although this is a potential threat, it is unlikely to occur in the limited time span of the pre-hospital setting.

## ***Modified Forms of Respiration***

There are several modified forms of respiration. They include:

- Coughing - Forceful exhalation of a large volume of air from the lungs. This performs a protective function.
- Sneezing - Sudden, forceful exhalation from the nose, usually caused by nasal irritation.
- Hiccoughing - Sudden inspiration caused by spasmodic contraction of the diaphragm. It serves no known physiological purpose.
- Sighing - Slow, deep inspiration followed by a prolonged expiration. Sighing hyperinflates the lungs and re-expands atelectatic areas.
- Grunting - A sound that occurs primarily in neonates when the infant expires air against a partially closed epiglottis. It is usually an indication of respiratory distress.

## ***Measures of Respiratory Function***

The respiratory rate is the number of respirations per minute-normally 12-20 breaths per minute in adults, 18-24 breaths per minute in children, 40-60 breaths per minute in infants. Several factors affect respiratory rate:

- Fever - Increases rate
- Anxiety - Increases rate
- Pain - Increases rate
- Hypoxia (Inadequate tissue oxygenation) - Increases rate
- Depressant drugs - Decreases rate
- Sleep - Decreases rate

The capacity of the lungs and airways has been extensively studied and is important in emergency care. Maximum lung capacity in the average adult male is approximately 6 litres and is termed the total lung capacity (TLC). These are some additional respiratory capacities and measurements paramedics must be familiar with. These include:

**Tidal Volume (VT)** The tidal volume is the average volume of gas inhaled or exhaled in one respiratory cycle. In the adult male this is approximately 500ml.

**Dead Space Volume (VD)** The dead space volume is the amount of gas in the tidal volume that remains in the passage-ways unavailable for gas exchange. It is approximately 150ml in the adult male.

**Alveolar Volume (VA)** The alveolar volume is the amount of gas in the tidal volume that reaches the alveoli for gas exchange. It is approximately 350ml in the adult male. The following equation shows this relationship.

$$V_T - V_D = V_A$$

**Minute Volume (Vmin)** The minute volume is the amount of gas moved in and out of the respiratory tract in one minute. It is represented in the following equations.

$$V_{\min} = V_T - V_D \times \text{Respiratory Rate}$$

OR

$$V_{\min} = V_A \times \text{Respiratory Rate}$$

**Functional Reserve Capacity (FRC)** The amount of air that can be forcefully exhaled after a maximum inspiration is termed the functional reserve capacity or functional residual capacity. It is approximately 4500ml in an adult male.

## **Assessment of the Respiratory System**

Assessment of the respiratory system begins with the primary (initial) assessment followed, when practical, by a thorough secondary assessment.

### ***Primary (Initial) Assessment***

The purpose of the primary (initial) assessment is to identify any immediate threats to the patient's life. First, the airway should be assessed to assure that it is patent. Patients of any age who are responsive and talking or crying have an open (patent) airway, while the presence of snoring or gurgling may indicate potential problems with the airway. Although airway and breathing problems are not the same, their signs and symptoms often overlap.

To check for the adequacy of breathing, observe the patient's ability to speak without difficulty. A patient who can speak only two or three words without pausing to take a breath, a condition known as two-to three word dyspnea, has a severe airway obstruction (a narrowing of the airways caused by trauma or disease) or other breathing problems. The presence of retractions or the use of the accessory muscles of respiration is also a sign of airway obstruction. Nasal flaring and the use of the accessory muscles, indicate that a child has an airway obstruction. Finally, obviously labored breathing is also a sign of airway or breathing difficulties.

Patients with altered mental status warrant further evaluation. Feel for movements of air with your hand or cheek. Look for rise and fall with each respiratory cycle. In an adult patient, the respiratory rate generally ranges between 12 and 20 breaths per minute.

Breathing should be spontaneous and regular. Irregular breathing suggests a significant problem and usually requires some ventilatory support. The chest wall should be observed for any area of asymmetrical movement. This condition, known as paradoxical breathing, may suggest flail chest.

If the patient is not breathing, or if you suspect problems with the airway, open the airway by using the head-tilt/chin-lift or jaw-thrust maneuver, as described later. If the possibility of trauma exists, use the modified jaw-thrust method instead and maintain stabilization of the cervical spine. If the first breath does not go in, reposition the patient's head and try again. Once the airway is open, re-evaluate the status of breathing. If breathing is adequate, provide supplemental oxygen and assess circulation. If breathing is inadequate, or absent, begin artificial ventilation. When assisting a patient's breathing with a ventilatory device (bag-valve mask device or other positive pressure device), or after placing an airway adjunct (nasopharyngeal airway, oropharyngeal airway, endotracheal tube or combitube), monitor the rise and fall of the chest to determine correct usage and placement.

## ***Secondary (Detailed) Assessment***

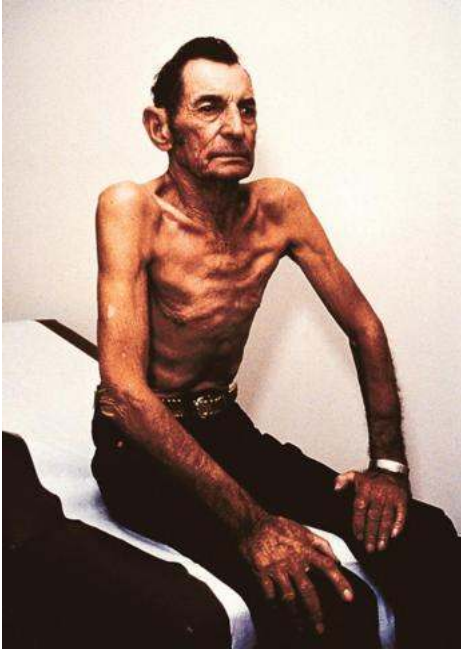
Following completion of the primary (initial) assessment, and correction of any immediate life threats, the secondary (detailed) assessment should be completed.

### **History**

Inquire about recent trauma, food intake, and drinking. Determine whether the onset of the problem was slow or rapid. Ask about allergies and anaphylaxis. If an injury is involved, evaluate the mechanism of injury. Blunt trauma to the neck may have caused a laryngeal injury.

### **Physical Examination**

Begin the physical assessment with inspection. Evaluate the adequacy of breathing. Note any obvious signs of trauma. Assess skin color as an indicator of oxygenation status. Early in respiratory compromise, the sympathetic nervous system will be stimulated to help offset the lack of oxygen. When this happens, the skin will often appear pale and diaphoretic. Cyanosis is another sign of respiratory distress. When oxygen binds with the hemoglobin, the blood appears "bright red." Deoxygenated hemoglobin is blue and will give skin a bluish color (cyanosis). However, this is not a reliable sign, since severe tissue hypoxia is possible without cyanosis. In fact, cyanosis is considered a late sign of respiratory compromise. When it does appear, cyanosis will usually affect the lips, fingernails and skin. A red skin rash, especially if accompanied by hives, may indicate an allergic reaction. A cherry red skin discoloration may be associated with carbon monoxide poisoning.



Note any decrease or increase in the respiratory rate, one of the earliest indicators of respiratory distress. As mentioned earlier, look for use of the accessory respiratory muscles - intercostal retractions, suprasternal retractions, use of the abdominal muscles - another indicator of respiratory distress. Also remember that in infants and children, nasal flaring and grunting indicate respiratory distress.

*Fig. 1-4 Notice patient is sitting in the tripod position and the use of accessory muscles.*

Following inspection, listen for the adequacy of air movement at the mouth and nose. Then listen to the chest with a stethoscope. In a pre-hospital setting, the sites to be auscultated include the right and left apex (just beneath the clavicle), the right and left base (eighth or ninth intercostal space, midclavicular line), and the right and left mid-axillary line (fourth or fifth intercostal space, on the lateral side of the chest). There are also six locations on the posterior chest that can be monitored. When the patient's condition permits, the posterior surface is actually preferred over the anterior one. At this location heart sounds do not interfere with auscultation. However, since patients are usually supine during airway management, the anterior and lateral positions usually prove more accessible. Sounds that point to airflow compromise include:

- *Snoring* - results from partial obstruction of the upper airway by the tongue
- *Gurgling* - results from the accumulation of blood, vomitus, or other secretions in the upper airway
- *Stridor* - a harsh, high pitched sound heard on inhalation associated with laryngeal edema or constriction
- *Quiet* - the absence of breath sounds is an ominous finding and indicates a serious problem with the airway, breathing, or both

When assessing the effectiveness of ventilatory support or the correct placement of an airway adjunct, realize that air movement into the epigastrium may sometimes mimic breath sounds. Thus, listening to the chest should be only one of several means used to assess air movement. Another method of checking correct placement of an airway adjunct is to auscultate over the epigastrium; it should be silent during ventilation. When providing ventilatory support, watch for signs of gastric distention. This will suggest inadequate hyperextension of the head, undue pressure generated by the ventilatory device, or improper placement of airway adjuncts. Listening over the sternal notch will also confirm the presence of airflow when an endotracheal tube is correctly placed in the trachea.

Finally, palpate. First, feel for the movement of air with the back of your hand or your cheek. If an endotracheal tube is in place, the proximal end can be checked for this movement. Next, palpate the chest for rise and fall. In addition, palpate the chest wall for symmetry, abnormal motion, crepitus and subcutaneous emphysema.

When ventilating with a bag-valve device, gauge airflow into the lungs by noting compliance. Compliance refers to the stiffness or flexibility of the lung tissue, and it is determined by how easily air flows into the lungs. When compliance is good, airflow occurs with minimal resistance. When compliance is poor, ventilation is harder to achieve. Compliance is often poor in diseased lungs and in patients suffering from chest wall injuries or tension pneumothorax. It will decrease when the upper airway is obstructed by the tongue. If a patient shows poor compliance during ventilatory support, look for potential causes. Questions to aid in assessment include:

Is the airway open?

Is the head properly extended (non-trauma patients)?

Is the patient developing tension pneumothorax?

Is the endotracheal tube occluded?

Has the endotracheal tube been inadvertently pushed into the right or left mainstem bronchus?

A bag that compresses too quickly or “collapses” should arouse suspicion. It may indicate incorrect placement of the endotracheal tube into the esophagus or a defect in the bag-valve mask device.

Pulse rate abnormalities may also suggest respiratory compromise. Tachycardia usually accompanies hypoxemia in an adult, while bradycardia hints at anoxia (absence or near-absence of oxygen) with imminent cardiac arrest.

## ***Foreign Body Removal***

Initially, basic life support measures should be carried out in order to open the airway. These include abdominal and chest thrusts based on the age of the patient, and whether they are conscious or unconscious.

<b>Age Group</b>	<b>Conscious</b>	<b>Unconscious</b>
0-1	combination back blows and chest thrusts	CPR
1-8	Heimlich Maneuver	CPR
8 and up	Heimlich Maneuver	CPR

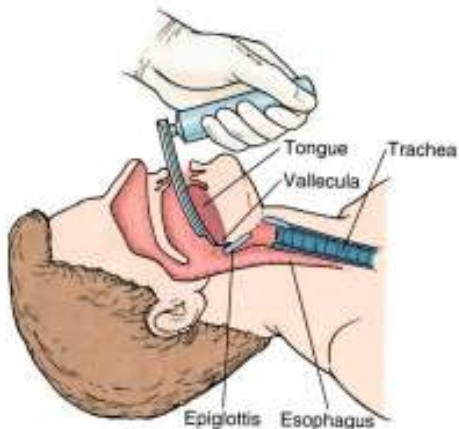


Fig. 1-5 Failing basic life support attempts, the paramedic should immediately proceed to direct visualization of the larynx with a laryngoscope, and attempt to remove the foreign body with Magill forceps or a suctioning device. The procedure for visualizing the airway is identical to that used for endotracheal intubation.

### ***Managing Stoma Patients***

Often, patients who have had a laryngectomy (removal of the larynx) or a tracheostomy (surgical opening into the trachea) breathe through a stoma, an opening in the front of the neck that connects the trachea with the outside air. These patients frequently have tracheostomy tubes in place to keep the soft tissue stoma open. These tracheostomy tubes consist of an inner and outer cannula and can be metal or synthetic, cuffed or uncuffed.

When a stoma patient requires ventilatory assistance, the responder may employ a mouth to stoma technique. Most rescue personnel will use a BVM or a pocket mask to prevent communicable disease transmission. Make certain to seal the mouth and nose if air leaks for these areas during ventilation.

Stoma patients often have problems with excessive secretions, based on a less effective cough, which can cause a mucous plug. This plug can block or occlude the stoma, thereby blocking the airway. Timely suctioning of the stoma using a #14 or #18 French Catheter or a tonsil tip is essential to open the airway. Failing this, the inner cannula should be quickly removed if present.

If there is no inner cannula, the paramedic must check if the tube is cuffed, and if so, deflates it using a syringe. The outer cannula can then be safely removed. Following removal of the outer cannula, the paramedic must select the largest size endotracheal tube that will pass through the opening, lubricate it with gel, instruct the patient to exhale, and insert it about 1-2 cm beyond the distal cuff. Inflate the cuff and confirm patency and patient comfort.

Suctioning the stoma patient must be done cautiously, as the process may cause soft tissue swelling. After pre-oxygenating the patient, inject 3 ml of sterile saline into the stoma. Instruct the patient to exhale and gently insert the pre-lubricated catheter until

resistance is met. As the patient coughs or exhales, suction the airway as the catheter is withdrawn. The same technique is employed to suction through an endotracheal tube.

### ***Airway Management in Immobilized Patients***

It can be difficult to manage the airway in immobilized patients. However, this is the number one priority in any patient. Appropriate equipment, including suction and oxygen, must be available on a moment's notice.

Patients often become nauseated and vomit during transport. If this occurs, the patient and long backboard should be turned to one side and the patient's airway rapidly suctioned. This may require the enlistment of multiple crew members during the actual turning. It is imperative that the patient be tightly secured to the backboard before being turned to prevent further movement.

### ***Suctioning***

Suctioning devices must be readily available for all patients to remove blood, secretions or vomit from potentially blocking the airway. These devices may be handheld, oxygen-powered, battery operated, or mounted (non-portable). There are advantages and disadvantages to each:

<b>Type</b>	<b>Advantages</b>	<b>Disadvantages</b>
Hand-powered	Lightweight, portable inexpensive, simple to operate	Limited volume, manually powered, fluid contact components are not disposable
Oxygen-powered	Small, lightweight	Limited suction power, uses a lot of oxygen
Battery-operated	Lightweight, portable, excellent suction power, simple to operate and troubleshoot in the field	Battery memory decreases with time; mechanically more complicated than hand-powered, some fluid contact components are not disposable
Mounted	Strong suction, adjustable vacuum power, disposable fluid contact components	Not portable, cannot be serviced in the field, no substitute power source

Other suction devices in use are bulb (globe) syringes and DeLee suction traps which are used primarily on infant patients.

The most commonly used suction catheters are either rigid (“Yankauer” or “tonsil tip”) or soft (Whistle tip or French) catheters. Their uses, differences, advantages and disadvantages are compared below:

**Hard/rigid catheters**

A large tube with multiple holes at the distal end

Suctions larger volumes of fluid rapidly

Standard size

Used in oropharyngeal airway only

Removes larger particles

**Soft catheters**

Long, flexible tube; smaller diameter than hard-tip catheters

Cannot remove large volumes of fluid rapidly

Various sizes

Can be placed in the oropharynx, nasopharynx, or down the endotracheal tube

Suction tubing without catheter (facilitates suctioning of large debris)

To prevent hypoxia from prolonged suctioning attempts, suctioning should be limited to 5 seconds per attempt, unless the airway is still obstructed, which indicates extended suctioning. Also, whenever possible, hyperventilate the patient with 100% oxygen prior to suctioning attempts. Do not apply suction while inserting the catheter. Suction while withdrawing after properly positioning the catheter.

Other complications of suctioning may include anxiety related tachycardia and hypertension, or vagus nerve stimulation, causing bradycardia and hypotension. Also, stimulation of the cough reflex will cause an increased intracranial pressure and a reduction in cerebral blood flow.

Suctioning of thick secretions may block the catheter or suction tubing. To reduce this problem, suction water between suctioning attempts to dilute the secretions and encourage flow to the collecting canister.

## **Supplemental Oxygenation**

Oxygen administration plays an important role in patient care. It is essential in cases that involve suspected hypoxia of any cause, including cardiac chest pain and cardiac arrest. Oxygen assists the patient by: increasing the percentage of inspired oxygen, increasing the oxygen concentration at the alveolar level, increasing arterial oxygen levels, and increasing the amount of oxygen delivered to the patient's cells.

### **Oxygen Delivery Devices**

#### **Nasal Cannula**

The nasal cannula is a frequently used device that is comfortable and easily tolerated by the patient. It can deliver oxygen concentrations ranging from 28-44% based on the litre flow set on the regulator:

Litre flow/Min.	Approximate Concentration Delivered
2.0 Litre/Min.	28%
3.0 Litre/Min.	32%
4.0 Litre/Min.	36%
5.0 Litre/Min.	40%
6.0 Litre/Min.	44%

Flow rates of higher than 6 litres do not increase oxygen concentrations and may dry out mucous membranes and cause headaches.

Nasal cannulas are commonly used for patients who: have mild respiratory distress, are experiencing nausea or vomiting, feel suffocated by a mask, or are prone to carbon dioxide retention. It allows the patient to speak easily, thereby permitting the paramedic to continue gathering a history of the patient's condition.

#### **Simple Face Mask**

This device includes oxygen tubing and a face mask. On the outside of the mask are two inlet/outlet ports. Oxygen is delivered through tubing in the bottom of the mask through the inlet port at a concentration of 34-46% based on a flow rate of 8-12 litres/minute. Disadvantages of the face mask include: a suffocating feeling to the patient, muffling speech making assessment difficult, and the requirement of a tight seal to deliver higher oxygen concentrations. It should be used with caution in patients who are nauseated or vomiting.

## **Non-Rebreather Mask**

This device consists of oxygen tubing and a face mask with a reservoir bag attached to the bottom. The outlet port is covered with a rubber flap that prevents ambient air to enter the mask on patient inhalation. Oxygen is administered from the regulator through the tubing at a rate of 10-15 litres/minute, delivering 60-95% oxygen concentrations. The reservoir bag should remain inflated to insure adequate oxygen delivery.

Its disadvantages are similar to the simple face mask. The main applications are in the treatment of the severely hypoxic patient, including shock, severe respiratory distress, acute myocardial infarction, trauma, or carbon monoxide poisoning.

### ***Supplemental Oxygen for Infants***

Infants requiring oxygen may be oxygenated by using the oxygen tubing only and by blowing it across the patient's face near the mouth and nose at a rate of 6-8 litres/minute.

Pediatric size oxygen masks are available for children requiring supplemental oxygen.

### ***How long will the oxygen tank last?***

To calculate how long an oxygen tank will last in minutes, determine the current tank pressure, subtract 200, and multiply by a constant based on the size of the tank. Then, divide the total by the flow rate set on the regulator:

$$\text{Time (minutes)} = \frac{(\text{tank pressure (lb)} - 200 \text{ lb}) \times \text{constant}}{\text{Flow-rate (lpm)}}$$

constants: D tank = 0.16, E tank = 0.28, M tank = 1.56, H tank = 3.14

### ***Resuscitation Oxygen Administration***

Paramedics will be asked to provide ventilatory support to patients who are not breathing (apneic) and to those patients with severe respiratory depression. A significant decrease in the patient's rate or depth of breathing will lead to a decreased minute volume, causing hypercarbia (increase carbon dioxide levels), hypoxia, and a lowered pH (respiratory acidosis). If not corrected, this will lead to respiratory and cardiac arrest. For the paramedic to effectively treat this problem, the adult patient must receive supplemental ventilations at a rate of 12 breaths/minute with a tidal volume of at least 500-600 ml of oxygen.

To provide this ventilatory support in the field, the paramedic must consider three conditions. First, the airway must be open. This can be achieved by any of the

previously mentioned techniques. Second, a closed system must be established. This requires some skill and practice, particularly with a bag-valve device. Air will choose the path of least resistance, so a tight mask-face seal is essential to deliver the appropriate tidal volume. Third, adequate volumes of oxygen must be delivered to oxygenate the lungs (observed by the rise and fall of the patient's chest).

### **Bag-Valve Devices**

The bag-valve-mask (BVM) is used to deliver oxygen or room air to a patient who is not breathing at all or not breathing effectively. The BVM will hyper expand the patient's lungs, improving alveolar ventilation, thus preventing hypoxia. The BVM consists of an oblong, self-inflating silicone or rubber bag, an oxygen reservoir bag, a series of one way valves, and a transparent face mask. They are available in adult, pediatric, and infant sizes. The infant and pediatric sizes are equipped with a "pop-off" valve to prevent hyper-inflating the lungs. In the adult patient with poor lung inflation (compliance), the "pop off" valve is not desirable.

When used without supplemental oxygen, BVM's deliver 21% oxygen (room air). At 12 litres per minute of supplemental oxygen, the percentage of delivered oxygen increases to 60%. The bag valve mask can deliver 90-95% oxygen at 15 lpm in the hands of an experienced paramedic.

For patients that are intubated and being ventilated with a BVM, disposable colormetric end-tidal CO<sub>2</sub> detectors are available to attach to the ET tube. These detectors detect the presence of carbon dioxide in the patient's expired air. They are not 100% reliable, particularly in cardiac arrest situations.

## **Airway Management**

In the primary (initial) assessment, the first step is to establish if the patient has a patent airway. Appropriate cervical stabilization must be taken into consideration while assessing an airway of a trauma victim. Any airway compromise must be rapidly corrected. Initially, manual and basic maneuvers should be applied to correct any compromise. Shortly thereafter, advanced airway maneuvers should be performed to maintain the airway effectively. Failing advanced airway techniques, a surgical method may have to be used.

### ***Manual Airway Management***

Manual maneuvers are the simplest airway management techniques. They require no specialized equipment, are safe and are non-invasive.

## Head Tilt-Chin Lift

In the absence of trauma, the preferred technique for opening the airway is the head tilt-chin lift maneuver. However for infants, the sniff position is used.

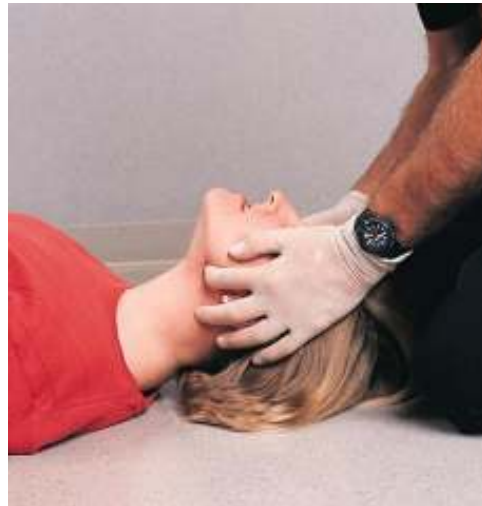


- The patient should be supine.
- Place one hand on the patient's forehead and tilt the head back by applying firm downward pressure with your palm.
- Use your other hand to grasp the chin.
- Lift the jaw upward to open the airway.

## Jaw Thrust (non - trauma)

A jaw thrust is also an acceptable method for protecting an airway in a patient without the risk of cervical spine injury.

- With the patient supine, kneel at the top of the patient's head.
- Place the fingertips of each hand on the angles of the patient's lower jaw.
- Firmly displace the jaw upward, while gently tilting the patient's head backward.



## Modified Jaw Thrust (trauma)



This method is used for patients who have potentially suffered a head or neck injury. This maneuver is performed in the same manner as the Jaw Thrust except that the head should be held firmly without tilting backward or allowing lateral movement. The modified jaw thrust can be used with a cervical collar in place.

## ***Basic Airway Management***

In the absence of trauma, secretions, foreign bodies and edema, basic manual airway maneuvers should clear the tongue from the air passages. However, the tongue often falls back to block the airway again. Both the oropharyngeal (OPA) and nasopharyngeal (NPA) airways are designed to lift the base of the tongue forward and away from the posterior oropharynx. With either airway adjunct in place, the proper head position is still important. These mechanical devices only assist with maintaining an open airway. The manual methods should still be employed prior to the use of these devices.

### **Oropharyngeal Airway**



An oropharyngeal airway should not be used in conscious or semi conscious patients who have a gag reflex, as its insertion may induce vomiting or laryngospasm. Selecting the proper size is important. The correct size is best obtained by measuring. A properly sized airway will extend from the corner of the patient's mouth to the tip of the earlobe.

#### **Advantages:**

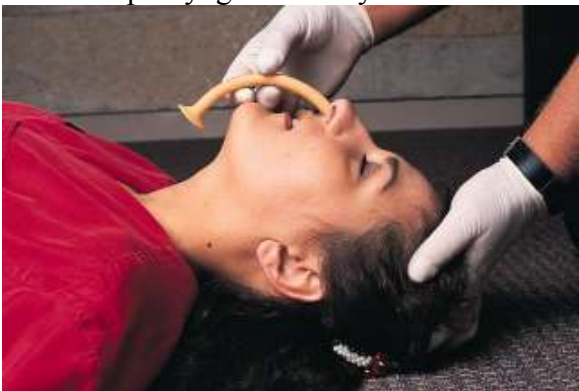
- It allows air to pass through and around the device.
- It helps to prevent obstruction by the teeth and lips.
- It allows for easier suctioning of the pharynx.
- It serves as an effective bite block in the case of seizures or to protect the endotracheal tube.

#### **Disadvantages:**

- It does not isolate the trachea.
- It cannot be inserted when the teeth are clenched.
- It may obstruct the airway if it is improperly inserted.
- It can be easily dislodged.

### **Nasopharyngeal Airway**

The nasopharyngeal airway should not be used in patients who are predisposed to nosebleeds or who have a nasal obstruction. It should also never be used in the presence of a suspected basilar skull fracture, as the tube can inadvertently pass into the brain. It is important to lubricate the exterior of the tube to prevent trauma



during insertion. Forceful insertion of a nasopharyngeal airway may injure internal structures and lead to considerable bleeding. A properly sized nasopharyngeal airway will be slightly smaller than the size of the patient's largest nostril and will be measured for length from the corner of the patient's nose next to the cheek to the tip of the patient's earlobe.

**Advantages:**

- It can be rapidly inserted.
- It bypasses the tongue.
- It can be used in the presence of a gag reflex.
- It can be used if the patient has suffered injury to the oral cavity.
- It can be used on a patient with clenched teeth.

**Disadvantages:**

- It does not isolate the trachea.
- It is difficult to suction through.
- It may cause nosebleeds if inserted too forcefully.
- It cannot be used in a patient with a suspected basilar skull fracture.

***Advanced Airway Management***

Methods of advanced airway management currently used in Manitoba are the Esophageal Tracheal CombiTube (ETC) and the Endotracheal Tube (ETT). Although the endotracheal tube is the preferred method of advanced airway management, the CombiTube can be useful in situations such as repeated unsuccessful attempts at endotracheal tube intubation or access to the patient's head is inhibited due to entrapment.

**CombiTube**

The CombiTube airway is a two-tube system with their lumens separated by a partial wall. The distal end of the tube has a cuff for occluding the structure into which it is placed (esophagus or trachea). Proximally, there is a balloon that occludes the pharynx. This airway is inserted blindly, (with the head and neck in the neutral position) entering either the esophagus or the trachea. Ventilation can be accomplished through either the esophageal or tracheal lumen. The majority of times, the tube will enter the esophagus. In this case, ventilation is initiated through the longer (blue) connector,



which leads to the esophageal lumen. The distal end of this tube is closed, preventing the escape of air into the esophagus. Escape of air through the mouth is prevented through inflation of the pharyngeal balloon.

Auscultation of bilateral breath sounds, and the absence of gastric sounds, confirms placement in the esophagus. However, if you hear gastric sounds instead of breath sounds, the device is in the trachea. In this case, ventilation should be performed through the shorter (clear) connector without changing the position of the tube. Air is now directed into the tracheal lumen and the device functions like an endotracheal tube.

**Indications:**

Unconscious patient, with no gag reflex, requiring assisted ventilation

**Contraindications:**

Patient height less than 48 inches/125 cm.

Conscious patient

Patient with intact gag reflex

Patient with known esophageal disease

Known or suspected ingestion of a caustic substance

**Advantages:**

It may be inserted without spinal extension

It does not require visualization of the larynx

The airway is anchored behind the hard palate because of the pharyngeal balloon

The patient may be ventilated regardless of tube placement (esophageal or tracheal)

The pharyngeal balloon can prevent aspiration of teeth and vomitus

**Disadvantages:**

Suction of tracheal secretions is impossible when the airway is in the esophageal position.

Placement of an endotracheal tube is difficult with the CombiTube in place.

It cannot be used on patients with a gag reflex.

If the patient becomes conscious or regains a gag reflex, removing the CombiTube will become necessary. To remove the tube, the patient should have the oropharynx suctioned; roll the patient onto their side if no contraindications. The cuffs should then be deflated and the tube removed.

## **Endotracheal Intubation**

Endotracheal intubation is the procedure where a tube is placed in the trachea for the purpose of securing a patent airway. This is the preferred method of intubation as it is the only procedure that effectively isolates the trachea. The equipment and supplies necessary for endotracheal intubation include:

### **Laryngoscope**

The laryngoscope is an instrument for lifting the tongue and epiglottis out of the way so that the vocal cords can be visualized.

### **Appropriate size ETT**

The endotracheal tube is a flexible, translucent tube approximately 35 to 37 cm long and open at both ends. The proximal end is a standard size that attaches to a bag-valve-mask. The distal end has an inflatable cuff that is used to seal the trachea. The size of a tube reflects the internal diameter (i.d.) in millimetres. The typical size for adult males is 7.5 to 8.5 i.d. and 7.0 to 8.0 i.d. for females.



### **10cc syringe**

The syringe is used to inflate the cuff with air.

### **Stylet**

The stylet is made of a malleable metal and is coated in plastic. It is inserted inside the ETT to allow the tube to be shaped into the desired curve.

### **Lubricant**

Water-soluble lubricants help facilitate the tube's insertion.

Means to secure tube placement

During the process of moving a patient the tube can be easily dislodged or the tube may accidentally be pushed down into either mainstem bronchi. Tying down the device prevents accidental displacement or movement of the tube.

### **Magill forceps**

Magill forceps are scissor-style clamps with circular shaped tips. They are used to remove foreign materials.

### **Additional Equipment**

A suction device, a bag-valve-mask (BVM) and a bite block (OPA) should also be close at hand.

### **Indications:**

Respiratory or cardiac arrest.

Unconscious without a gag reflex.

Decreased minute volume, due to decreased respiratory rate or volume.

Possible airway obstruction due to foreign bodies, trauma or anaphylaxis.

### **Contraindication:**

ETT intubation should not be used on a patient with suspected epiglottitis.

**Advantages:**

- It isolates the trachea and permits complete control of the airway.
- It prevents gastric distension by channelling air directly into the trachea.
- It eliminates the need to maintain a mask seal.
- It offers a direct route for suctioning of the respiratory passages.
- It allows for aspiration of medications (Atropine, Ventolin, Epinephrine, Lidocaine).

**Disadvantages:**

- It requires considerable training and experience.
- It requires specialized equipment, the retrieval of which can slow efforts to secure the airway.
- It demands direct visualization of the vocal cords therefore the requirement of enough room to access the head.

**Verification of Proper Endotracheal Tube Placement.**

Correct placement of the endotracheal tube should be routinely checked and rechecked. There are many ways to confirm proper placement of the tube. Any may be used to verify proper tube placement. Remember, however, that it is important to consider the entire patient and all the parameters when evaluating for proper tube placement. Do not become over-reliant on technology.

**Visual confirmation**

The best confirmation is to visualize the tube passing through the vocal cords by use of a laryngoscope. If visualization is maintained throughout the intubation, there is little chance of inadvertent esophageal intubation.

**Observation of Chest Rise**

Following tube placement, watch to be sure that the patient's chest rises with ventilations.

**Auscultation of breath sounds**

After tube placement, breath sounds should be auscultated over both sides of the chest and epigastrium. Air entry should only be heard in both sides of the chest and not over the epigastrium.

**End tidal CO<sub>2</sub> detectors**

There are a number of commercially available devices, which detect expired carbon dioxide. The air expired from the lungs contains carbon dioxide. Adequate levels of exhaled CO<sub>2</sub> as detected by the end tidal CO<sub>2</sub> detector, further confirm proper endotracheal tube placement.

**Condensation in the endotracheal tube**

Exhaled air approaches 100% humidity. Usually, the ambient relative humidity is less than 100%. Thus when condensation forms on the inside of the endotracheal tube, this suggests proper tube placement.

## **Complications:**

### ***Hypoxia***

Delays in oxygenation, either from interruption of basic airway techniques and BVM ventilation with 100% oxygen or from performing prolonged intubation attempts, can produce profound hypoxia. One basic rule that helps to avoid hypoxia during intubation is to limit each intubation attempt to no more than 20 seconds before re-oxygenating the patient

### ***Esophageal intubation***

Misplacement of the endotracheal tube in the esophagus deprives the patient of oxygenation and ventilation. It is potentially lethal, resulting in severe hypoxia and brain death if you do not recognize it immediately. Esophageal intubation directs air into the stomach, encouraging vomiting, which can lead to aspiration.

### ***Endobronchial Intubation***

Endobronchial intubation is when the tube is placed too deeply. In this situation, the tube could be resting up against the carina. Placement here would produce decreased air entry on auscultation in all fields. Ventilation with the BVM could also feel more difficult. The tube may be in either mainstem bronchus. Placement of the tube in a bronchus would produce decreased to no air entry audible on the opposite side to which the tube is placed. Either scenario could lead to hypoxia as well.

## **Sellick** Maneuver

Vomiting occurs frequently during ventilatory support and intubation efforts. Vomitus that enters the airway can be a severe complication. To help prevent this from occurring, a simple procedure can be employed that is referred to as the Sellick Maneuver. In this procedure, slight pressure, directed posteriorly, is applied over the cricoid cartilage. Since the esophagus lies just behind the cricoid, this exertion against the cartilage at the front will close off the esophagus.

## **Surgical Airway Management**

A surgical airway, although rarely used, can be life saving when applied. It involves placement of a catheter through the skin into the trachea. This method is used in patients where there is an airway obstruction that cannot be corrected or managed by other means.

## **Needle Cricothyrotomy**

Cricothyrotomy means making a puncture in the cricoid membrane and creating an airway tube. Cricothyrotomy allows rapid entrance to a patient's airway for temporary ventilation and oxygenation. A large gauge catheter, typically a 14 gauge, is desirable for adult use. Once the catheter has passed through the cricoid membrane into the trachea, using a tracheal jet insufflator adaptor can then ventilate the patient.

Transtacheal jet insufflation uses high-pressure jet ventilation to force oxygen through the small diameter catheter and provide adequate ventilation and oxygenation. Because very high pressures are used to supply adequate O<sub>2</sub>, *barotrauma*, including pneumothorax, is a potential complication.

## **Complications:**

- Barotrauma from over inflation.
- Excessive bleeding due to improper catheter placement.
- Subcutaneous emphysema from improper placement.
- Hypoventilation from improper use.



## **Mechanical Ventilation**

In the pre-hospital setting, it is the responsibility of the paramedic to determine which patients require endotracheal intubation (ETI) and mechanical ventilation (MV). There are several groups to consider:

The first group consists of those patients who require airway protection but have an adequate ventilatory drive, such as the patient who has suffered acute upper airway trauma. The second group is made up of those patients requiring overdrive ventilatory support, such as the head trauma patient who needs hyperventilation to decrease intracranial pressure. ( routine hyperventilation not indicated for head injured patients)

By far, the vast majority of patients who will require intubation are those with impending respiratory failure. In fact, 66% of all patients in ICU that require mechanical ventilation are admitted due to acute respiratory failure. This group includes patients suffering from: heart failure, pneumonia, sepsis, complications from surgery and trauma. An additional 13% of mechanically ventilated patients are admitted due to exacerbation of COPD. Acute respiratory failure can be defined by two out of the following four criteria: acute dyspnea, room air PaO<sub>2</sub> < 50 mm Hg, PaCO<sub>2</sub> > 50 mm Hg, and respiratory acidemia.

It is the general consensus to treat the patient and the underlying problem and not the blood gas values. Paramedics do not have the luxury of these values in the pre-hospital setting. Paramedics can use pulse oximetry, end-tidal CO<sub>2</sub> readings, and patient assessment to provide sufficient support for the decision to intubate. The paramedic must also give consideration to non-invasive ventilatory support in the form of bag-valve devices that provide positive pressure ventilation (PPV) to avoid ICU admission and offer the receiving emergency room physician the non-invasive ventilatory support (NIVS) options of CPAP or BiPAP upon arrival to their department. The paramedic must also consider the risks of PPV to their patients. These include: increased mean intrathoracic pressure, decreased venous return to the heart and decreased cardiac output, air trapping and intrinsic PEEP (auto-PEEP), barotraumas and respiratory alkalosis.

## **Non-Invasive Ventilatory Support (NIVS)**

Both continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP) involve placing a tight-fitting mask over the patient's face and delivering breaths by positive pressure. CPAP delivers a continuous amount of positive airway pressure during and after inspiration and expiration. BiPAP not only provides a set positive pressure during exhalation, but also delivers a set inspiratory pressure when the patient initiates a breath. The inspiratory pressure is always set higher than the expiratory pressure, can be sustained for various periods of time, and stops when the patient ceases to inhale or begins to exhale.

NIVS has shown to be useful in patients with pulmonary edema, pneumonia, asthma, and COPD. This may prevent the difficult process of weaning patients off mechanical ventilators and reduce ICU admissions.

### **Invasive Ventilatory Support (IVS)**

There are several types of mechanical ventilators available, including portable transport ventilators, which accompany the patient from one facility to another. Regardless of the model, all ventilators share a common goal. They deliver positive pressure to the airway and provide mechanical assistance based on the patient's respiratory effort.

The objectives of mechanical ventilation are primarily to: decrease the work of breathing and reverse life threatening hypoxemia or acute respiratory acidosis.

Beyond these factors, newer mechanical ventilators are designed to: enhance respiratory muscle rest, prevent deconditioning, improve gas exchange, prevent lung damage, enhance co-ordination between ventilatory assistance and patients' respiratory efforts, and foster lung healing.

## ***Mechanical Ventilation Concepts and Settings***

<b>Concept</b>	<b>Definition</b>
<b>Tidal Volume (Vt)</b>	The volume inspired or expired during a normal breath. During mechanical ventilation, tidal volume is calculated as 5 to 15 ml/kg.
<b>Inspiratory Time (Ti)</b>	The time from the beginning of inspiratory flow until the beginning of expiratory flow. During mechanical ventilation of adults, Ti is 1 to 2 seconds. In infants Ti is 0.5 to 1 second.
<b>Expiratory Time (Te)</b>	The time from the start of expiratory flow to the start of inspiratory flow.
<b>Inspiratory Flow (Vi)</b>	The flow of gas measured at the airway opening during inspiration. Normal inspiratory flow during mechanical ventilation is 60 to 100 L/minute.
<b>Respiratory Frequency</b>	Breathing cycles or breaths per minute delivered by the ventilator.
<b>I:E ratio</b>	The ratio of inspiratory time to expiratory time. Normal I:E ratio is 1:3. During mechanical ventilation I:E should be 1:2 or greater to prevent air trapping.
<b>Positive end expiratory Pressure (PEEP)</b>	Positive pressure applied during the expiratory phase following delivery of a mandatory breath or spontaneous breath.
<b>Auto-PEEP</b>	Develops when a positive-pressure breath is delivered before complete exhalation of the previous breath. As a result, air becomes trapped and pressure within the lungs becomes trapped potentially leading to complications such as decreased cardiac output, hypotension, barotrauma, and pneumothorax.
<b>Peak Inspiratory Pressure (PIP)</b>	The highest proximal airway pressure produced in the patient circuit during the inspiratory phase. The stiffer the patient's lungs, the greater the PIP.
<b>Control Variable</b>	Which variable the ventilator will control. Ventilators normally control either flow (tidal volume) or pressure (peak pressure).
<b>Trigger Variable</b>	The initiation of a breath is known as a trigger. Breaths can be triggered by the ventilator (time triggered) or by the patient (pressure triggered).
<b>Oxygen conc. (FIO2)</b>	Fraction of inspired oxygen delivered to patient, may be set between 21% and 100%; usually adjusted to maintain PaO2 level greater than 60 mm Hg or SaO2 level greater than 90%.
<b>Inverse ratio (IRV)</b>	Proportion of inspiratory to expiratory time is greater than 1:1; can be initiated using pressure-controlled breaths (PC-IRV) or volume-controlled breaths (VC-IRV).

## **Ventilator Modes**

The main modes of ventilation are controlled mechanical ventilation (CMV), assist control (AC), intermittent mandatory ventilation (IMV), and synchronized intermittent mandatory ventilation (SIMV). In the CMV mode, the ventilator delivers a certain volume or pressure at a preset rate, regardless of any ventilatory effort by the patient. AC is similar to CMV in that the tidal volume or inspiratory pressure and minimum respiratory rate are set. It differs from CMV by allowing patients to trigger the ventilator over a set minimum respiratory rate. IMV allows the patient to breathe spontaneously without having a preset tidal volume or pressure. In addition, a set rate similar to CMV mode is in place. This allows the patient to breathe spontaneously while still ensuring a set respiratory rate and tidal volume. SIMV differs from IMV in that the ventilator senses the patient's spontaneous respirations and does not deliver a breath if the patient has already triggered the ventilator. This prevents stacking of respirations, which can be a component of the IMV mode.

## **Complications of Mechanical Ventilation**

The most common complication of mechanical ventilation is barotraumas. High pressures lead to rupture of the alveolar wall, which can lead to pneumothorax, and subcutaneous emphysema. Other complications include: increased intracranial pressure, fluid retention, renal failure, local trauma to nose and mouth, and pneumonia.

## **Transport Ventilators**

New compact mechanical ventilators are now available for pre-hospital and inter-facility use. They have proven superior to bag-valve devices in maintaining minute volume. In cases of cardiac arrest, the automatic ventilator allows for chest compressions interposed between mechanical breaths.

The compact ventilator typically comes with two controls: one for the ventilatory rate and the other for tidal volume. Some of these automatic units deliver controlled ventilation only. Others function as IMV's, reverting to CMV's in patients who are not breathing. Most units provide an adjustable tidal volume, while ventilatory rate and oxygen concentration (100%) are fixed or may be adjustable.

The disadvantage of using a mechanical ventilator during transport is that the nurse, respiratory therapist, or paramedic loses the ability to evaluate the patient's lung compliance. Some ventilators may have limited alarms, and if the patient should develop such complications as a pneumothorax, displaced ET tube, or obstruction, it may not be easily recognized until the patient is in severe distress.

## **Respiratory Complications**

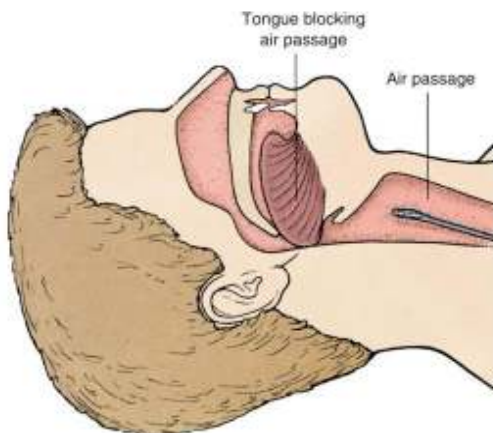
Respiratory emergencies may result from problems in the upper or lower airway, impairment of the respiratory muscles, or a problem with respiratory control centers in the brain.

### ***Airway Obstruction***

Airway obstruction can be either “partial” or “complete”. Partial obstruction allows for either adequate or poor air exchange. With adequate air exchange, the patient can cough effectively. Therefore the treatment for a partial airway obstruction in an adult with good air exchange, is simply to encourage the patient to cough. Patients suffering poor exchange can no longer generate an effective cough. They often emit a high-pitched noise while inhaling and may have increased breathing difficulty and cyanosis. Complete obstruction exists when airflow is not felt or heard from the nose and mouth, or when the patient cannot speak, breathe or cough. A patient with complete airway obstruction will quickly become unconscious and death will occur if the obstruction is not relieved. In the absence of breathing, complete airway obstruction can be recognized by the difficulty encountered when trying to ventilate the patient.

### **Tongue**

The tongue is the most common cause of airway obstruction. In the absence of sufficient muscle tone, the relaxed tongue falls back against the rear of the pharynx, thus occluding the airway. The epiglottis may also block the airway at the level of the larynx. If the tongue and epiglottis are in this position, airflow into the respiratory system is at least diminished, and breathing efforts may inadvertently suck the base of the tongue into an obstructing position. Airway blockage by the base of the tongue depends on the position of the head and jaw. It can occur regardless of whether the patient is in a lateral, supine or prone position.



The most common cause of airway obstruction is the patient's tongue, which can fall back into the throat when the muscles of the throat and tongue relax.

### **Foreign Body**

Large, poorly chewed pieces of food can obstruct the upper airway by becoming lodged in the laryngopharynx. (Alcohol consumption and dentures are often involved in these cases.) This often occurs in restaurants and is frequently mistaken for a heart attack. For this reason, it is commonly referred to as a “café coronary”. The patient may clutch the throat with one or both hands, a universal distress signal for choking. Children, especially toddlers, often aspirate foreign objects, as they have the tendency to put objects into their mouths.

### **Trauma**

In trauma, particularly when the patient is unconscious, the airway may be obstructed by loose teeth, facial bone fractures, tissue, and clotted blood. Blood contains many components-proteins, fibrin, water, and electrolytes-that may clog the alveoli, bronchioles and bronchi if allowed to enter the lungs in large amounts. Additionally, penetrating or blunt trauma may obstruct the airway by fracturing or displacing the larynx, allowing the vocal cords to collapse into the tracheal lumen.

### **Laryngeal Spasm**

Also called, Laryngospasm- is a term to define the reflex closure of tissue in and around the glottis. Since the glottis is the narrowest part of an adult’s airway, edema or spasm of the vocal cords is potentially lethal. Even moderate edema can severely obstruct airflow and result in asphyxia. Just beneath the mucous membrane that covers the vocal cords is a layer of loose tissue where blood or other fluids can accumulate. This tissue may swell following injury and the swelling will be slow to subside. Laryngospasm can be the result of any condition (infection, injury, aspiration, inhalation of super-heated air, smoke, or toxic substances, anaphylaxis and epiglottitis) that irritates the laryngeal mucosa, or be provoked by unsuccessful intubation attempts.

### **Aspiration**

In adults, dentures, teeth, and vomitus are likely to obstruct the airway. Vomitus is made up of food particles, protein-dissolving enzymes, and hydrochloric acid that have been regurgitated from the stomach into the oropharynx. This mixture, if allowed to enter the lungs, can result in increased interstitial fluid and pulmonary edema, and can severely damage the alveoli. Gas exchange can be seriously impaired by the marked increase in alveolar/capillary distance, thus causing hypoxemia, and hypercarbia. These complications occur in 50-80% of the patients who aspirate foreign matter, but they can usually be avoided by proper airway management and suction.

### ***Inadequate Ventilation***

As stated earlier, the adequate intake of oxygen and removal of carbon dioxide depends on sufficient minute volume respirations. A reduction of either the rate or the volume of inhalation leads to a reduction in minute volumes. In some cases, the respiratory rate may be rapid but so shallow that little air exchange takes place. This state of decreased ventilation may be brought on by depressed respiratory function, fractured ribs, a drug overdose, spinal injury, or head injury. It can lead to hypercarbia or hypoxia.

## **Pharmacology**

Below is a list of medications commonly used in the pre-hospital setting for the treatment of airway emergencies:

### **Oxygen**

**Class:** Gas

**Description:** Oxygen is a colorless, odourless, tasteless gas necessary for life.

**Mechanism of Action:** Oxygen enters the body through the respiratory system and is transported by hemoglobin found in the red blood cells. The administration of supplemental oxygen increases the oxygen concentration in the alveoli, which increases the oxygen saturation of available hemoglobin.

**Indications:** Hypoxia- lack of oxygen caused by any medical or traumatic emergency such as: cardiac (ischemic) chest pain, or any respiratory problem. Oxygen is used for every critical patient.

**Contraindications:** There are no contraindications for oxygen.

**Precautions:** Patients with Chronic Obstructive Pulmonary Disease (COPD) may suffer respiratory depression if high concentrations of oxygen are delivered. Whenever possible, oxygen administration should be monitored by a pulse oximeter. This is a non-invasive device that measures the oxygen saturation of hemoglobin (usually attached to a finger).

**Side Effects:** Prolonged use of non-humidified oxygen may cause drying of mucous membranes.

**Interactions:** Oxygen may increase the toxicity of certain uncommon herbicides if ingested by a patient. This is a very rare occurrence.

**Dosage:** The dosage of oxygen is determined by the underlying problem of the patient. In the pre-hospital setting, oxygen should be administered at the highest setting if hypoxia is suspected.

## ***Epinephrine 1:1000***

**Class:** Sympathetic agonist.

**Description:** Epinephrine is a naturally occurring catecholamine that affects both alpha and beta adrenergic receptors, but its beta effects are more profound.

**Mechanism of Action:** Some of the effects of epinephrine include: increased heart rate, increased cardiac contractile force, increased cardiac electrical activity, vasoconstriction, increased blood pressure, and increased automaticity.

**Indications:** Many cardiac applications, as well as severe allergic reactions (anaphylaxis) and severe asthma.

**Contraindications:** A different dilution is required for cardiac arrest emergencies.

**Precautions:** Epinephrine should be protected from the light.

**Side Effects:** Palpitations, anxiety, tremors, headache, dizziness, nausea and vomiting can occur with epinephrine administration. Because epinephrine affects both heart rate and contractility, it causes increased myocardial oxygen demand. Therefore, oxygen should be administered in conjunction with epinephrine.

**Interactions:** The effects of epinephrine can be intensified in patients taking anti-depressants.

**Dosage:** Based on the age of the patient, epinephrine 1:1000 should be administered subcutaneously or I.M. between 0.15-0.3 mg every 15 minutes as required for anaphylaxis.

## ***Lidocaine Spray***

**Class:** Topical Anesthetic.

**Description:** Non-aerosol spray applied in metered-dose form to be used for conscious orotracheal intubation.

**Mechanism of Action:** When applied topically to the oral cavity, it acts on mucous membranes to produce local anesthesia. This occurs within 1-5 minutes, and persists for 10-15 minutes.

**Indications:** Topical anesthetic for procedures in the respiratory tract, including orotracheal and nasotracheal intubation.

**Contraindications:** Patients with a known hypersensitivity to the drug.

**Precautions:** Care must be used with patients having traumatized mucosa as this may increase the rate of absorption.

**Side Effects:** Central nervous system (CNS) side effects may include light headedness, confusion, dizziness, blurred vision, nausea, vomiting, seizures and drowsiness which may be an early indicator of toxicity. Cardiovascular side effects include: impaired cardiac conduction, bradycardias.

**Interactions:** May have additive effects in conjunction with other local anaesthetics.

**Dosage:** 12 mg per metered dose (10 mg lidocaine base). The recommended dose for intubation is between 50-400 mg in adults, 4-5 mg/kg in children.

## ***Ventolin (Salbutamol)***

**Class:** Sympathetic agonist.

**Description:** Sympathomimetic that is selective for beta 2 adrenergic receptors.

**Mechanism of Action:** Causes prompt bronchodilation with duration of approximately 5 hours.

**Indications:** Bronchial asthma, reversible bronchospasm associated with chronic bronchitis and emphysema.

**Contraindications:** Hypersensitivity to ventolin.

**Precautions:** Monitor vital signs. Use caution with patients having hypertension or cardiovascular disease. Lung sounds should be auscultated before and after ventolin treatments.

**Side-Effects:** Palpitations, anxiety, dizziness, headache, skeletal muscle tremors, hypertension, nausea, vomiting.

**Interactions:** Beta blockers may blunt the effects of ventolin.

**Dosage:** Metered-dose inhaler 90 mcg, nebulized 2.5 mg in 2.5 ml solvent.

## ***Atrovent (Ipratropium)***

**Class:** Anticholinergic.

**Description:** Parasympatholytic bronchodilator related to atropine.

**Mechanism of Action:** Causes bronchodilation and dries respiratory tract secretions. Atrovent blocks acetylcholine receptors, thus inhibiting parasympathetic stimulation.

**Indications:** Bronchial asthma, reversible bronchospasm associated with chronic bronchitis and emphysema.

**Contraindications:** Not indicated where rapid response is required.

**Precautions:** Monitor vital signs, auscultate air entry before and after drug administration, and use caution in patients with hypertension and cardiovascular disease.

**Side Effects:** Palpitations, anxiety, dizziness, headache, nausea and/or vomiting.

**Interactions:** Few.

**Dosage:** Generally nebulizer dose is 500 mcg, also available in metered-dose inhaler (20 mcg).

## **Glossary of Terms**

**Auscultation:** the act of listening to body sounds.

**Barotrauma:** injury caused by pressure.

**Catheter:** flexible, usually rubber or soft plastic, tube inserted into the body for removing or instilling fluids.

**Contraindications:** any factors prohibiting the use of a particular procedure or drug because of the likelihood of unwanted results.

**Endobroncheal:** within the bronchus.

**Endotracheal:** within the trachea.

**Epiglottitis:** inflammation of the epiglottis which produces narrowing of the airway.

**Esophageal varices:** an abnormal condition in which the veins of the esophagus are swollen.

**Gastric distension:** the stomach being in an enlarged or stretched out state.

**Hypoventilation:** the process by which the movement of gases in and out of the lungs is insufficient.

**Hypoxia:** inadequate amounts of oxygen in the blood.

**Laryngospasm:** closure of the larynx that blocks the passage of air into the lungs.

**Lateral:** to a side, away from the centre.

**Lumen:** the cavity or channel within a tube.

**Non-invasive:** a diagnostic or therapeutic technique that does not involve puncturing the skin or entering the body or an organ.

**Patent:** open, as a tube or a passageway.

**Posterior oropharynx:** the back of the mouth.

**Proximally:** closer to the point of reference.

**Subcutaneous emphysema:** air beneath the skin.

## **References**

“An Alternative Route to Maintenance of Licensure”, Manitoba Health Emergency Services, Revised March 14, 2001

Brady First Responder Workbook, Fifth Edition, Keith J. Karren, Brent Q. Hafen, Daniel Limmer, Prentice Hall, Inc., 1998

Critical Care Nursing, Diagnosis and Management, edition not available at present.

Basic Patient Care Protocols and Procedures, City of Winnipeg, Fire Paramedic Service, Level I, II, and III

EMT Prehospital Care, Henry Stapleton, W.B. Saunders, 1992

Mosby’s EMT-Intermediate Textbook, Workbook, Bruce Shade, EMT-P, Mosby Lifeline, 1997

National Occupational Competency Profiles and Curriculum Blueprints, June 29, 2001, Paramedic Association of Canada

Paramedic Emergency Care, Third Edition, Brady, Prentice Hall Inc., 1997

The New England Journal of Medicine, Volume 344, Number 26, June 28, 2001, “Advances in Mechanical Ventilation”, Martin J. Tobin, M.D.

Rosen’s Emergency Medicine, Volume 344, Number 26, June 28, 2001, “Advances in Mechanical Ventilation”, Martin J. Tobin, M.D.

The Practice of Prehospital Nursing, edition unavailable at present time.