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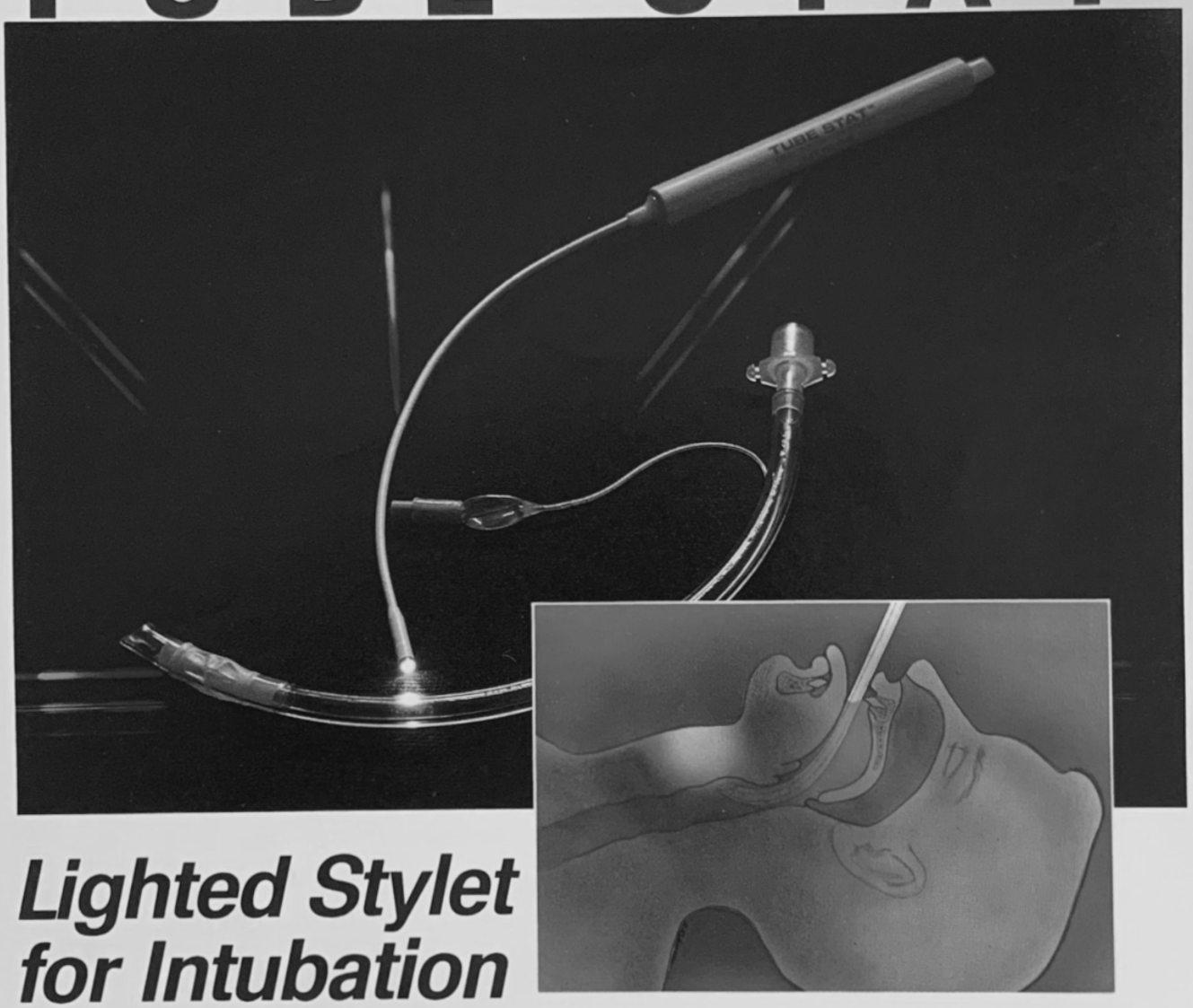

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Tampa Bay EMS Journal

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Clinical Anatomy and Physiology of Ventilation

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The respiratory system plays two major roles in the body, for the introduction of oxygen and the removal of carbon dioxide. This paper will give an overview of respiratory anatomy and physiology, with an emphasis on information clinically relevant to acute airway control and ventilatory support.

CLINICAL ANATOMY OF THE AIRWAY

Air enters the body through the nares and mouth. Through the nares, air passes into the nasal cavity, which is separated vertically into right and left halves by the nasal septum. In each nasal cavity, there are shelf-like bony projections called turbinates. They add surface area to the mucous membranes that line the airway and create turbulence in the airflow entering the nose. The mucous membranes are covered with tiny hairs, called cilia, which slowly and continuously move a blanket of mucous from the lower airway up to the nares and mouth. As air is inhaled, it impacts the various mucous membrane covered surfaces of the airway. This allows dirt, germs and other foreign materials to be trapped in the mucous blanket and expelled. The large surface area of the upper and lower airways readily exchange heat and moisture with the inspired air. By the time air reaches the alveoli, the air is at body temperature, 100% humidified, and is essentially sterile.

After air passes through the nasal cavity, it enters a somewhat vertical chamber called the pharynx, which extends from the back of the nasal cavities down to the larynx. The upper part of the pharynx that joins the nasal cavities is called the nasopharynx. The section which joins the oral cavity is the oropharynx. The lower section extending down towards the larynx is the hypopharynx (Figure 1).

The anatomy of the hypopharynx is important in consideration of esophageal and endotracheal intubation methods. Notice that the larynx and the trachea are on the midline and anterior in the neck. The esophagus and its opening in the hypopharynx are also in the midline, but posterior to the trachea and larynx. Therefore, when an esophageal airway or nasogastric tube is inserted, it should be kept toward the posterior surface of the airway. Inserting the esophageal tube and letting it slide against the posterior hypopharyngeal wall on the midline will bring it to the esophageal opening. In contrast, the endotracheal tube needs to be kept towards the anterior of the neck. However, entry of the endotracheal tube in the opening of the trachea, called the glottis, requires passage around the epiglottis. The epiglottis acts as a door to the glottis, which is closed during swallowing or gagging to prevent entry of food or foreign materials into the lower airway. If an endotracheal tube or tracheal suction catheter is inserted too anteriorly, they may lodge in the vallecula (Figure 1). If esophageal or tracheal devices stray from the midline, they can be caught on either side in the pyriform sinuses. Forceful efforts can perforate these tissues, potentially leading to serious bleeding and/or subcutaneous emphysema.

The larynx houses the vocal apparatus, with the various structures labeled in Figure 2. It is important to remember that the glottic opening between the vocal cords is the narrowest point along the upper airway. Pieces of food or foreign material that can obstruct the airway often become lodged here. Gag and other airway protection reflexes can tighten up the airway to prevent material from falling deeper. The vocal cords can tighten to close off the airway completely.

When an upper airway obstruction cannot be removed by simple means (i.e. back blows, abdominal thrusts, or laryngoscopy with forceps extraction), it may be necessary to make a surgical opening below the vocal cords to allow ventilation. This is usually performed in the field at the level of the cricothyroid membrane (Figure 1).

The cricoid cartilage is a rigid and complete ring, unlike the tracheal cartilage rings that are open on their posterior surfaces. Applying posteriorly directed pressure with the fingers on the the cricoid cartilage, the airway remains open and is displaced posteriorly. This has two advantages. It can sometimes make visualization of the vocal cords easier during laryngoscopy. It can also pinch the esophagus closed, as it becomes compressed between the cricoid cartilage and the spine. This can prevent regurgitation and prevent the entry of air into the stomach during ventilation without an endotracheal or esophageal airway adjunct (1-3).

The trachea runs from the larynx to the carina - the point where the trachea bifurcates into the right and left mainstem bronchi. The right divides off the trachea without as much angulation as does the left. Consequently, if an endotracheal tube is inserted too deep, it usually ends up in the right mainstem bronchus and only the right lung may be ventilated. Each of the mainstem bronchi divide into major bronchi that serve anatomically distinct lobes of the lung. Good technique in lung auscultation requires listening to each of these lobes.

As the bronchi in each lobe divide into smaller and smaller airways, there are lesser proportions of cartilage in their walls and more smooth muscle. Thus, bronchoconstric-

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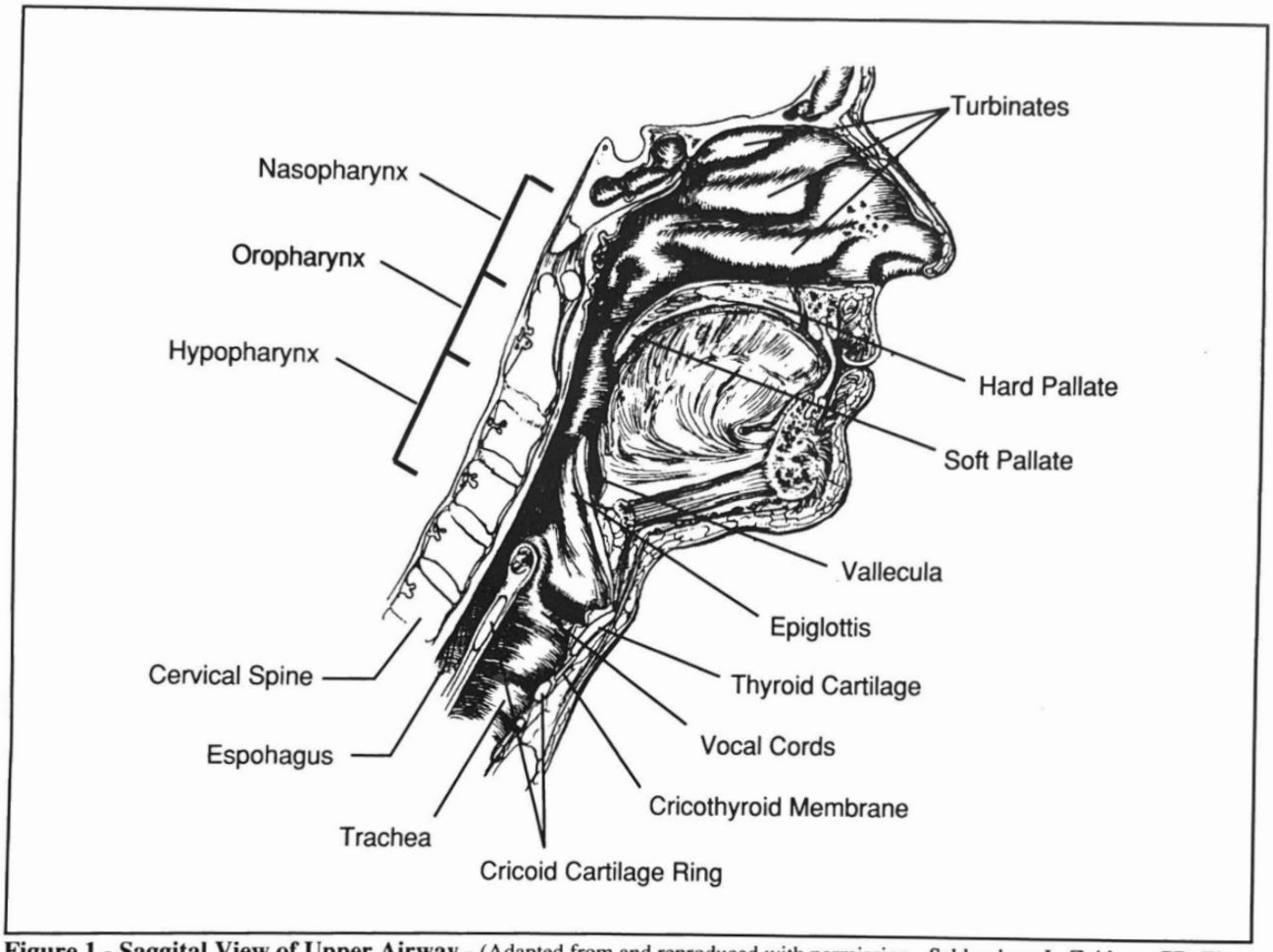

Figure 1 - Saggital View of Upper Airway - (Adapted from and reproduced with permission - Schlossberg L, Zuidema GD: *The Johns Hopkins Atlas of Human Functional Anatomy.* Johns Hopkins University Press, Baltimore 1977.)

tion has its greater effects on the smaller bronchial passages. Like the stems in a cluster of grapes, the terminal bronchiole enters a cluster of alveoli. The sac-like alveoli are thin membrane structures surrounded by a dense network of pulmonary capillaries (Figure 3). This is where the business of oxygen and carbon dioxide exchange between the air and blood takes place.

MECHANICS OF BREATHING

Inhalation

Inhalation is an active muscular process. The primary muscle of inhalation is the diaphragm. It is a dome-shaped muscle stretched across the lower end of the thorax. When the diaphragm contracts, it pulls downwards towards the abdomen. This enlarges the vertical dimensions of the chest cavity, creating a potential vacuum that can draw air into the lungs. However, the vacuum must be inside the lung, not just the chest cavity. Therefore, the outer surface of the lung must cling to the inner surface of the chest cavity, including the diaphragm. Thus, when the chest walls expand, the lungs expand with it to create the vacuum (negative pressure) that brings in the air.

The clinging of the outer surface of the lung to the inner surface of the chest cavity is facilitated by the pleural membranes. There are two pleural membranes in the chest, for the right and left sides, respectively. The point where a mainstem bronchus penetrates its respective pleural membrane is called the hilum.

Each pleural membrane covers an entire lung and then folds on itself at the hilum to line the respective hemisphere of inner chest wall. The portion of the pleural membrane that covers the lung is called the visceral pleura. The part that lines the chest wall is the parietal pleura. The parietal and visceral portions of the pleural membrane normally cling to each other because of high surface tension in the very small volume of lubricating pleural fluid between their surfaces. Thus, as the chest wall expands, so does the lung. If a wound

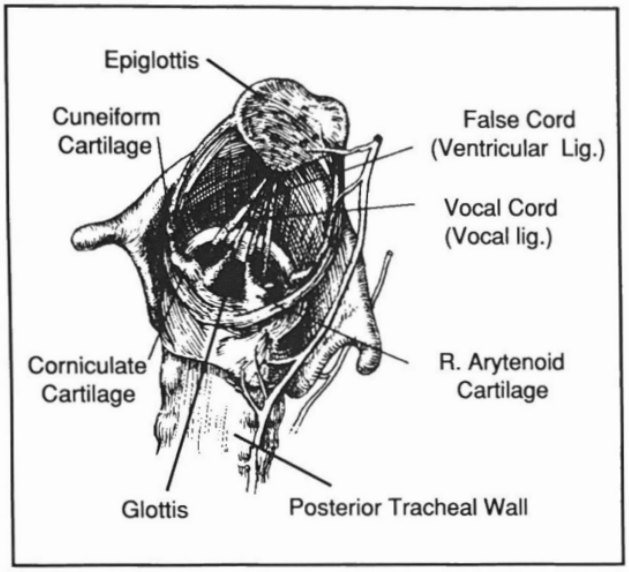

Figure 2 - Vocal Apparatus - (Adapted from and reproduced with permission - Schlossberg L, Zuidema GD: *The Johns Hopkins Atlas of Human Functional Anatomy.* Johns Hopkins University Press, Baltimore 1977.)

on the pleural membrane allows air to get in the potential space between the parietal and visceral layers, called the pleural space, this is called a pneumothorax.

Besides the vertical expansion of the chest cavity caused by the diaphragm, the chest can expand in its anterior-posterior dimension. This is facilitated by the ribs. Each pair of ribs hinge on the spine and join together anteriorly on the sternum or costal margins. This is analogous to a series of bucket handles, all joined in the middle. At rest, the ribs are angled slightly inferior. With inspiration, they swing out anteriorly and superiorly to enlarge the chest cavity. This normally occurs as a passive consequence of lung expansion pushing out against the ribs. However, with the more forceful inhalation that occurs with respiratory distress or exercise, the so-called accessory muscles of inhalation lift the ribs as an active muscular effort. The intercostal muscles can pull the ribs together, raising the angle and extending the chest wall outwards. The sternocleidomastoid muscles on the sides of the neck attach to the sternum, pulling it and the attached ribs with it up and out during its contraction. Observing effort by the intercostal muscles or the sternocleidomastoid muscles during inspiration is a helpful clinical indicator of respiratory distress.

Exhalation

Exhalation is normally a passive activity. The elastic recoil of the lung tissues and muscles of the chest wall forces out air in an amount generally equal to the preceding inhaled volume. In respiratory distress or exercise, exhalation can become an active process.

The primary muscles for exhalation are the abdominal muscles. By contracting them, the contents of the abdomen are pushed up against the diaphragm to force air from the lung. Additional effort in exhalation may be provided by intercostal muscles, separate from those used for inhalation. Just as utilization of the accessory muscles of inhalation indicates respiratory distress, so does activity with the accessory muscles of exhalation.

VENTILATORY MEASUREMENTS

Airway Resistance

When air is drawn into or out of the lungs, there is friction between the air and the walls of the airway that is referred to as airway resistance. Airway resistance depends on three factors - airway radius, airway length, and airflow velocity[1].

The airway radius, assuming a cylindrical airway, is inversely proportional to resistance. The larger the airway radius, the lesser the resistance[2]. This is why the largest possible size endotracheal tube should be used during intuba-

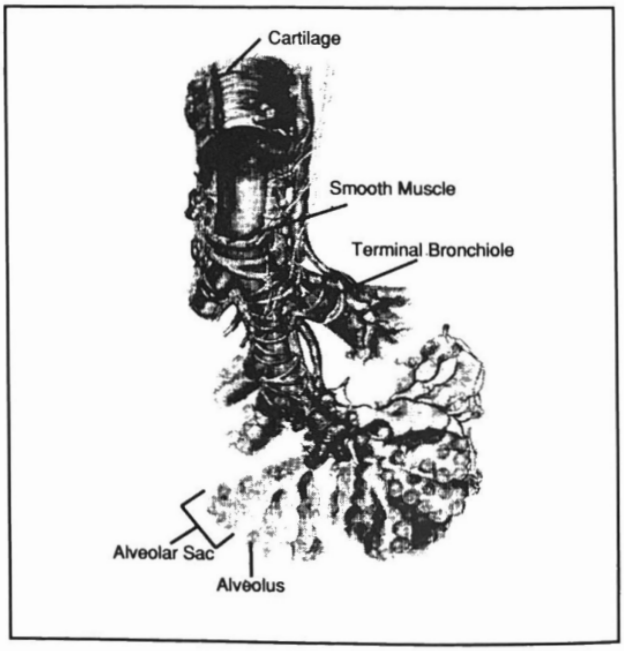

Figure 3 - Terminal Airway Structures - (Adapted from and reproduced with permission - Schlossberg L, Zuidema GD: *The Johns Hopkins Atlas of Human Functional Anatomy.* Johns Hopkins University Press, Baltimore 1977.)

1 The mathematical relationship between these factors applies not only to air, but to any gas or liquid, as shown in the following equation: Resistance =8 x viscosity x length/(π x radius^4).

2 Firefighters have an excellent appreciation for this in selection of hose sizes. Even though a 1 1/2" hose is only 1/4" smaller than a 1 3/4" hose, firefighters know the 1 3/4" hose has much less friction loss and has a significantly greater water flow capacity (gallons per minute).

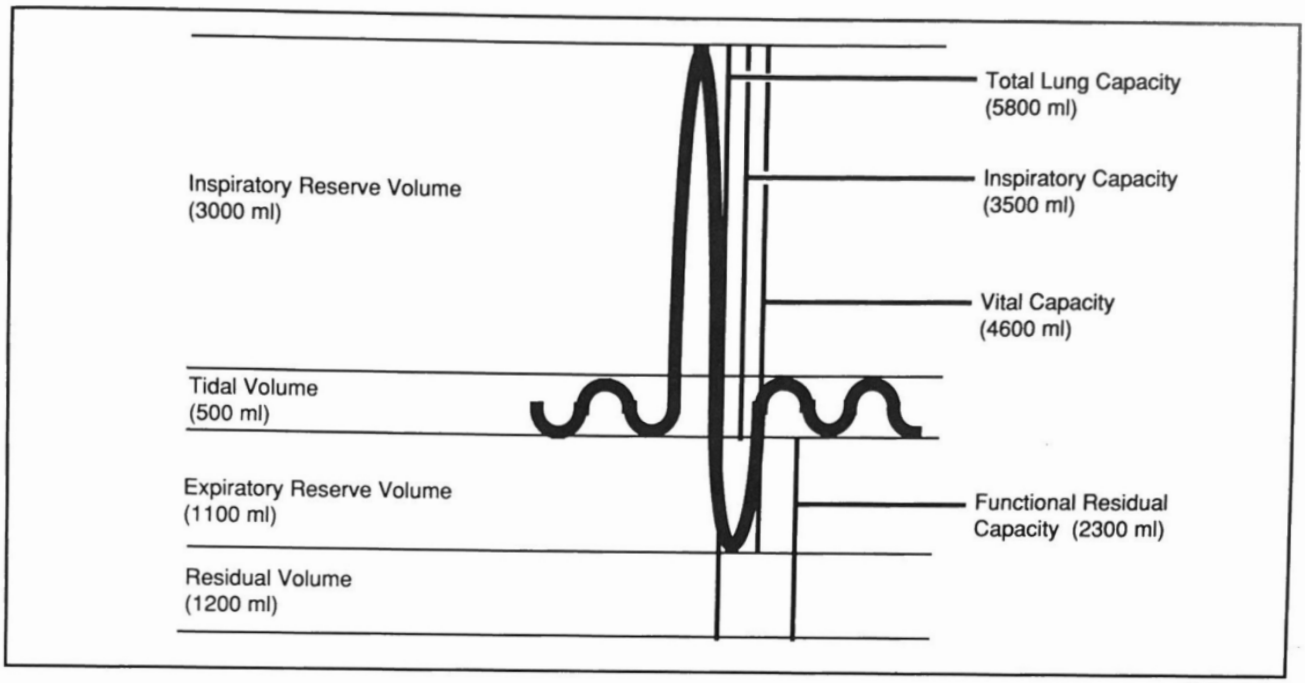

Figure 4 - Lung Volumes and Capacities - The figure shows a graphic recording of air volumes during normal breathing and maximum inspiratory effort followed by a maximum expiratory effort. These figures are for a healthy young adult male. Data taken from Guyton A: *Textbook of Medical Physiology*. 5th Ed. WB Saunders. Philadelphia, 1976. Pg 521.

tion. A smaller tube might be a bit easier to insert, but ventilation, spontaneous or artificial, will require more effort. Even though the airway is not exactly cylindrical, the concept still applies.

The length of the airway is also an important factor. Resistance is proportional to length - a longer airway has a higher resistance. However, even a short segment of airway with a small radius can act as a nozzle, dramatically increasing airway resistance. Bronchial smooth muscle spasm, bronchial swelling or accumulated secretions are frequent causes for narrowed bronchial diameter with increased airway resistance.

The speed at which air is moved in or out of the airway, the airflow velocity, is directly proportional to airway resistance. A fast breath, artificial or spontaneous, will meet more resistance than a slower breath.

Pulmonary Compliance

The lungs and chest are elastic structures. Inflation with air must also overcome this elastic resistance. The value for this total resistance, combining the resistance of the airway and elastic resistance lung and chest wall, is called compliance. Compliance is expressed as the amount of lung expansion that occurs with incremental increases in the intra-alveolar pressure. Normally, this value is 0.13 liters per centimeter of water, such that an intra-alveolar pressure increase by one centimeter of water will expand the air volume in the lungs by 130 ml (4). Decreased compliance, like airway resistance, makes spontaneous and artificial ventilation more difficult.

There are many conditions that can cause decreased compliance, such as obesity, muscle tightness (i.e. seizures) or pleurisy. A patient whose chest has restricted expansion due to a tightly bound extrication vest, tight stretcher straps, or has their chest pinned by a car or dirt in a collapsed trench, may have little or no compliance. The compliance may also be reduced when airway resistance alone increases (i.e. during airway constriction with asthma or anaphylaxsis). Changes in the lung itself can reduce compliance, such as with accumulation of interstitial and/or alveolar fluid with pulmonary edema or with COPD, by loss of overall lung elasticity.

Lung Volumes and Capacities

The total capacity of air in the lung can be divided into four basic volumes (Figure 4). The tidal volume is the amount of air passing through the airway during inhalation or exhalation. The tidal volume is approximately 500 ml in a normal young adult male at rest (Figure 4A). At the peak of normal inhalation, the lung can accommodate still more air with additional inspiratory effort (Figure 4B). That extra maximum inspired volume is the inspiratory reserve volume. It is

normally about 3000 ml. At the peak of normal expiration, an additional maximum expiratory effort (Figure 4C) can push out more air. This extra expired volume is called the expiratory reserve volume, normally about 1100 ml. There is air that must remain in the lung even after a maximum exhalation, or else the lung would collapse. This is the residual volume, normally about 1200 ml (Figure 4D).

Two or more of these ventilatory volumes may be considered together for the sake of ventilatory descriptions. These are called capacities. Adding together the expiratory reserve volume and the residual volume gives the functional residual capacity. The tidal volume and the inspiratory reserve volume equals the inspiratory capacity. Adding together the inspiratory capacity and the expiratory reserve volume gives the vital capacity. The vital capacity plus the functional residual capacity gives the total lung capacity.

Tidal and Minute Volumes

The tidal volume is an important clinical value. In normal quiet breathing for the adult, the tidal volume is about 500 ml. During emergency ventilatory support, there is physical stress with a greater rate of oxygen consumption and carbon dioxide removal. A tidal volume of 10-15 ml/kg of ideal body weight is often used as a starting point for emergency ventilation (5,6). In a 70 kg patient, this would result in a tidal volume of 700 to 1050 ml. The respiratory rate is usually set at 12 per minute. Multiplication of the tidal volume by the respiratory rate gives the minute volume. With a 15 ml/kg tidal volume and a respiratory rate of 12 per minute, the minute volume is 12,600 ml or 12.6 liters per minute. This minute volume is important to remember in the spontaneously breathing patient who has a tight-fitting oxygen mask in place. An oxygen flow less than a patient's minute volume can cause them to try to forcefully pull in more air through leaks in the mask seal or side vents, giving the patient a sensation of suffocation and dramatically increasing their respiratory work (7).

ALVEOLAR GAS EXCHANGE

Dead Space and Alveolar Ventilation

Anatomic Dead Space - Not all inspired air actually reaches the alveoli. Some inspired air remains in the airway passages leading to the alveoli - including the mouth, pharynx, trachea, bronchi and bronchioles. This air does not participate in gas exchange due to its anatomic separation from the alveoli. It is therefore called the anatomical dead space. In a normal young adult male, this is about 150 ml.

Apparatus Dead Space - Artificial airways and ventilation devices can add apparatus dead space. It is the additional volume of air that fills the adjunct(s) in addition to the anatomic dead space. Before adding apparatus dead space, the figure used for anatomical dead space may need to be reduced. An endotracheal tube bypasses all anatomic dead space from its distal tip to the mouth and nose.

Alveolar Dead Space - Not all alveolar air necessarily participates in pulmonary gas exchange. Some alveoli may have little or no blood perfusion. Some alveolar ducts may be blocked or collapsed. This is considered alveolar dead space or partial alveolar dead space for physiological reasons.

Physiological Dead Space and Alveolar Ventilation - The physiological dead space is the arithmetic sum of the anatomic, apparatus and alveolar dead space volumes. In the normal individual, the anatomic is very close to the physiological dead space. In acute emergencies, the physiological

Gas Concentrations in the Atmosphere and Airway

	Atmosphere	*Alveolar Air*	*Expired Air*
Nitrogen (N_2)	597.0 (78.62%)	569.0 (74.9%)	566.0 (74.5%)
Oxygen (O2)	159.0 (20.84%)	104.0 (13.6%)	120.0 (15.7%)
Carbon Dioxide (CO2)	0.3 (0.04%)	40.0 (5.3%)	27.0 (3.6%)
Water Vapor (H2O)	3.7 (0.50%)	47.0 (6.2%)	47.0 (6.2%)
Total	760.0 (100%)	760.0 (100%)	760.0 (100%)

Figure 5 - Gas Concentrations on a Typical Cool Clear Day - Data taken from Guyton A: *Textbook of Medical Physiology*. 5th Ed. WB Saunders. Philadelphia, 1976. Pg 535.

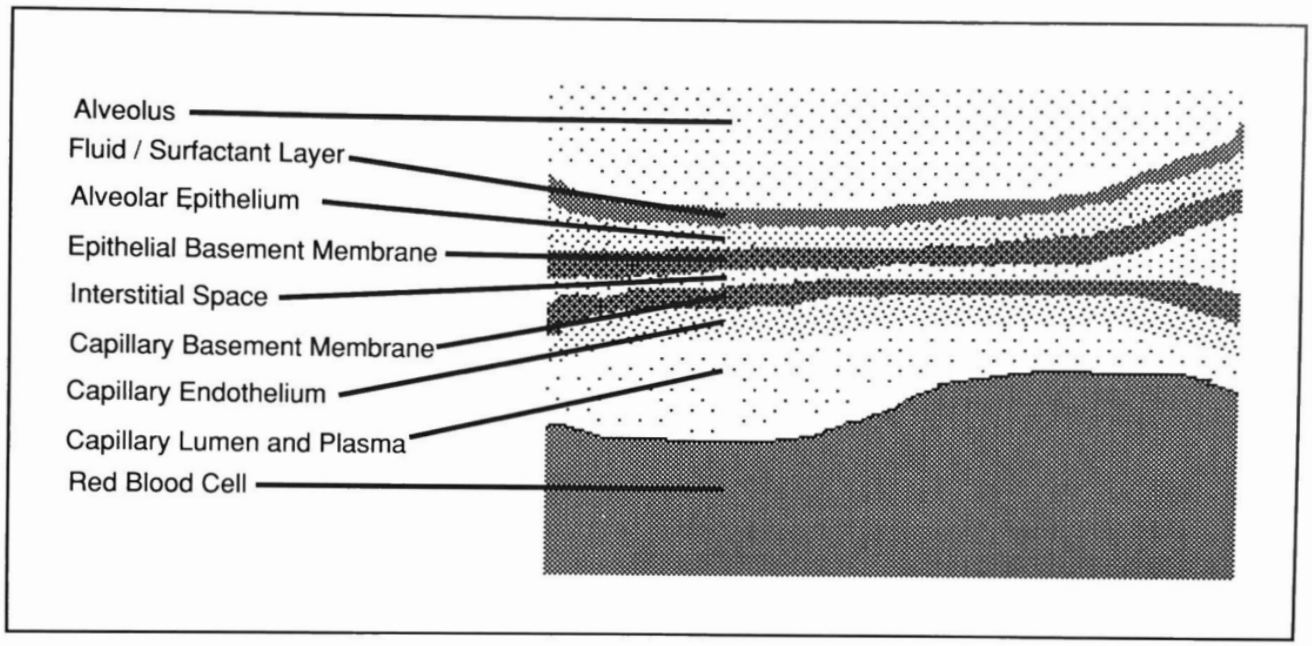

Figure 6 - Barriers to Alveolar-Capillary Gas Diffusion - There are several physical barriers through which gas molecules must pass in order to achieve alveolar - capillary blood gas exchange. In the above diagram, the normal situation is portrayed. In disease or injury, many of these barriers may enlarge with impediment to the gas exchange process.

dead space can be 1000 ml or more. This introduces the idea of alveolar ventilation. The tidal volume less the physiologic dead space is the amount of air that actually participates in effective alveolar ventilation. Multiplying this by the respiratory rate gives the alveolar minute volume This value reflects what all the other mechanical factors in ventilation actually accomplish in terms of moving air in and out of the functional alveoli.

Physical Principals

The freshly inspired air in the alveoli must impart oxygen to the blood and absorb carbon dioxide excreted by the blood.

Without active processes or barriers working the contrary, all particles tend to spread out or diffuse from an area of greater concentration to one of lesser concentration for each particular type of particle. This is also expressed as movement down a concentration gradient. This diffusion continues until the concentration of particles is evenly distributed - the concentration gradient is reduced to a flat line. This is called dynamic equilibrium. Movement of particles still occurs but just as many are coming as they are going.

This principle holds true for dissolution of gasses in water or other solutions. If gas over a solution has more of a particular particle, that particle will diffuse into the solution until the concentration is equal in the air and the solution. Thus, equilibrium will tend to occur between gases in the alveoli and gases dissolved in the pulmonary capillary blood.

Partial Pressure - The atmosphere contains almost 21% oxygen. That is, of all the gasses in the air, 21% of the total volume is oxygen. Instead of expressing this as a percentage, science and medicine often uses terms of partial pressure. Of all the pressure in the air (the current barometric pressure), partial pressure expresses how much of it is due to the presence of a particular gas. The average barometric pressure at sea level is 760 mm Hg. If 21% of that pressure is due to oxygen, oxygen has a partial pressure in the atmosphere of .21 x 760 mm Hg or 160 mm Hg. The atmosphere has almost 79% nitrogen or a partial pressure of 600 mm Hg at sea level.

Alveolar Air Composition - When atmospheric air is inhaled, it is diluted in the air that remained in the lung at the end of exhalation - the expiratory reserve and residual volumes. Additionally, the gasses are humidified to 100%, adding more water vapor. The turbulence and other physical factors mix this fresh and stale air that ultimately composes the alveolar air. On an average cool and clear day, the inspired air contains the concentrations of gasses shown in Figure 5. Also shown are gas concentrations in the resulting alveolar air. Notice that oxygen starts at 159 mm Hg in the atmosphere and ends up at 104 mm Hg in the alveoli.

Oxygen Exchange

The unoxygenated blood coming into pulmonary capillaries has a partial pressure of oxygen of 40 mm Hg, represented as P_v0_2 (P is for partial pressure, $_v$ for venous, 0_2 for oxygen). The alveolar air has a P_A0_2 (P for partial pressure, $_A$

for alveolar, 0_2 for oxygen) of 104 mm Hg. This sets up a gradient that will propel diffusion of oxygen from the alveoli into the blood.

Despite the diffusion gradient, there are factors which impede this gas exchange. A given red blood cell passes through the pulmonary capillary bed in about one second. All gas exchange must occur during this time. With a total pulmonary capillary blood volume of 100 ml, this might seem impossible were it not for the fact that this 100 ml of blood is in contact with approximately 300 million alveoli having a surface area of approximately 750 square feet - about the size of a basketball court.

There are other barriers. Oxygen must cross the alveolar membrane and fluid/surfactant layer, pass through the pulmonary interstitial space, cross the pulmonary capillary membranes, diffuse through the plasma, cross the red cell membrane and reach the hemoglobin. Under normal conditions, the red blood cell is literally squeezing through the pulmonary capillary, making the plasma diffusion factor negligible. The pulmonary interstitial space is also negligible under normal conditions. The capillary and alveolar walls are extremely thin, minimizing their diffusion barrier effect (Figure 6). However, all these barriers can enlarge with disease or injury, making gas exchange much more difficult.

After blood is effectively oxygenated in the pulmonary capillaries, it will mix with blood that has not been oxygenated, due to bypassing of the pulmonary capillary beds or perfusion through poorly ventilated alveoli. This poorly oxygenated blood is called the venous admixture. This normally takes the oxygenated blood coming out of the pulmonary capillaries from a $P0_2$ of 104 mm Hg down to 95 mm Hg.

Carbon Dioxide Exchange

Blood coming into the pulmonary capillaries is loaded with carbon dioxide wastes from the body. It has a P_vC0_2 of 45 mm Hg and the alveolar air has P_A0_2 of 40 mm Hg. This is a much smaller alveolar-capillary blood concentration gradient than found with oxygen. However, carbon dioxide dissolves almost 200 times more readily (has higher solubility) than oxygen, thereby making up for the lower concentration gradient. With the large alveolar surface area and minimized barriers of diffusion that were discussed under oxygen exchange, the carbon dioxide in arterial blood and alveolar air quickly reaches equilibrium.

CONTROL OF VENTILATION

Ventilation is part of a system for homeostatic control of oxygen and carbon dioxide levels in the blood and tissues. These mechanisms regulate the oxygen and carbon dioxide levels with remarkable accuracy under a wide variety of conditions.

Brain Stem Mechanisms

The medulla and pons contain the respiratory center - a group of neurons that collectively stimulate rhythmic breathing. The respiratory center is subdivided into the medullary rhythmicity, pneumotaxic and apneustic areas. Without all three components, ventilation becomes irregular or incorrectly proportioned between inspiration and expiration. Another central nervous system mechanism, the Hering-Breuer reflex, responds to impulses from stretch receptor cells in the lung to prevent over and under inflation. The vasomotor center can stimulate increased ventilation with falling blood pressure. The hypothalamus can stimulate increased ventilation as a heat dissipation mechanism in hyperthermia.

Carbon Dioxide Control Mechanisms

The most influential homeostatic mechanism for basic ventilatory control in normal individuals is based on levels of carbon dioxide in the blood.

Carbon dioxide levels in the body are regulated minute by minute with ventilation. The amount of carbon dioxide in the blood is directly proportional to the alveolar minute volume. The homeostatic objective is adjustment of alveolar minute volume to correspond to increases or decreases in the rates of carbon dioxide production by tissues - usually a function of metabolic activity. Like all homeostatic control systems, the carbon dioxide effect on ventilation has a measurement component with feedback to a regulatory component.

As metabolic activity increases, more carbon dioxide is excreted as waste into the blood by the tissues. As carbon dioxide levels increase, a chemical process ensues that produces carbonic acid, which lowers the blood and interstitial fluid pH. This stimulates chemoreceptors in the brainstem to increase ventilation, thereby lowering $C0_2$ and pH levels back towards normal, eventually dissipating the stimulus for increased ventilation.

In the opposite direction, a fall in $C0_2$ will decrease ventilatory stimulation, allowing $C0_2$ to build up until normal levels are restored. This will finally lessen the stimulus for the ventilatory inhibition.

Oxygen Control Mechanisms

Oxygen levels in the arterial blood are monitored by chemoreceptors in the aortic arch and carotid bodies in the neck. If P_a0_2 rises, it will inhibit ventilation. If P_a0_2 falls, it will stimulate ventilation.

The oxygen regulatory system is not very influential in control of ventilation in normal individuals. In COPD patients, the carbon dioxide control system fails, making the oxygen control system become primary. COPD patients with

spontaneous breathing must therefore receive supplemental oxygen under careful monitoring of respiratory rate and depth, to avoid undetected inhibition of their spontaneous ventilatory activity by a high P_aO_2. Their chronically lower P_aO_2 maintains their ventilatory stimulus - this is the so-called hypoxic drive.

INSTRUMENTS FOR CLINICAL MEASUREMENT OF VENTILATION

Without adjunctive equipment, the emergency clinician can assess ventilation by observation of chest movement, activity in accessory muscles of breathing, skin color, etc. However, quantification with instruments allows treatment decisions to be made with specific data. Responses to therapy may be quantified and used to regulate intervention as a replication of natural homeostatic measurement-control systems.

Historically, the limiting factor in reaching higher levels of clinical sophistication and precision of intervention is the sophistication and precision of our monitoring of the patient. In practical terms, particularly in the field, any monitoring devices must not be such that they detract from basic care. The magnitude of that risk is a function of logistics, training and medical control.

In the apneic or severely impaired case requiring ventilatory assistance, ventilatory measurement may be used to control the tidal volume. It was mentioned earlier that in emergency artificial ventilation, a 10-15 ml/kg tidal volume is desirable (5,6). However, that figure assumes a limited component of dead space, probably of about 150 ml in an adult. If an airway adjunct adds a significant amount of apparatus dead space, tidal volume may need to be adjusted.

Tidal volume may be measured by devices in-line with the airway (usually an endotracheal tube) or by components within a ventilator. However, tidal volume measurement may be inspiratory or expiratory. Expiratory tidal volume is generally preferred, as it will reflect the net ventilation if there are leaks in the apparatus, such as a torn cuff in an endotracheal tube.

Another artificial ventilation monitoring device is an airway pressure manometer. Barotrauma to the lung is a very real risk in ventilatory support, particularly when pop-off valves are not utilized. Further, notation of the changes in airway pressure required to deliver a specific tidal volume with a specific inspiratory time can track changes in pulmonary compliance.

Quantification of ventilation in a conscious and spontaneously breathing patient cannot be as direct, because complete airway control with intubation is usually not available. Here, ventilatory quantification is used not to regulate tidal volume and alveolar minute volume but to make serial measurements to assess the need and effects of respiratory interventions.

Peak expiratory flow is a simple bedside measurement that reflects pulmonary function. The patient's lips seal around a small hand-held peak expiratory flow meter during a maximum forced expiratory effort. Full patient cooperation is essential for this test. By quantification of ventilatory compromise, peak expiratory flow may allow protocols to be developed that might specify values under which certain interventions, like bronchodilator drug therapy, might be considered and responses to which may be documented for contemplation of follow-up treatment or other interventions if initial measures were unsuccessful.

Another helpful field monitor may be transcutaneous oximetry. These devices monitor oxygen saturation by measurement of the color of blood as it passes through the skin beneath its sensor. Oximetry can be an early warning sign for hypoxia, indicating need for immediate intervention - before the patient becomes obviously cyanotic or "crashes". Technology is also available for transcutaneous measurement of oxygen in carbon dioxide partial pressures. These values correlate closely to arterial blood gas values, but diverge with decreased peripheral perfusion.

There is a significant lack of quantification in assessment and measurement of responses to treatment during emergency care. This is often due to a primary concern of simply keeping the patient alive during acute decompensation where interventions are primarily supportive and straightforward. Initiation of monitoring in these extremely acute situations is often impractical. However, if monitoring is initiated prior to or as soon as possible during crisis, the information might allow for better clinical decisions and improvement in patient outcomes.

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Mechanical Ventilation in Prehospital Life Support

BRIAN W. COBB, MD

Mechanical ventilation in the prehospital setting is used primarily for the treatment of acute respiratory failure (ARF), which may occur *de novo* as a result of illness or injury, or superimposed upon chronic respiratory insufficiency. Regardless of its cause, the immediate goal of therapy in ARF is the maintenance of adequate tissue oxygenation and pH.

The physiology of ventilation is considered by Gunderson in this issue. Standard definitions of ARF focus on blood gas values, which are unavailable to field personnel. Recognition of the need for artificial ventilation rests therefore, on clinical assessment. Physical signs such as restlessness, tachycardia, tachypnea, sweating, and cyanosis are indicative of hypoxia. Hypercarbia is suspected when somnolence develops. When doubt exists, it is preferable to err on the side of intervention, as hypoxia results in rapid and irreversible damage.

Once the airway is established, ventilation may commence. Several types of positive pressure ventilation units are currently available. Volume cycled units deliver a specific tidal volume at a specific rate, unless the pressure exceeds the set point of the pop-off valve. Pressure cycled units deliver gasses until a given airway pressure is reached, at which point inspiratory flow ceases and expiratory flow begins (2). Pressure cycled ventilators are not recommended for use in resuscitation or in cases with abnormal lungs (3).

Several commercial positive pressure, volume cycled automatic ventilators are on the market. They have the advantage of freeing personnel for other tasks (as opposed to bag-valve-mask units or demand valves). They can deliver 100% oxygen and may be used in patients of all sizes, infant to adult.

Mechanical ventilation may assume several modes (Figure 1):

1. Controlled Mechanical Ventilation (CMV): the ventilator delivers the preset tidal volume at the preset rate regardless of the patient's intubation effort
2. Assist Control Mechanical Ventilation (ACMV): the machine responds to the patient's respiratory efforts, but will deliver controlled ventilation in their absence.
3. Intermittent mandatory ventilation (IMV): this is essentially spontaneous ventilation with superimposed controlled ventilation.
4. Synchronized intermittent mandatory ventilation (SIMV): this mode combines spontaneous and assisted ventilation.

The bag-valve device permits manual ventilation in any of the above modes. It is inexpensive, easy to use, reliable and can deliver inspired oxygen contrations approaching 100% with a reservoir. Its primary disadvantage is that it is labor intensive, requiring a full time operator.

In an attempt to facilitate ventilation with 100% oxygen, the demand valve, a high flow manually triggered device permitting all four modes was developed. However, these devices may produce inadequate ventilation in the presence of high airway pressure, like the pressure cycled devices. This catastrophe may be unapparent to the operator (4).

A current third generation of prehospital ventilation units are now on the market. In this article we will discuss, as examples, the specifications for: the Impact *Univent*®, Life Support Products' *Autovent 2000*®, and the Ohmeda *Logic 07*®.

The *Univent*, Model 700 delivers controlled ventilation (CMV) only with adjustable tidal volumes from 0-1250 milliliters at fixed rates which vary from 12 to 20, depending on whether the adult child or infant setting is selected. The inspired oxygen concentration is fixed at 1.0 (5).

The LSP *Autovent* 2000 functions as an IMV ventilator, reverting to CMV in the non-breathing patient. The rate can be set from 8 to 20 breaths per minute, and the tidal volume is independently adjustable from 400 to 1200 milliliters. It also delivers 100% oxygen (6).

The Ohmeda *Logic 07* offers rates from 10-20 breaths per minute and tidal volumes which are set with a minute volume control (minute volume / respiratory rate = tidal volume). It functions in the IMV and CMV modes as does the LSP *Autovent*. Unlike the *Autovent* however, spontaneously breathing entrains room air and decreases the inspired oxygen concentration by a variable and uncertain amount. The inspired oxygen concentration during controlled breathing can be adjusted to 0.5 or 1.0 (7).

Any of the above devices will function acceptably in

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CPR, except the demand valve and pressure -cycled ventilators. Thus, depending on individual preference and budget, the bag valve device or any of the three commercial volume cycled ventilators may be used. In the spontaneously breathing patient requiring ventilatory assistance, the units offering IMV capability may be more useful, although known inspired oxygen concentration during spontaneous breathing is desirable. Finally, the use of inspired oxygen concentrations less than 1.0 in the ARF patient may be questionable if blood gas measurements such as pulse oximetry are not available. Lower inspired oxygen concentrations could presumably be used in transporting stable patients between facilities.

Standard settings for emergency ventilation include tidal volumes of 10-15 ml/kg and rates of 8 to 10 per minute for adults and up to 20 ml/kg for children and infants (8). This should maintain normocapnia. When hyperventilation is desired (e.g., for patients with increased intracranial pressure), this rate must be higher. Since arterial blood gasses and end-tidal capnography are not generally available in the prehospital setting, these "rules of thumb" must be relied upon.

To avoid barotrauma, volume cycled ventilators normally feature "pop-off" valves that vent a portion of the tidal volume to the atmosphere when a pre-set level of airway pressure is exceeded. The *Univent* can be set to a pop-off at 60 or 80 cm H_20. The *Autovent* has an alarm which sounds above 45 cm H_20, and the *Logic 07* may be adjusted from 20 to 90 cm H_20 pressure limits. Higher airway pressures than normal may be required in patients with cardiogenic pulmonary edema, ARDS, pulmonary contusion, bronchospasm, or other disorders.

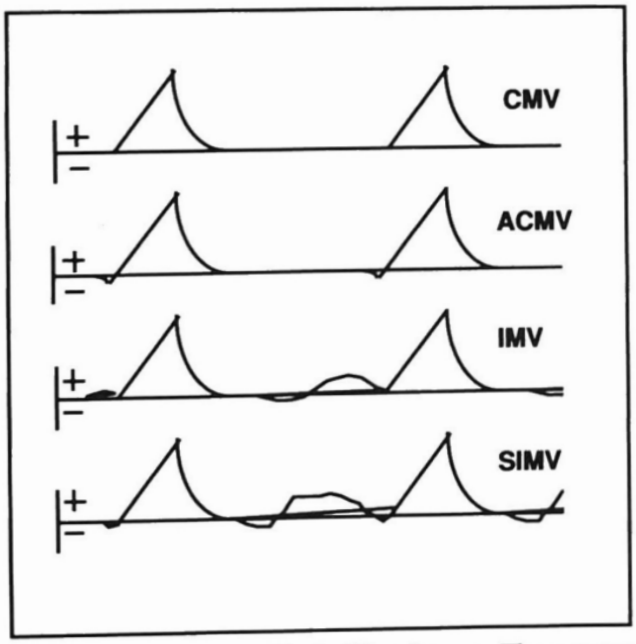

Figure 1 - Ventilatory Mode Waveforms - The pressure waveforms of the most common ventilator types are shown. With controlled mechanical ventilation (CMV) the ventilator delivers a breath regardless of patient effort. In assist-control mode (ACMV), the ventilator is triggered to deliver by the patients' inspiratory effort. Intermittent mechanical ventilation (IMV) will interpose mechanical breaths in addition to the patients' own breaths. Synchronized intermittent mechanical ventilation (SIMV) will allow some totally spontaneous breaths and the mechanical breaths are also triggered by spontaneous inspiratory effort.

Positive end expiratory pressure (PEEP) has become popular for treatment of hypoxic states secondary to cardiogenic or non-cardiogenic pulmonary edema (9). Although barotrauma, particularly pneumothorax, is a feared complication of PEEP, the incidence of pneumothorax is no higher in patients treated with PEEP than with mechanical ventilation alone (10). PEEP may also decrease venous return and cardiac output, particularly in the hypovolemic patient. Worsened ventilation-perfusion ratios may also be produced, decreasing arterial oxygen tensions (11). The use of PEEP in the prehospital arena must, therefore, be considered experimental at present.

Prehospital life support personnel, including EMT's, paramedics, and flight crews have an increased spectrum of ventilatory devices at their disposal. Selection of the appropriate devices can facilitate care. Those responsible for these choices should understand their capabilities and limitations, and personnel using them must be thoroughly trained and have periodic retraining.

REFEREE DISCUSSION

(This section was excerpted and edited from the discussion following presentation of this paper at the Protocol Roundtable Symposium on Airway Control and Ventilation, March 2, 1988, Tampa, Florida)

Gunderson: *(Michael R. Gunderson, REMT-P, Palm Harbor Fire Department / Pinellas County EMS; Tampa, FL)* Could you give us some additional comments on use of the manually triggered demand valve? What do you see as the pros and cons of it versus the bag and these other automatic ventilators?

Cobb: We've opened another whole can of worms there. The demand valve, when it first came out, was very attractive to a lot of us. It's simple to use, it's relatively compact, it is manually triggered. However, Dr. Melker and his colleagues in Gainesville (Florida) have demonstrated some real problems with the demand valve - that you may be delivering virtually no tidal volume with that device and you may not even know it. For that

reason, I think the demand valve is best deleted from our inventory of equipment and I think that this newer generation of devices should replace the demand valve, really. I think it's just too fraught with problems.

Gunderson: Am I correct in assuming that the reason why they were finding inadequate tidal volumes from the demand valve was that when the pop-off valve was actuated, the operator wasn't aware of it. I notice the sound - it's a recognizable sound. When the pop-off valve isn't actuated and I'm getting chest rise, I haven't seen any problems with it. When the pop-off valve does start to actuate, I know that I can no longer use that device. The thing I like about the demand valve is it is small, it does deliver 100% oxygen, and it does put an upper limit on peak airway pressure. I've always been concerned in situations where I have to use less than optimally trained people to assist me on a code, and sometimes they end up on the airway. I'm concerned about a big, burly fireman who is handling the airway - maybe that isn't what I should do, but sometimes that happens. I'm worried that they can be over-aggressive in how fast they squeeze the bag and potentially generate dangerously high peak inspiratory pressures with the bag. At least if they're using the demand valve, there is an upper limit on it, so long as I listen for that pop-off valve actuation.

Cobb: To speak from an idealistic or ivory tower viewpoint, I think that the ideal solution to that problem is proper training of personnel. And again, that comes back to basics with any type of equipment that we use. We have to have well trained personnel who completely understand the equipment they are using - its limitations, and whatever problems can be generated with that equipment. I realize sometimes it's necessary in a field setting to use untrained or relatively untrained personnel because that's all that's available, but I think more training of personnel, if it can possibly be accomplished, is the best way to approach that problem. There is no piece of equipment that is completely idiot-proof.

Gunderson: How about if the demand valve was modified so that when the pressure relief valve becomes actuated, it would have a more distinct noise. Or, you could have an adjustable airway pressure relief valve, perhaps even distinct or separate from the device itself, just like hooking up an in-line manometer or respirometer?

Cobb: You could do that, but the demand valve is fairly labor intensive. Somebody has to sit there and push that button. And with this new generation of ventilators on the market, I just really don't see the need for it. I think with the newer more mechanized ventilator devices you can get better results more easily. So I don't really see the advantage.

Brown: *(Michael Brown, REMT-P, Hillsborough County EMS; Tampa, FL)* The demand valve still is about one tenth the cost of the average transport ventilator. The American Heart Association's latest report on emergency cardiac care and CPR did derive standards that are applicable to demand valve devices, but unfortunately at the present time they have only been incorporated into these transport ventilators. This includes a reduced flow rate of 40 L/min and the incorporation of a distinctly audible proximal airway pressure pop-off valve.

Cobb: If the improvements were made - But again, the reservations I have are based on the currently available equipment. The ones that are available now I would not recommend for use.

Walters: *(Cline Walters, Aero Products; Longwood, FL)* There are two situations that are being overlooked here with the demand valve. The demand valve you (Mr. Gunderson) currently use in your department, is it gated down to 40 L/min or is at the 100 L/min flow rate?

Gunderson: I believe it's still set at 100 L/min..

Walters: At the 100 liter per minute flow rate, we note problems with barotrauma, intracrainial pressure, and you could even run into ventilation/perfusion mismatching with that device at that setting. When you take a new generation device and gate it down to the JAMA recommended 40 L/min flow rate, you've got to look at what's going on there. Given your formula of 10-15 ml/kg, a seventy kilogram patient on the low end (10 ml/kg) is going to have a tidal volume of 700 ml. Now that's making no compensation for dead space or whatever. On the high end (15 ml/kg), its a tidal volume of 1,050 ml. Now let's take a real world patient, somebody like me. That would be a 110 kilogram patient times the low end, 10 ml/kg, is going to equal 1100 ml per breath. The demand valve, at 40 L/

min, is actually incapable of delivering that, because in the CPR setting we're limited now to a maximum inspiratory period of 1.5 seconds. The American Heart Association recommends pausing for up to a one and a half second period for ventilation time. At 40 L/min, that's 0.66 liters per second. Multiplied by one and a half seconds gives you less than a liter of gas - which is totally inadequate for a patient my size, not even compensating for mask leakage, dead space, things like that. So you've got to look at the demand valve from that aspect also.

Cobb: I think there are so many problems with the demand valve, that's a good point, and to me, it's hard to recommend it.

Scarberry: *(Eugene Scarberry, Respironics, Inc.; Monroeville, PA)* These things are very excellent points. I respectfully disagree with Dr. Melker. I know he has some strong biases against demand valves. In a face mask situation, where I loose a lot of tidal volume, the demand valve is not a volume limited device, it's a pressure safe device. It gives me the option of insuring reasonable tidal volume if I'm doing what I'm supposed to be doing, which is monitoring chest rise. With a bag valve resuscitator, to get 1200 cc stroke volume every time with one hand? - its also not real. So you're saying you can't use demand valves and you're saying the patient really needs a 1200 cc tidal volume, you're not going to even get close to that without a cuffed tube, so that's not going to work. You've just taken away the two existing devices.

Boothby: *(Charles Boothby, DO, Medical Director, Pasco County EMS; New Port Richey, FL)* If you haven't got a fixed rate, you can ventilate somebody with a bag-valve-mask just as fast as you can squeeze a bag to make up. So you've got the same tidal volume, the same minute rate.

Scarberry: The problem is if you take 500 cc's stroke volume and you do it twenty times a minute and then you take a 1000 cc's stroke volume and you do that ten times a minute you do not get alveolar ventilation that's equivalent.

Cobb: You doubled your dead space ventilation.

Scarberry: So that what you're finding is that the ideal breath is a large slow breath, fewer times a minute, rather than a high-frequency breath of short volume. Just doubling the ventilation rate is not going to buy you or necessarily improve alveolar ventilation.

Kinsey: *(Dave Kinsey, REMT-P, Clearwater Fire Department / Pinellas County EMS; Clearwater, FL)* I think that the other thing we're overlooking here is Stewart's study up in Pittsburgh. What were the tidal volumes they were achieving with a mask? It was not but 300 to 500 cc's.

Scarberry: In some cases, it was up to 800 cc's.

Kinsey They didn't really have an explanation as to why one person could achieve 800 cc and another person only 300 cc.

Gunderson: Did they look at the hand size?

Kinsey: They looked at the hand size. Unless we hired people with size 9 hands —

Cobb: Only basketball players need apply.

Kinsey: We're lucky to get 500 ml of ventilation on a bag. Realistically in the field, we're talking 300 ml.

Cobb: Again I think this points out the advantage of this new generation of transport ventilators is that they can reliably deliver large tidal volumes at reasonable rates. I think that they are currently the only devices available for prehospital ventilation that can do that.

Nelson: *(Joe A. Nelson, DO, Emergency Department, Carrollwood Community Hospital; Tampa, FL)* But you can't use them for cardiac arrest situations.

Cobb: Actually I don't mind doing that. I have just left the patient on the ventilator during a code, as long as the pop-off valve is turned up high enough. I don't mind that because I'm one of these people that doesn't believe in interposing ventilations between compressions. I realize that this is controversial.

Scarberry: But it assumes a protected airway.

Cobb: Yes - I've always intubated these people while they were on a ventilator or prior to their arrest or whatever. But let's face it, the vast majority of the time, either in the field or in the hospital, the patient is intubated very quickly after cardiac arrest. So in that setting, I don't feel that it's necessary to interpose the ventilations between compressions. I feel that there are some potential advantages of using other modes of ventilation. It's up to the individual clinician's preference or your protocols, depending on where you are. I think that the use of mechanical ventilators is perfectly acceptable in a CPR setting provided they have appropriate pop-off valve settings and that they're volume cycled rather than pressure cycled devices.

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ERRATA

In the January-March, 1988 issue, the proceedings for the Protocol Roundtable on Acute Congestive Heart Failure *(Protocol Roundtable: Acute Congestive Heart Failure. Tampa Bay EMS Journal 1(3):62-70, 1988)* contain errors in Figure 6 on page 69, listing items for the model protocol. Most significantly, the section on furosemide and the dosage for aminophylline were omitted. The corrected contents for the figure, with underlined changes, are shown below.

1. General Supportive Care
   - ECG monitoring
   - Venous access (IV D5W, t.k.o. or reseal)
   - History, physical assessment
2. Patient Positioning - Upright
3. High Flow O_2
4. Positive Pressure Ventilation
5. Intubation, if any of the following:
   - Decreased level of consciousness
   - Decreased ventilation (RR>36 or <10)
   - Hypotensive
6. PEEP (intubated cases)
   - 5-10 cm. H_2O
7. Nitrates
   - 2.5 mg. isosorbide or 0.4 mg. nitroglycerin, sublingual
8. Morphine
   - 2.5 mg. increments @ 5 min. intervals until diastolic 70-100 or systolic 120-160
9. Furosemide
   - 40 mg. (80 mg. if on oral furosemide); Repeat at double dose, if needed
10. Aminophylline
    - 250 mg. in 50 ml. over 30 min.
      (if not on oral theophylline products)

We apologize for the omission and any confusion it may have caused. Despite the very limited time and resources under which we produce the Journal, we make no excuses for such errors - We take our responsibility for the content of this publication very seriously. We appreciate the support of our readers and assure that as we grow, we will continue to improve the composition and academic quality of its contents.

The Editorial Staff

Tampa Bay EMS Journal

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PROTOCOL ROUNDTABLE

Airway Control and Ventilation

The following article contains an edited transcript taken from the Protocol Roundtable Symposium sponsored by the Acute Care Foundation in Tampa, Florida on March 2, 1988.

The Protocol Roundtable is a session in which paramedics, physicians, nurses and other acute care clinicians review a specific emergency disorder. This entails discussion of the pathophysiology, clinical recognition, therapeutic objectives, review of current EMS agency protocols, and a computerized literature search. The session culminates in a "roundtable" group discussion to develop a model protocol.

Securing an airway and providing ventilation are among the most basic tasks in emergency medicine, and among the most important. The session began to consider airway access and ventilation as separate protocols, but the structure appeared to be more appropriate as a single integrated sequence.

A lecture on the clinical anatomy and physiology of ventilation was delivered by Michael Gunderson, REMT-P and appears elsewhere in this issue. Michael Brown, REMT-P, from the Hillsborough County, Florida EMS system, delivered a presentation on airway access. Brian Cobb, MD provided a lecture on mechanical ventilation, also appearing in this issue. After discussion of the airway and ventilation literature search, also in this issue, the model protocol development effort was moderated by Mr. Gunderson.

Protocol Structure

Mr. Gunderson: *(Michael R. Gunderson, REMT-P, Palm Harbor Fire Department / Pinellas County EMS; Tampa, FL; - Moderator)* We will list out what our therapeutic objectives are in getting the airway open, and then we'll try to choose which specific therapies we might want to use to meet those therapeutic objectives. We, of course, want to have a patent airway. And perhaps that might be the limit of our therapeutic objectives. What we might want to do is consider a spontaneously breathing patient, an apneic patient, and patients with or without cervical spine injuries. Dr. Nelson?

Dr. Nelson: *(Joe A. Nelson, DO, Emergency Department, Carrollwood Community Hospital; Tampa, FL)* I would like to break this into something a little bit more detailed, and that is, a fast patent airway versus something that takes a little longer. My idea is a recommendation for stepwise airway management beginning with something you can do immediately that's a sure thing -something as simple as putting in an oral airway. Then use some sort of a mask device until the patient can be further managed or until inserting something that's a little more secure and safe.

Mr. Gunderson: Instead of discussing this as separate airway access and ventilation protocols, perhaps we should consider this in terms of an airway support and ventilation protocol - one single protocol in which this sequence of events could take place for the spontaneously breathing patient as well as the apneic patient. Anybody have any feelings on that? For example, Dr. Geeslin, in your system, do you have a specific protocol for airway access separate from ventilation, or is it blended together?

Dr. Geeslin: *(John L. Geeslin, MD, Medical Director, Lake County EMS; Eustis, FL)* We're more like Dr. Nelson states in that you try to go stepwise from what you do immediately or initially to what you do later on to secure your airway.

Mr. Gunderson: Any other feelings on this? Do we have a consensus about blending together the airway access as well as the ventilation protocols? Do you think it would be appropriate for us to consider as a separate sequence the spontaneously breathing as opposed to the apneic and/or arrested patient? Gene?

Mr. Scarberry: *(Eugene Scarberry, Respironics Corp.; Monroeville, PA)* That's just simply shades of the same patient. What breaks apart easily is the C-spine injury potential patient and the non-C-spine. If you take both of those and follow a path of C-spine injury: spontaneously breathing, troubled breathing, apneic, non-C-spine injury patient, — you may find some deviations as you break down the decision tree.

Dr. Cobb: I think the presence or absence of spontaneous ventilation is important, though, because it may influence your choice of techniques. For instance, nasal technique is probably going to be your first choice of intubation routes for the patient who is spontaneously breathing. For the apneic patient, you're going to go with an oral intubation. So I think that there would be some differences there that may be important.

Mr. Brown: *(Michael Brown, REMT-P, Hillsborough County EMS; Tampa, FL)* It would seem that our starting point in the therapeutic objectives is to differentiate the trauma from the non-trauma patient as the first therapeutic objective when considering airway management or airway assistance. As Gene said, it neatly divides into the trauma and the non-trauma patient, and then you follow a decision tree from that point.

Mr. Gunderson: That seems reasonable to me using the "trauma"/"non-trauma," and the "spontaneously breathing" versus the "apneic" patient. I'm just trying to limit the number of permutations we can have.

Mr. Brown: The decision tree should start from those two points (trauma / non-trauma), then immediately go to "spontaneously breathing with adequate respirations" or "inadequate respirations and/or apnea." In which case, you would choose between simple supplemental oxygen and then the need to assist ventilations. Those are identical for the trauma and non-trauma patient. In terms of specifying a protocol, simply identify the trauma versus the non-trauma patient. For the trauma patient, we would also have to include immediate manual management of the cervical spine.

Dr. Nelson: For purposes of time constraints, I would suggest that we just put the patients with adequate ventilation that need supplemental oxygen off to the side. I don't think we should consider those here. I think we should just consider those patients that we know are going to need some sort of an artificial airway management such as endotracheal intubation.

Mr. Gunderson: And they could simply withhold the ventilatory component if they have an adequate spontaneous tidal volume.

Dr. Geeslin: What you might do in your first step, is evaluation of their airway - That's number one. Then, you break that down to two trees. The first one is going to be "adequate" or "near-adequate needing supplemental oxygen." We can kind of not watch that one for a minute. Then we can go to "inadequate," which would be either "severely compromised" or "apneic." Then break that down into "trauma" and "non-trauma."

Mr. Brown: The reason for inserting the differentiation between "trauma" and "non-trauma" early on is the basic airway maneuvers need to be accompanied by manual cervical management. This is the way that it's included in all the trauma life support curricula.

(See Figure 1 for the decision tree structure)

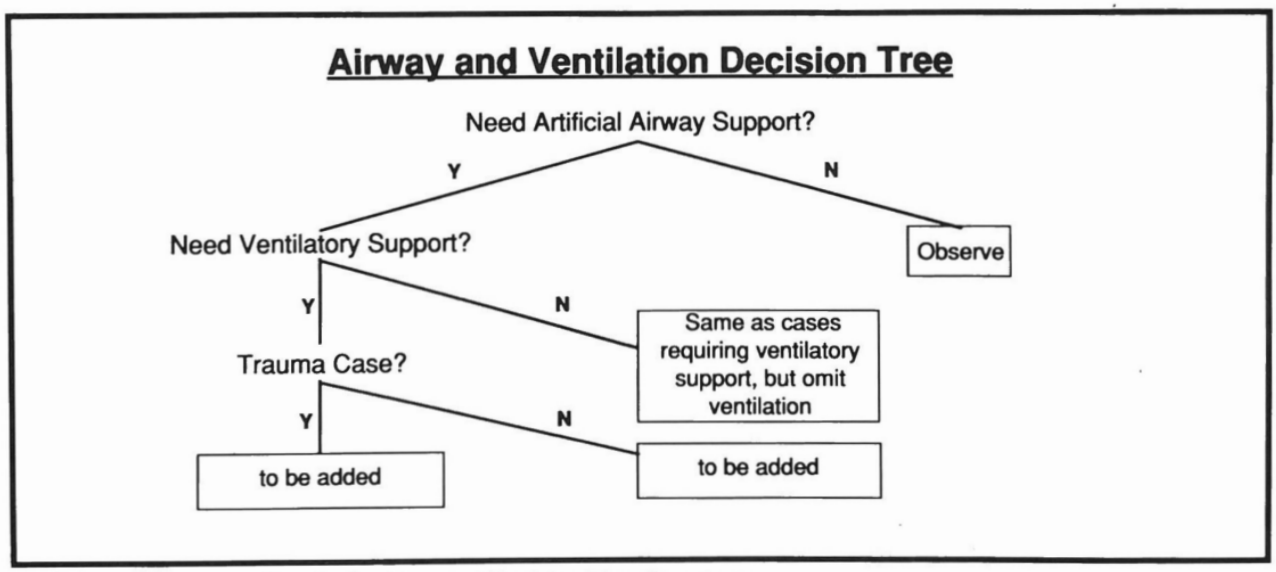

Figure 1 - Airway and Ventilation Protocol Decision Tree Structure

Airway Candidates

Mr. Gunderson: Determining whether or not the patient needs an airway, that's fairly clear cut. Maybe it isn't. Which patients should receive an artificial airway? Brian?

Dr. Cobb: First of all, any patient who is manifesting evidence of airway obstruction as indicated by stridor, by the presence of secretions in the oral cavity, by impaired level of consciousness, or in patients that are not able to defend his or her own airway.

Mr. Brown: For a patient requiring supported airway patentcy, the patient needing to be guarded against secretions or vomitus, and the patient requiring ventilations. Those seem to be three clear ones.

Mr. Gunderson: The obstruction would be all of the secretions and whatnot. The reduced level of consciousness being those people who are not able to protect their airway. That seems to be workable for which candidates need the airway. Is everybody comfortable with that?

Mr. Brown: The third one that needs to be put on there is the patient requiring ventilation - That's the obvious one.

Dr. Cobb: There's a third category of apnea or hypoventilation.

Mr. Gunderson: This is where we had some controversy earlier this afternoon - deciding which patient is adequate and which patient is

inadequate in terms of their spontaneous respiratory effort. Obviously the patient who is apneic will clearly be in this inadequate category, but how can we discriminate between the patient who needs and doesn't need ventilatory assistance by artificial means? Gene?

Mr. Scarberry: Would not the circumstances in which you find the patient suggest a need? - such as he's been burned, has been in an automobile accident, or received trauma to specific parts of his anatomy to where you would want to guard or where your suspicion level is higher, where you would then say for an insurance policy, I'm going to proceed to do something as opposed to just simply asking what are the clinical symptoms? The same set of symptoms on two different patients may produce two different modes of procedure.

(See Figure 2 for factors to consider in determining need for airway intervention)

Selection of Cases Needing Ventilatory Assistance

Mr. Brown: Something that is a little more difficult as far.as decision-making is the alert patient who has an.adequate tidal volume but who requires ventilatory. assistance. And I'm speaking specifically of, for instance, a congestive heart failure patient that needs to have his respiratory work eliminated and simply needs that ventilatory assistance or they will rapidly progress from congestive failure to cardiac arrest.

Mr. Shepler: *(Patrick Shepler, REMT-P, Clearwater Fire Department / Pinellas County EMS; Clearwater, FL)* What are some of the parameters that would determine who requires assisted ventilation? Restate the question.

Mr. Gunderson: What we're concerned about is differentiating which leg of this decision tree we want to go down. Are they adequately ventilated and they simply are going to need an airway, or are they going to need an airway plus ventilatory assistance? All of the patients are going to need an airway. Which patients are we going to need to supplement ventilation in?

Mr. Shepler: I think the initial criteria should be rate of respirations. We could come up with some type of term as far as the rate.

Mr. Gunderson: That's something solid. We can deal with that. Anybody have a number? Should we deal with a number, or should we look in terms of minute volume? We can't measure alveolar minute volume because we don't know what their dead space is.

Mr. Shepler: Part and parcel with the rate is going to also be the chest wall expansion. If there are intercostal and subclavicular retractions, if the patient is retracting versus breathing normally, if they have symmetrical respirations.

Mr. Gunderson: Let's pull back from this. Dr. Geeslin, you have a patient who is breathing spontaneously but not real well. What things would you look at to decide whether or not you need to provide supplemental ventilation? - Clinical signs, things that would be available to your paramedics in the field?

Dr. Geeslin: Well, first of all you have to diagnose or define "real well." This is a real problem because we're dealing with paramedics in the field. And as we discussed earlier today, we have very little that we can actually quantitate for specific parameters. I think you mentioned their respiratory rate, skin color, whether or not they're cyanotic, whether or not they're using the accessory chest muscles. These are certainly all indications of how well that patient ventilates. Also you have to consider their level of consciousness - are they restless? Are they sedated from it? You have got to take everything together. That's a real problem when we're dealing with the brand new paramedic out in the field. This is his first run as a paramedic, and he comes on an elderly lady with status asthmaticus. Well, is it cardiac asthma, or is it because she went out with goldenrod? That's where we have the problem. I see a lot of difficulties in making out a set protocol that says, "In this case you do this, and in this case you do that" because it's gray. It's not black and white.

Mr. Gunderson: Maybe we just have to accept that fact. Simply delineate some of the clinical signs and circumstances under which it would seem that ventilation may be inadequate. Simply list those and chalk it up to clinical judgement.

Dr. Geeslin: I think you have to make a protocol for your brand new or weakest paramedic. You don't make it for the hot-dog person who has ten years of experience, who's worked in emergency rooms, who's been out in the ambulances, and who has done teaching. He's going to be as good as we are - maybe better. You have to make it for your weakest man, something as objective as we can.

Mr. Gunderson: This brings up an issue we brought up at the last protocol meeting - At which level the model protocol should be directed? Should we go for this least common denominator factor, which would be the brand new paramedic who doesn't have a lot of clinical experience to base his clinical judgments on? Should we go for a median? Should we shoot for an optimal from which we would simply allow the medical directors for the different agencies to make their own assessment as to how much of the model protocol they may be ready for at whatever point in time? Consider the wide disparity in experience levels between agencies, busy systems versus slow systems, systems with very intensive continuing education and medical control as opposed to those with less intensive training and continuing education. What we're trying to do, and I appreciate your concern, is to aim for an optimal protocol, taking a near optimal set of circumstances given the constraints of the field. From that point, the agency and you as a medical director for your agency, can see which components from the model protocol you feel comfortable with. It might even be a goal to which you would try to gear your continuing education and medical control to capacitate. Mike?

Mr. Brown: With the optimal protocols stated, it can be up to the medical director to draw a line through that protocol and say, "Beyond this point, mandatory physician contact is required." The only unfortunate circumstance here is that airway is usually a high priority, and in the manpower poor environment that we encounter prehospital, it can be very difficult to continue to

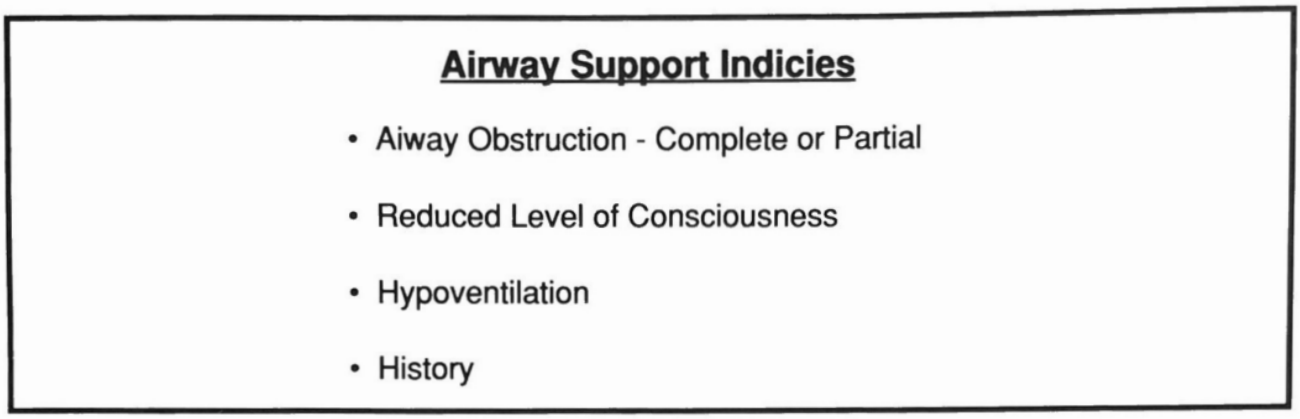

Figure 2 - Factors To Consider in Evealuating Need For Airway Support

maintain the patient at a certain state and communicate not only adequately but coherently with a physician in order to get those orders at that time. So we do have to limit here, and I certainly appreciate that, but once again the optimal protocol can be stated beyond which physician contact can be mandated.

Dr. Nelson: I think we need to first of all lay aside the discussion we had earlier today - I don't think that spirometry and oximetry and these things at this time are of sufficient value to make a distinction in whether or not we should intubate someone.

Mr. Gunderson: Good research topics, but not ready for widespread application?

Dr. Nelson: I think they may be very valuable in the future, but at this time I don't think we're far enough along on the research to be able to put that as a definite parameter. So what are we left with? We're left with physical evaluation and clinical judgment. And I think the simplest way to do that is much as we did the last Protocol Roundtable discussion. That is put some parameters, physical exam parameters, in our criteria such as respiration rate. Just throw that out to start with. What are some minimum respiratory rates below which you would like to see intubation or some sort of aggressive airway management to take place?

Dr. Cobb: That's age dependent. If we're talking about adults, I would say a respiratory rate of less than eight to ten would be a range where I would start to feel uncomfortable and consider instituting mechanical ventilation. Obviously in a neonate, we could say less than 24. It's going to be somewhat age dependent.

Mr. Gunderson: Let's restrict it to adults. Pediatrics bring in a whole new set of constraints. So which number?

Dr. Cobb: I would say less than eight to ten respirations per minute is the range at which the presence of cyanosis certainly appears.

Mr. Gunderson: Let's stop at the respiratory rate. Anybody have any disagreement or comment on eight to ten? Now, cyanosis —

Mr. Brown: Before we get to cyanosis, let's go to the top end of respirations. Usually that's coupled with another clinical observation, and that is heart rate. Heart rates in excess of a certain amount coupled with — or below a certain amount coupled with tachypnea should also be an indication that this patient should be evaluated for intensive airway management.

Mr. Gunderson: Dr. Geeslin, does that sound reasonable?

Dr. Geeslin: I agree.

Mr. Gunderson: What number heart rate would set off a red flag with you in the context of a patient who may be inadequately ventilated?

Dr. Geeslin: It depends on the age of the patient. I think anything over a hundred you're really going to have to look at.

Dr. Cobb: Less than 60 or greater than a hundred —

Mr. Brown: Coupled with tachypnea over —

Dr. Cobb: Well, we can come up with a number of parameters for respiratory rate —

Mr. Gunderson: Exactly.

Mr. Brown: Any patient with a heart rate greater than 120 with respiratory rate over 30 - I consider that person should be evaluated for intubation regardless of their state of alertness, which is why I think that the heart rate should be coupled specifically in this instance with a respiratory rate as a clinical deciding factor; certainly the lower end of the respiratory rate is an indication. Tachypnea coupled with the other evidences of elevation of sympathetic tone is another indication.

Mr. Gunderson: So we're looking at the respiratory rates below 8, greater than 30, heart rates lower than 60, greater than 100. Does everybody feel comfortable with that?

Mr. Shepler: I don't feel particularly comfortable with saying that as a carte blanche.

Mr. Gunderson: They are not. These are not definite. These are clinical guidelines that are put together with the cyanosis, mechanism of injuries, and other circumstances. These are simply factors that we're going to ask the clinician to consider in deciding which leg of the decision tree he's going to follow - if the patient is adequate or inadequate in ventilation. These are the parameters he should look at, but it will not be an absolute because I think we've already come to a conclusion that absolutes are darn hard to come up with. We could go with apnea, but everything else seems to be gray.

Mr. Brown: Pallor, diaphoresis, or cyanosis.

Mr. Gunderson: Abnormal skin color.

Dr. Cobb: Presence of intercostal or supraclavicular retractions, accessory muscle usage, decreased level of consciousness, certainly, or profound agitation. Arrhythmias on EKG monitoring - ventricular arrhythmias especially.

Mr. Gunderson: Anything else figure into this equation?

Mr. Brown: Gastric contents in the oral cavity.

Dr. Cobb: We're back to our obstruction criteria there.

Mr. Gunderson: Realizing the limitations of this decision, in looking at the overall patient, does everybody seem to feel we've tagged the appropriate bases in deciding which leg of the decision tree we're going to go with? Adequate or inadequate ventilation? We simply have to consider these factors in making the decision and rely on clinical judgment. Any more detail you can see in this, Dr. Geeslin?

Dr. Geeslin: Do you want to put something in there about auscultation? If you feel that they've got a significant decrease in breath sounds, if they've got a lot of rales or rhonchi, a lot of bronchospasm or wheezing.

Mr. Kinsey: *(Dave Kinsey, REMT-P, Clearwater Fire Department / Pinellas County EMS; Clearwater, FL)* Don't forget stridor.

Mr. Brown: Fulminant pulmonary edema.

Dr. Cobb: Which would be diagnosed, as he said, if the rales are present. Then that's going to fall under the abnormal breath sounds.

Mr. Gunderson: Frothy sputum.

Mr. Brown: Well, certainly someone who actually has pulmonary edema visible as an expectorant.

Dr. Cobb: Frothy sputum.

Dr. Geeslin: Now we're back to obstruction again.

Mr. Gunderson: Yes, we are. We can probably just leave that out, then. Okay. Taking the listing here on the table into consideration, are we ready now to move further down the tree to the traumatized versus the non-traumatized patient?

Mr. Shepler: We can add one more thing, Mic, - capillary refill. Do you think it's covered?

Dr. Cobb: I think that's more an indication of cardiac output, a volume status than respiratory status per se.

Mr. Gunderson: That's a perfusion indicator that may not be specific enough to ventilatory function. The color, yes. We've got the skin color and the skin moisture, but the capillary refill itself I don't think is specific.

Dr. Geeslin: Do you think it's reasonable to put anything to do with the history, what the patient tells you? Because you can have a lot of those be normal and the patient says "I'm suffering" or "I'm smothering to death." And I don't know, a lot of that is subjective, and we should include that in there. I would like to hear someone else's opinion on that.

Mr. Brown: For instance, the patient on beta blockers who is in congestive heart failure is going to mask many of the things such as pallor, tachycardia, and diaphoresis.

Mr. Gunderson: Gene, you mentioned something I remember earlier in the discussion about history or circumstance?

Mr. Scarberry: I was more referring to the location in which you find the patient in view of the trauma discussions. The patient's history and the patient's verbal account is an excellent way.

Dr. Geeslin: You can have a patient who says they are significantly short of breath and really that's not their problem. But I just was wondering if we should consider it or not?

Dr. Cobb: I think that's an important point. More often than not in my experience, when patients tell you, "I'm going to die," they're right.

Dr. Geeslin: They do.

Dr. Cobb: So I think that's something that you have to consider.

Mr. Gunderson: How could we phrase that eloquently? Just "symptoms"?

Dr. Nelson: History - history of the chief complaint.

Mr. Brown: Subjective findings?

Mr. Gunderson: That would be symptoms. History and symptoms?

Dr. Nelson: A specific case that comes to mind is one that someone mentioned earlier. That is the case of a burn injury involving the airway. It may not be an immediately apparent problem.

Mr. Gunderson: But it's a very high potential for obstruction.

Dr. Nelson: High potential for obstruction even though there may not at that time be an actual obstruction, so we want to be able to include that under history and symptoms.

Mr. Gunderson: Ron, what do you think of all this? Is this making sense? Are we on the right track?

Mr. Johnson: *(Ron Johnson, REMT-P, Brevard County EMS; Cocoa, FL)* I believe so, yes.

(See Figure 3 for factors to consider in determining need for ventilatory assistance)

Airway Support of Trauma Cases

Mr. Gunderson: Now, let's take the harder one first. Let's take the traumatized patient, who we've decided by whatever mechanism is going to need an airway, and he's going to need ventilatory assistance, using these criteria. How should we go about securing their airway? We have a trauma victim. He's in whatever position, in the car or out of the car, and we need to make our first initial step on his airway? Dr. Nelson?

Dr. Nelson: Before we start anything further, we need to include C-spine control. Now, we don't have to delineate that for the purpose

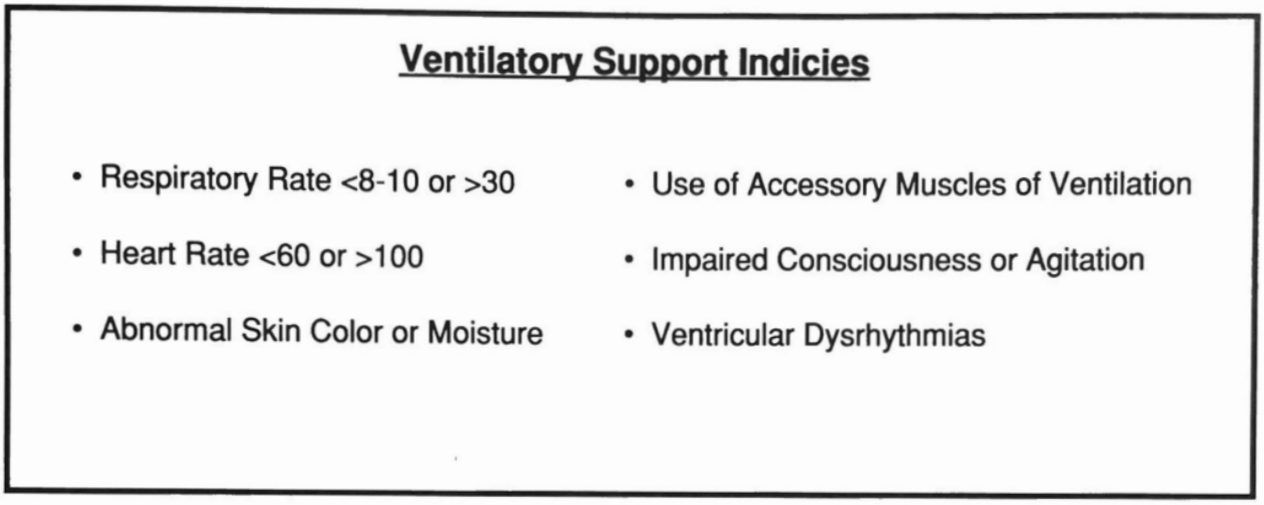

Figure 3 - Factors To Consider in Evaluating Need For Ventilatory Support

of this discussion, but we must include airway with C-spine control. And that should pervade throughout the trauma part of this algorithm.

Mr. Gunderson: Right. Let me digress just a moment conceptually in use of the protocol. Any given patient may require more than one protocol. We may have a patient who has respiratory embarrassment who is going to need an airway secured. He will need ventilatory assistance. He may also have a dysrhythmia in which case he might be falling into a ventricular ectopy protocol. He may also have some other injury following a different protocol. In this protocol, we want to concentrate on the respiratory components of the patient's problems, keeping in mind that we may need to also use a multi-system trauma protocol to include cervical spine protection.

Mr. Brown: It's generally not difficult to determine who is going to fall into the category of "trauma" versus "non-trauma." If they're a trauma patient, include cervical spine management with all that it implies. When we're selecting methods of placement of specific airways, then you have to re-include that in your decision tree.

Dr. Cobb: I think at this point in the decision tree we need to address whether the patient is spontaneously breathing or not. That's going to affect the method that we use to secure the airway.

Mr. Gunderson: If there is any ventilation at all in this stage of the decision tree, it is inadequate and it's going to require supplemental breathing.

Dr. Cobb: But it's still going to be different at this point. I would say that the patient who say is having respiratory embarrassment but still has spontaneous respirations would be a candidate for nasal intubation whereas the patient who is apneic now is not a candidate for nasal intubation, and our airway technique of choice is going to change in that patient. And we can get into that discussion in a minute, but I think that whether the trauma patient is spontaneously breathing or not is an important discrimination point.

Dr. Geeslin: Are they structurally intact? Do you have all your avenues available to you, or are you limited because of either copious amounts of blood or damaged facial structures where you really couldn't pass either an NT or an oral tube? In that case, you have only one choice.

Mr. Gunderson: So the first thing we're going to have to decide is whether or not we're going to need to go to cricothyroid or if we can come in from the top.

Dr. Cobb: We could actually branch the decision tree. One thing is going to be either apneic or severe mid-face injuries because those are going to have the same management, essentially.

Mr. Gunderson: They might not have the same route of access, though. All apneic patients won't necessarily require a cricothyroid airway whereas the mid-face injuries —

Dr. Cobb: Well, in view of the recent data I would wonder about that.

Dr. Nelson: You are saying that any patient that has sustained trauma and is apneic requires cricothyroid puncture?

Dr. Cobb: At this point the other methods are not clear. Orally intubating these patients, at least as traditionally taught using axial cervical traction, has now been demonstrated to be unsafe and, therefore, that method is out. Nasotracheal intubation, at least in most of the literature, is considered to be contraindicated in a patient who is not spontaneously breathing. Presumably, you could try retrograde intubation as opposed to cricothyrotomy, but as was pointed out earlier, that still involves a cricothyroid membrane puncture.

Mr. Gunderson: Well, let me ask you this, Dr. Cobb. When you have a patient today who is apneic and has sustained trauma, do all of them get a surgical airway in your hands?

Dr. Cobb: I would do that, yes.

Mr. Gunderson: Okay. Dr. Nelson, how would you handle this patient? He's apneic and has sustained trauma. He's in bad shape.

Dr. Nelson: I don't do surgical airways on every patient that is apneic and has sustained trauma. I know some centers recommend that, but I would like to see some sort of oral or nasal route of endotracheal intubation prior to attempting a surgical airway. I think that the retrograde intubation using a cricothyroid puncture with a guide wire is still an acceptable and a good method of accomplishing this intubation without compromising a cervical spine injury.

Mr. Gunderson: Initially what should they do? We still haven't even put in an oral pharyngeal airway. We still haven't put in a nasopharyngeal airway. What would be our first intervention?

Dr. Nelson: Oral or nasal pharyngeal airway with a modified jaw thrust.

Dr. Geeslin: And suction if indicated.

Dr. Cobb: As a first measure, yes.

Dr. Nelson: Does anybody disagree with me on that? Does anybody say we should go directly to intubation?

Mr. Gunderson: All right. So we have a pharyngeal airway in place now. We have the patient suctioned, if needed. We're going to need to ventilate them because we've decided that it's inadequate. How can we supplement their ventilation at this point? Should we use the bag? Should we use the demand valve? Should we use an automatic ventilator? We're in the mud and the blood and the beer right now.

Dr. Cobb: At this point I think I would go with a bag mask device with 100% oxygen.

Mr. Gunderson: Any discussion on that point? Okay. We have a pharyngeal airway. We have the patient suctioned, and he's now being ventilated with a BVM with supplemental oxygen. Obviously we want to get a more secure airway because secretions can still come in. We can develop edema, et cetera. We need a more definitive airway. Again, we realize the patient has the potential for cervical trauma, and we need to be cognizant of that. Mike, you gave the lecture on airway control. In your opinion, what at this point is the airway device and approach of choice? This is a trauma patient.

Mr. Brown: It depends on their state of consciousness. As I said before, certain quiescent patients can become very combative once you start stimulating their airway. At this point I would choose for the apneic patient an airway other than an endotracheal tube because we have to do cervical management. We can't be certain about the placement of an endotracheal tube if we introduce it nasally in this apneic patient. The literature indicates that we should go directly to cricothyroid puncture at this point. We do have other airway devices, for instance, the pharyngeo-tracheal lumen airway. That is one alternative. If you have a patient who does have spontaneous ventilations, as long as they don't have massive maxillofacial injuries, then blind nasal intubation is indicated. If they have no maxillofacial injuries, then we would have to proceed with an oral intubation. It occurs to me I didn't talk about the digital intubation nor did I talk about transillumination. If you have the apneic patient you can always choose one of those two methods - transillumination or digital intubation.

Mr. Gunderson: Let's consider the apneic patient here. We have a traumatized patient. We've decided that they need an airway, and we've decided that they need ventilatory assistance because they are apneic. Okay. We've narrowed it down a little bit. I hear concerns about whether or not they have maxillofacial injuries or not, and their approaches seem to be very different. I don't want to get it again real complicated, but if we have maxillofacial injuries, which one would we then want to go with?

Dr. Geeslin: You may want to bypass all of your first three or four steps up there. If they've got significant facial injuries, to be sticking in a pharyngeal airway, again with a jaw thrust, and putting a bag valve mask over them probably is not going to do any good, wastes a lot of time, and may cause further injury. So if you've got a massive facial injury, particularly with significant bleeding into the oral cavity, go straight to your cricothyroid.

Dr. Cobb: I agree completely.

Mr. Scarberry: I sat in on an airway lecture four days ago in Las Vegas, and they showed exactly the patient you just described. They passed two nasal airways into what was a horrendously destroyed face, opened the airway, used those two devices, and ventilated the patient properly, and that's all they had to do. They brought them in alive.

Dr. Cobb: They were lucky they didn't pass them into the frontal lobe or somewhere else.

Mr. Scarberry: No, I did not say nasotracheal tubes. I said just simple nasal airways.

Dr. Cobb: Still, you can't be assured of the direction they'll take. And there are devices that are blindly placed and somewhat rigid. And I just think in a patient who has a potential for a cribiform plate fracture or open sinus fractures and so on, the potential of false passage is just too high to recommend blindly passing any sort of tube through the nose.

Mr. Gunderson: Were they able to keep the lungs clear of blood in that case, Gene? They survived, but —

Mr. Scarberry: All I heard was the presentation, and he simply showed an example of one patient. When they passed this first tube in, the patient started breathing on his own and that's all they did. He stayed breathing on his own while they transported him to the hospital.

Mr. Shepler: I would like to make a suggestion. I agree with Dr. Cobb that the literature has stated that with the possibility of cribiform plate fracture, nasal intubation is contraindicated, though more studies do need to be done in facial fractures including mandibular fractures. Access of the trachea is possible with blind endotracheal intubation and also with use of the transillumination method, either using digital method with transillumination or what was described and not mentioned in the airway lecture is a hooked method described by Stewart and Paris. One thing in the real world is that these patients will often be very hypoxic because of long periods of airway compromise, and so rapid airway access is important. They have found that they were typically able to achieve airway access by the hooked stylet method within approximately 20 seconds.

Mr. Gunderson: So how about if we made a statement saying if they have maxillofacial injuries, consider the following airway interventions: Consider cricothyroid, consider lighted-tip stylet, consider —

Dr. Nelson: Retrograde.

Mr. Gunderson: — retrograde — well, we're still at square one. At that early point, would we want to include retrograde? They're getting no ventilation at all right now.

Dr. Nelson: Sure.

Dr. Cobb: I think retrograde is questionable in the patient who is not breathing spontaneously.

Dr. Nelson: Not at all. I've been involved in it being done at Tampa General at least twice. and it's worked well both times - both patients were non-breathing or barely breathing.

Dr. Cobb: I still think you can probably establish an airway faster just with cricothyrotomy. And again, you don't have as much potential for false passage as you do passing the guide wire. But that's a matter of individual preference. I think the clinician's skill and experience has to be weighed in there. I think that either method would be appropriate. This is my preference, but, you know, Dr. Nelson feels comfortable with the retrograde, and I'm sure in his hands it's a good technique.

Dr. Geeslin: Remember, we're talking about paramedics out in the field even though we may be talking about protocol, it's not in the emergency room at all.

Mr. Shepler: Dr. Cobb, have you had any experience with trans-tracheal jet insufflation? And what about that as a temporary maneuver?

Dr. Cobb: I have not had any personal experience with it. I will say that I do have reservations about the technique for a couple of reasons. One is there have been many reports of hypercapnia developing in patients ventilated that way. Oxygenation doesn't seem to be as much of a problem, but hypercapnia can develop. The other is that I think your airway is still unprotected from secretions. Some people claim that at least on theoretic grounds that the rapid insufflation will displace the secretions into the oropharynx, but I think that is not proven. We still have to consider that as an unprotected airway where there's a great potential for aspiration. I think it can be a useful temporizing measure, but I do have some questions about it.

Dr. Nelson: Two points. When was the last time that you assembled and carried the equipment required for trans-tracheal jet insufflation? It's very hard to find, and it is difficult to carry. And you have to assemble it. It's a technically difficult thing to do. The second point I would like to make about trans-tracheal jet insufflation is take a 14-gauge or even a 12-gauge catheter and attempt to breathe out through it. The problem of hypercapnia is a significant problem with trans-tracheal jet insufflation. And I'm not sure you won't build up severe airway pressures by trying to jet oxygen through that small catheter without allowing any way for it to escape. That's been my experience with jet insufflation.

Mr. Gunderson: We've got the cricothyroid access. We're considering using the blind-lighted stylet intubation with the hook technique described by Stewart, et al., and we have retrograde intubation. These are just airways to have in your back pocket, so to speak, to call upon if the circumstances indicate. Are there any other airways with this massive maxillofacial injury that would be appropriate?

Mr. Scarberry: PTL (pharyngeo-tracheal lumen airway)

Mr. Brown: Tactile oral.

Dr. Nelson: Mic? I would like to reverse my position on the retrograde intubation. I don't think it's indicated for a patient with maxillofacial injuries. I should not have put that up there because it would be dangerous to pass a guide wire. I think it should come off of there. I think it's useful in other circumstances, but I don't think it's useful in facial injuries.

Mr. Gunderson: We have a number of airways. We do not have the EOA in there. I think that's because it can still allow bleeding to get into the trachea and into the lung.

Mr. Brown: I would like to point out that in the majority of the cases, blood would be coming from one of three sources, from the nasopharynx and the nasal sinus, from the oral cavity, and from the esophagus, in which case any type airway with a palatine balloon and with an esophageal obturator balloon will keep the airway clear from secretions from those sources.

Dr. Cobb: I will have to interject this. Those are good theoretical points, but I would have problems recommending this device in a protocol at this point because I don't think that there's been sufficient research done on that point to justify recommending it. I think that before we recommend something for general use in a protocol, that it should be something that's tried and true and that has some support in empiric experience. And that, again, is my reason for favoring the cricothyrotomy. It's a proven procedure that's been used for many years by a number of clinicians all over the world, and it has a demonstrated record of efficacy and safety. And these other things may be appealing on theoretic grounds and may in fact eventually supplant cricothyrotomy to some extent, but at this point I don't think that it's prudent to recommend things until they have undergone testing in the subgroup of patients for whom we're recommending their use.

Mr. Gunderson: Your apprehension with the PTL is the effects of the palatine balloon on head trauma?

Dr. Cobb: We're blindly passing a device into the oropharyngeal cavity in a patient with facial injuries. The potential for creating false passages and so on is just, in my opinion, too great to recommend that without some studies to demonstrate its safety.

Mr. Scarberry: The studies in terms of the palatine cuff occluding upper airway bleeding are in the Annals of Emergency Medicine. That's already published data using barium as opposed to using blood, but they did a study on cadavers. I thought the Trauma Society had recognized EGTA as a legitimate blind passage device in cases of facial trauma - that was an accepted device.

Dr. Cobb: At least in the current American College of Surgeons' guidelines in the Advanced Trauma Life Support curriculum, cricothyrotomy is still the recommended airway access in these cases. And, again, although there are cadaver studies using

barium, I would not want to be on the witness stand as a defendant in a malpractice trial and have to cite those as my clinical studies to support. I agree that it may well be a good device in this setting, but I think that until someone has done an adequate clinical trial in real trauma patients, that we should confine our recommendation to things that have been proven by experience.

Mr. Brown: A question, then. What current literature is there which documents false passage of any large, blunt object passed orally?

Dr. Cobb: Or that doesn't? I don't know.

Mr. Brown: The majority of the literature that talks about blind false passage refers to percutaneous as well as surgical cricothyroidotomy and most especially the passing of any device through the nose. So I would ask the question when it comes to this device which is to be passed orally, is there any documented incidence of false passage?

Dr. Cobb: Again, I would fall back on the argument that there are no documented series in which the safety has been proven. And although on the theoretical grounds that you're citing, I think it probably is appealing and would merit study, I just don't think that it's wise to include in a protocol something that's really unproven.

Mr. Brown: Then back to the practical aspect. Clinical privileges for cricothyroid puncture, surgical or percutaneous, are generally not within the protocols of many paramedic services. There are some exceptions. Given this other device (PTL) - which is more practical? To upgrade paramedic training to cricothyroidotomy or to give them this other device (PTL) that can be passed orally? We do have a dilemma here either way you look at it.

Mr. Scarberry: Are we really saying we're recommending? Or are we simply saying - here are the things loaded in your own armamentarium. There may be situations where one — any given device is totally not going to work. It may be in the protocol, and it may be the appropriate device. But when you make the final clinical assessment, you go, "No way - I'm going to go to Plan B or Plan C." I think we're simply listing a group of plans, and then it becomes up to the director or whoever to say "That plan is the appropriate one in my system" or "I'm giving you all three options in my system."

Mr. Gunderson: Brian, would you feel comfortable with that, or do you still have quite a bit of reservation about the esophageal devices in trauma patients?

Dr. Cobb: I would at least emphasize that I would strongly consider or recommend the cricothyrotomy and consider these other things as alternatives. I agree that in any given situation one needs to have therapeutic alternatives. And these unproven modalities could be considered as viable alternatives, but I think that, echoing the recommendations of the College of Surgeons, I would still recommend the cricothyrotomy. And as to the issue whether paramedics can do cricothyrotomy or not, that is going to be at the discretion of the medical director of that system knowing full well that any course you choose does have some pitfalls.

Dr. Nelson: I would just agree with Dr. Cobb in that we should recommend cricothyrotomy as the first choice with consideration given to the other indicated means.

Mr. Gunderson: Let's take this as a given, then. If we have the trauma patient we've previously described, he has a severe maxillofacial injury. Our primary airway access method may be cricothyrotomy, but being cognizant that other interventions as shown in our diagram may be appropriate. Now, for the patient who does not have significant maxillofacial trauma, we would then insert the pharyngeal airway with the modified jaw thrust, use suction as appropriate, institute ventilation with a BVM at 100% oxygen. And where do we go from this point? These are all definitive airways. But for the patients that just have the pharyngeal airway, how do we establish a definitive airway for them? Are those the same choices? Are they applicable?

Dr. Cobb: I think it would depend on whether the patient is breathing or not. If the patient is breathing spontaneously and does not have mid-face injuries, I think that the method of choice would be blind nasal intubation or styletted nasal intubation. However, if the patient is apneic, then you end up in the same situation that we were talking about above. Again, I would favor, at this point, based on the literature, favor cricothyrotomy in those patients as well. You could consider, if the operator was skilled, using the lighted stylet to rapidly place it or digitally intubating or something. Whatever technique you use, you would have to be certain not to disrupt the stability of the cervical spine which would effectively rule out laryngoscopic oral intubation.

Mr. Gunderson: This is going to be sticky, I think, no matter how we treat it. We just have to accept that. In an apneic patient who does not have massive maxillofacial injuries, Dr. Cobb has expressed a preference for cricothyroid access. Ron, what would you go with at this point?

Mr. Johnson: I believe I'm going to have to back up Dr. Cobb. We just revised our protocol in the last month, and that's basically the way we're leaning right now. Even the other ambulance service in the county is going that way. They're doing a modified trans jet, but we're still —

Dr. Nelson: Your paramedics are going to be cutting people's necks in the field?

Mr. Johnson: Yes, sir. The medical director is going to be coming out doing the actual training in about two weeks. We've got the protocols out for them to read. We're having mandatory meetings next week, and then he and the director will be coming out in about two weeks with actual training.

Mr. Gunderson: If you didn't do a cricothyroid, which approach would you take, Dr. Nelson? Obviously you don't agree with the cricothyroid. Which approach would you use in this patient?

Dr. Nelson: I don't disagree with cricothyroid. Surgical cricothyrotomy. My second choice of the cricothyroid routes would be a retrograde intubation, in this case using a guide wire.

Dr. Cobb: That's reasonable.

Dr. Nelson: My third choice, avoiding the cricothyroid route — let me add, I would not do trans-tracheal jet in any way — would probably have to be blind-lighted stylet intubation or the PTL.

Mr. Gunderson: Tactile oral?

Dr. Nelson: I'm not sure.

Mr. Brown: I would like to point out here, as far as the pharyngeal airway, the American College of Surgeons' Adv*anced Trauma Life Support* text does recognize that nasal airways can be placed in the head-injured patient. Once the tip is visualized in the oral airway or rather in the pharynx, you can safely pass suction catheters or NG tubes. The construction of nasal airways is very different from that of the harder PVC suction catheters or Levine tubes. Being soft and having a pre-curvature, they can be placed safely. I would emphasize you must visualize the tip protruding from the nasopharynx into the pharynx.

Dr. Cobb: Well, I think in the hospital situation, yes, but in the field situation where it's often difficult to visualize anything, you may not have really adequate suction. You may have darkness to contend with and so on. Nasal instrumentation is probably just best avoided entirely. I think that in the patient without facial injuries, the PTL or these other devices are perfectly appropriate. But in the patient with facial injuries, I still think the preponderance of the literature would support cricothyrotomy as the first airway measure.

Mr. Gunderson: Okay. These look very much the same, the only difference is we have blind nasal over here.

Mr. Scarberry: Mic, I think we also, out of fairness to your apneic category, you have to add EGTA because when you don't have facial trauma, it is a legitimate device.

Airway Support of Non-Trauma Cases

Mr. Gunderson: So we now have a patient who needs an airway, is inadequately ventilated or is apneic, but does *not* have trauma. We're looking at more of the typical medical cardiac arrest victim. What are our steps there? Reflecting on our trauma sequence, would a pharyngeal airway be our first step?

Dr. Nelson: I would also have to include the PTL because I think it's probably just about as fast to put that in as it is to slip a standard oral airway in.

Mr. Scarberry: Our current times are about 15 to 20 seconds.

Dr. Cobb: I think that's probably accurate, especially if you use a tongue blade to place the oral airway. You're probably talking about the same length of time. And actually with this device you then would have a definitive airway as opposed to temporizing. So actually there might be some advantage to doing it that way.

Mr. Gunderson: Suction.

Dr. Cobb: Yes, suction.

Mr. Gunderson: And now we're going to ventilate with BVM or the mechanical ventilator.

Dr. Cobb: Either.

Mr. Brown: Since the pharyngeo-tracheal lumen airway is mentioned in the non-trauma patient, are there any studies with the pharyngeo-tracheal lumen airway that looked at the patient that needed ventilatory support and an airway device, but were somewhat responsive? I ask this because cases such as the COPD patient and the CHF patient that require aggressive ventilatory support can tolerate a nasally introduced tube.

Mr. Scarberry: If he can tolerate an oropharyngeal airway he can probably tolerate a PTL. But a nasopharyngeal airway is more likely to be tolerated by a patient with a higher level of consciousness. If there's an intact gag reflex, the PTL is contraindicated.

Mr. Brown: We do have the option of administering oral cavity and pharyngeal anesthesia - topical anesthesia - for the same patients.

Dr. Cobb: If you're doing a blind nasal technique, for example, I think using a topical vasoconstrictor and a topical local anesthetic is reasonable.

Mr. Brown: However, with a congestive failure patient, I would tend to go ahead and use the endotracheal tube rather than the pharyngeo-tracheal lumen airway.

Dr. Cobb: Right. Well, you can entirely bypass using the pharyngeal airway by placing the nasotracheal tube partially into the nasopharynx, but not yet advancing it into the larynx, and then administer oxygen through that and use that as an oxygen administration device.

Mr. Gunderson: Essentially use a partially inserted nasal endotracheal tube as a nasopharyngeal airway.

Dr. Cobb: Right, pending definitive placement of the tube. So you actually begin administering oxygen into the patient's airway before the tube is placed in the trachea.

Mr. Gunderson: So it would still be a pharyngeal airway, that would be just an option instead of using a specific device.

Dr. Cobb: Right. But, I would say that the PTL should be reserved for the obtunded patient. In the conscious patient I think it really should not be used. And in that case one should go either with an oropharyngeal or a nasopharyngeal airway or an endotracheal tube.

Dr. Nelson: You can't use an oropharyngeal airway in a conscious patient anyway.

Dr. Cobb: Right, a nasopharyngeal airway.

Mr. Scarberry: Right.

Dr. Nelson: Neither.

Dr. Cobb: Nasopharyngeal airways? - Actually, I've seen people tolerate them.

Mr. Scarberry: A nasopharyngeal will work on a semi-intact gag reflex; the oropharyngeal airway will not work.

Mr. Brown: That's the chief reason for its popularity is that it is much more easily tolerated in the patient that falls into that gray area between fully unresponsive and fully responsive. And we've seen that fully responsive patients can also tolerate it.

Dr. Cobb: But that's why I think just going ahead and placing the nasotracheal tube gives you an advantage because you can administer oxygen while securing the airway.

Mr. Gunderson: Now, the only thing that remains is for the case in which we're not using the PTL is now providing a more definitive airway beyond the pharyngeal airway. Would it would be appropriate to simply say the non-surgical intubation methods since there's no trauma?

Dr. Cobb: Oral or nasal tracheal intubation.

Mr. Gunderson: And simply leave it at that?

Dr. Cobb: By whatever means are appropriate.

Mr. Brown: Again, direct laryngoscopy is the preferred method, whether it's an oral or a nasal tube simply because of the speed and the sureness —

Dr. Cobb: In the unresponsive patient.

Mr. Brown: — and the lack of — or the ability to avoid blunt trauma to those delicate structures.

Dr. Cobb: In the unresponsive patient.

Mr. Scarberry: I like that because that's the correct statement. The preferred method at that stage is direct visualization. So oral or nasal direct visual intubation, and then second, backup mode, is tactile, lighted stylet, and all the rest.

Dr. Nelson: Or the indirect methods.

Mr. Scarberry: Okay. Thank you.

Mr. Gunderson: Or indirect if difficult.

Mr. Scarberry: Right.

Mr. Gunderson: Does everybody feel comfortable with this (referring to notes on the board)?

Mr. Scarberry: I would add two more legs on your last statement. If indirect is difficult, you would still go with an EGTA or PTL. Those would be your other modes in advanced care.

Mr. Gunderson: Comments?

Mr. Brown: Difficult intubations have to do with one of two things, one of which is patient responsiveness and combativeness, and the other is difficulty in visualization or in blind placement.

Mr. Gunderson: Let's assume that we've done the procedure properly, and we've given them their topical anesthesia, so —

Mr. Brown: The point being is that if the intubation were difficult because of patient combativeness, that doesn't seem to be an indication for placement of an esophageal obturator airway.

Obstructed Airway: Non-Trauma Cases

Dr. Nelson: If you're dealing with a complete upper airway obstruction, your method of choice is, barring basic life support procedures to clear that obstruction, cricothyroid surgical management - cricothyroid puncture surgical. I'm talking about in the non-trauma patient.

Dr. Cobb: If you're unable to ventilate the patient after the pharyngeal airway or PTL is placed, I think is what he's getting at there. If you're unable to ventilate the patient at that point, then more than likely you're dealing with upper airway obstruction, and you should proceed either to airway clearing maneuvers and failing that to surgical airway.

Mr. Scarberry: Would you not want to visualize it before you went to surgical airway?

Dr. Nelson: That takes too long. You don't have that kind of time. You don't have that kind of time to sit there and try to visualize something.

Dr. Cobb: Especially in a patient who may be struggling.

Mr. Brown: Then, again, some textbooks say that the inability to ventilate calls for the immediate examination by laryngoscopy of the glottis.

Mr. Gunderson: With the Magil forceps in your hand.

Dr. Cobb: Again, I think that depends on the patient's status. It is a matter of clinical judgment. If you have a patient who's struggling and obviously becoming hypoxic but still struggling, trying to laryngoscope a patient like that is going to be exceedingly difficult. And administration of sedation or neuromuscular blocking drugs to that patient is fraught with hazard and most foolish.

Dr. Nelson: What do you do if you come at them with a knife?

Dr. Cobb: You get enough assistance and you hold them down.

Mr. Brown: Then a point of clarification. If you have an apneic, profoundly obtunded or flaccid patient, and you insert an oral or a nasal airway and then attempt to ventilate and find very low compliance, then the immediate maneuver should be laryngoscopy.

Dr. Cobb: Laryngoscopy is reasonable in that case, but in the patient who is struggling, laryngoscopy is almost impossible. And take it from me, I've tried it.

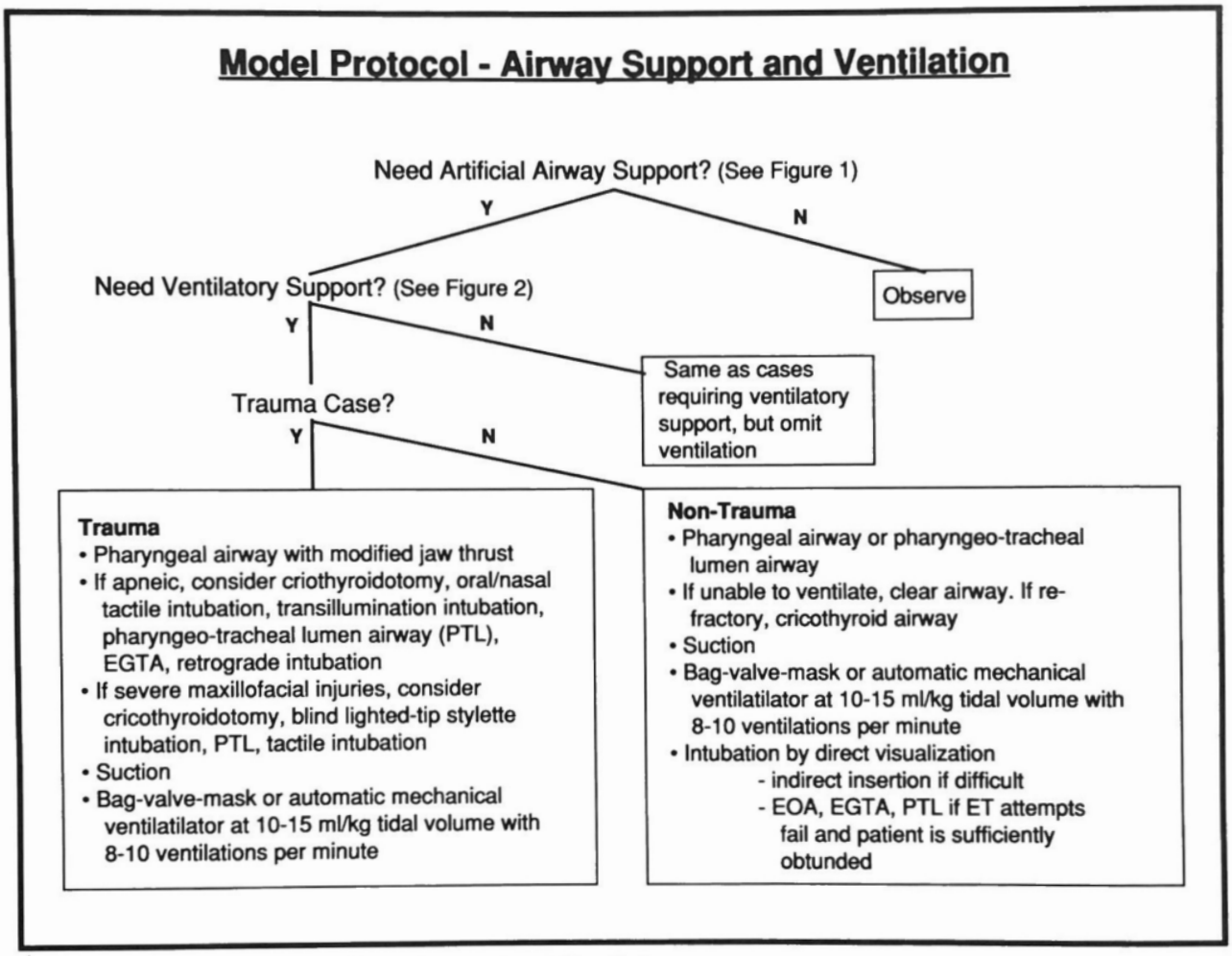

Figure 4 - Model Protocol for Airway Support and Ventilation

Mr. Brown: And I fully agree.

Dr. Nelson: That would fit under the "clearing the airway." You could try basic life support or laryngoscopy procedures to clear the airway. But the definitive treatment for obstructed airway that remains obstructed is going to have to be cricothyroid access.

Mr. Gunderson: So if they are refractory to whatever means are employed to clear the airway, which could be a whole separate sequence, then we go to the cricothyroid.

Mr. Brown: I would like to briefly solicit opinions on this point. When you have persons who are trained in laryngoscopy and you have a patient that you are unable to ventilate, should one go initially with the airway maneuvers described under basic life support, or should one proceed immediately to the laryngoscopy? I've seen both opinions written in the textbooks.

Mr. Gunderson: I, myself, I've gone directly to the laryngoscopy rather than the artificial cough if they're unconscious. If they're still struggling, then I'll —

Mr. Brown: Again, I'm referring to the profoundly obtunded patient.

Mr. Gunderson: Profoundly obtunded patient - I usually go with the laryngoscope.

Dr. Cobb: I think I would go with a laryngoscopy at that point, too, particularly in the adult. The object is most likely to be obstructing at the level of the vocal cords because that's the narrowest point of the upper airway, and so you're probably going to be able to visualize it and remove it. But in the patient who is struggling, again, I think that the other measures have to be used.

Mr. Gunderson: Again, assuming that you've got your laryngoscope and forceps immediately available. It certainly is not the type of situation where you would want to have your partner go back to the truck and get it.

Dr. Cobb: No, in that case you proceed with the BLS maneuvers.

Mr. Gunderson: Was there something else we had underneath the oral or nasal intubation by direct visualization?

Dr. Cobb: Mechanical ventilation.

Mr. Gunderson: We've already done that.

Mr. Scarberry: My comment was if difficult, the third fallback would be EGTA or PTL, because that's the backup.

Dr. Cobb: For failed intubation attempt. Again, with the caveat that that is to be in the unresponsive patient. A failed intubation attempt in the conscious patient would necessitate different management, administration of supplemental oxygen primarily, using an alternate method.

Mr. Brown: Preparing them with adequate topical anesthesia and/or the administration of analeptic agents.

Dr. Cobb: I personally am opposed to the use of neuromuscular blockade by personnel who aren't trained extensively in airway management.

Mr. Gunderson: That is an entirely separate issue beyond the scope of this discussion. That's a protocol for a specific intubation procedure.

Ventilation

Mr. Gunderson: The only point at which they (trauma and non-trauma cases) would come back together is in what we would use for ventilation. We're using BVM right now. Would we go to something else later on?

Dr. Cobb: I would say BVM, then consider mechanical ventilation.

Mr. Walters: *(Cline Walters, Aero Products; Longwood, FL)* Could you not consider the mechanical ventilation up there in the beginning?

Dr. Cobb: The problem is once you've instituted bag valve mask ventilation, I think it's best to continue with that until you've secured the airway and then change your modalities. To change your modality of ventilating the patient in the middle of trying to establish an airway, to me, would be unwise. I would wait until the definitive airway has been established, put the patient on the ventilator, and then go about the remaining tasks.

Mr. Walters: Certainly. But most of the newer ventilators also have BLS as well as ALS application. They can be used very similar to a bag valve mask.

Dr. Cobb: They can be. In general, the bag-valve-mask is more portable, easier to deploy, and requires less manipulation at the scene in say in a crashed car or in a ditch or something. You want to go with the simplest equipment you have at that moment.

Mr. Scarberry: And it may give you some tactile feedback.

Dr. Cobb: I think there's definitely a place for mechanical ventilation in these patients, but I would prefer — Joe, how do you feel about that? I would prefer to wait until the airway is definitively established.

Dr. Nelson: I would like to see mechanical ventilation be limited to those cases where an endotracheal tube or some other direct tracheal access is gained. That also doesn't rule out the use of the demand valve.

Mr. Walters: Let me bring up a couple of points. An inherent problem with bag valve resuscitators is having one hand used to squeeze the bag and the other hand being used to maintain the seal. If the automatic ventilator is carried in a small enough kit and is accessible, you can have a two-handed mask seal operation versus only one hand on the bag and one hand on the mask. So with the advantage you're going to gain there in time with the bag-mask, which may only be a matter of one or two seconds with the way some people have their kits set up, you're going to lose gas with mask leakage due to a one-handed seal method. Whereas, once you've got your automatic ventilator set up, you have two hands free to maintain that mask seal. I just throw that out as a consideration because tidal volume and rate can be controlled more accurately by the automatic ventilator, rather than with the human element of squeezing the bag.

Mr. Gunderson: It seems to be an ergonomic problem.

Mr. Brown: You're in a manpower poor environment when we're talking about the prehospital arena. Not always true if you have an adequate number of responders, but then you run into how skilled are your extra responders. So Cline has a very good point there - it (automatic ventilator) can be an aid in the manpower poor environment.

Mr. Gunderson: Assuming the ventilator is right there with you in your jump equipment, you just turn it on, he can use both hands to hold the seal rather than one hand on the mask, one hand on the bag.

Dr. Cobb: I have no major objection to it. We could put as an alternate —

Mr. Walters: Either/or.

Dr. Cobb: — consider mechanical ventilator at that point.

Dr. Nelson: However, I would like to interject that I don't think that any sort of mechanical device can be 100 percent dependable here. There should always be a backup.

Mr. Walters: Absolutely.

Dr. Nelson: But I don't have any problem with the mechanical ventilators.

Mr. Gunderson: Do we want to specify our tidal volume recommendation and a ventilatory mode?

Dr. Cobb: Use a 10 to 15 ml per kilogram tidal volume with a rate of 8 to 12 breaths per minute in the adult.

Mr. Gunderson: We're only talking about the adult.

Dr. Nelson: I would agree with that.

Mr. Gunderson: It looks like we have a ventilated trauma patient with a definitive airway.

(See Figure 4 regarding the model protocol)

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Protocol Roundtable Literature Search: Airway and Ventilation

A literature search was conducted on the general subjects of EMS, airway control and ventilation. The search was made by computer using the PaperChase system at Beth Israel Hospital in Boston, Massachusetts. PaperChase is an interface to the Medline medical bibliographic data base from the National Library of Medicine. The Medline data base indexes the articles from thousands of medical and scientific journals each month. Each article is characterized as to its subject matter with keywords. By using a combination of keywords, title words, and modifiers (such as language of publication), articles related to the general subject are efficiently identified.

The strategy used for the EMS related search on airway control and ventilation is shown in Table 1. During the search process, each keyword, title word or modifier is put on a separate list, labeled A....Z and continuing with 1A, 1B, 1C, et cetera. To the right of each search word in Table 1 is number which represents how many citations were found which satisfy the search word or search word combination. For example, the data base found 5,725 citations under the search word "airway" (List A) and 4,228 were found under "emergency medical services" (List D). List F shows how many citations there are in common between these two, lists A and D, returning 12 citations. This means that the data base has 12 citations which have both "airway" and "emergency medical services" as search words. List 1D compiled all the various lists into one list with 385 citations, excluding duplications. By using the modifier for obtaining English language articles only, that was narrowed to 115 citations, as shown on list 1E. These 115 citations are listed below for individual EMS agencies to use in researching their protocol modifications on the subject or to guide additional reading.

Consult you librarian for assistance in obtaining reprints of the articles. Alternatively, the PaperChase service will obtain reprints upon request for a fee. PaperChase may be accessed by most any computer with a modem via a local telephone number and the CompuServe information network.

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Search Strategy - EMS, Airway and Ventilation

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F) *ON A&D	12	V) *ON N&T	21
G) *ON B&E	30	W) PARAMEDIC...	4821
H) *ON C&E	0	X) *ON A&W	15
I) *ON B&D	50	Y) *ON C&W	0
J) *ON C&D	0	Z) *ON B&W	16
K) INTUBATION...	4220	1A) *ON L&W	37
L) INTUBATION...	10981	1B) ENGLISH	3678620
M) *ON D&L	39	1C) *ON T&W	8
N) PREHOSPITAL...	4550	1D) *SUM FGHIJMOPRUVXZ1A1C	385
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POSTPONED

Due to shceduling conflicts, the Medical Control and Continuing Education Symposium has been postponed frm its original date of May 6-7, 1988. Announcement of the new date and location will be made shortly. For further information, please contact the Acute Care Foundation, P.O. Box 280173, Tampa, FL 33682 (813) 988-0115

The philosophies, issues and methods for medical control and continuing education in tody's and tommorow's EMS systems will be the themes for this first unique two day national symposium. It will provide an excellent academic forum suited to medical directors, inservice instructors, quality asurance staff, educators and administrators.

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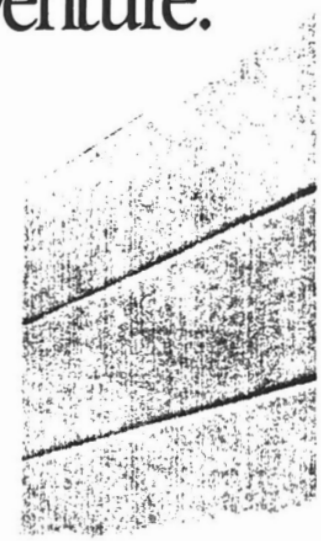

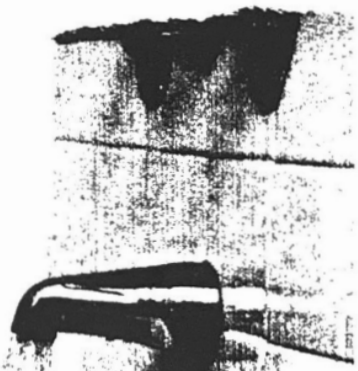

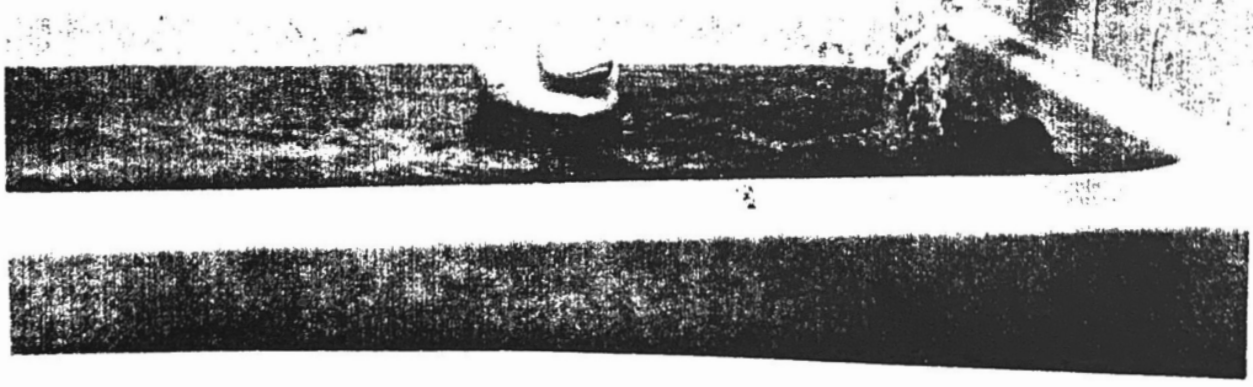

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Tampa Bay EMS Journal

Volume 1, Number 4
April - June, 1988

Abstracts

Compiled by Journal Staff

Complications from IV Therapy: Results from Field-Started and Emergency Department-Started IV's Compared

LAWRENCE DW, LAURO AJ

Annals of Emergency Medicine 17(4):314-317, 1988

A two month study was made of metropolitan hospital IV complication rates in two groups - Group A (N=82) had their IV started in the field by EMT-I or EMT-P's; Group B (N=109) had IV's initiated in the emergency department. Only patients admitted to general wards, as opposed to intensive care areas, were studied because cases with field started IV's are immediately replaced if brought into the ICU. All IV sites were at or distal to the antecubital area, using plastic catheters of several gauges and lengths. Patients were matched between groups for age, admitting diagnosis, IV fluid and medication, and other parameters. IV complications were characterized as phlebitis (local) or fever (systemic). The prehospital group (group A) had a 34% incidence of phlebitis versus 7% for the emergency department group (group B)($p < .001$). For fever, group A cases had a 22% incidence versus 4% from group B ($p < .01$). The authors claim the results support the hypothesis that prehospital IV therapy poses greater risk of complication compared to the emergency department. They suggest investigation into measures to improve aseptic technique in the field, such as cleaning the clinicians hands with alcohol based foam or wearing gloves. They suggest prehospital lines be replaced as soon as possible after hospital arrival. Suggestion is made that the catheter movement inherent to the prehospital phase during transportation may be a non-contamination cause of the observed prehospital phlebitis. The authors conclude the risk/benefit ratio should be considered in selecting patients for prehospital IV therapy. Reprints: Albert J. Lauro, MD, Emergency Medical Services, Charity Hospital, Room 1812, 1532 Tulane Ave., New Orleans, LA 70140

Hypokalemia and Out-of-Hospital Cardiac Arrest

FEDMAN R, WHITE RD

Journal of Emergency Medical Services 13(4): 56-58, 1988

Case histories of four patients and discussion are provided on the topic of hypokalemia as a possible etiologic factor in out-of-hospital cardiac arrest. The authors suggest that hypokalemia may have been a precipitating factor or even solely responsible for these arrests. All patients studied were found to have a low initial serum potassium level (2.4-2.8 mEq/L - normal range 3.6-4.8 mEq/L). All cases were defibrillated, 3 received CPR, 3 received lidocaine, 1 received epinephrine, none received sodium bicarbonate. The authors assert that the literature does not support the idea of defibrillation or CPR influencing serum potassium levels. Epinephrine can cause transient hypokalemia. The one patient who received epinephrine had hypokalemia persisting for over 24 hours post-arrest, minimizing the possibility of it as the cause. In 2 of the cases, myocardial infarction was identified. The dysrythmia generating potential for MI is well known, but it might have been further compounded by hypokalemia. Two patients did not have MI. Both were on diuretics, which may have caused the hypokalemia. The authors conclude that hypokalemia may be a pre-existing disorder, not induced by resuscitation. The potential role of prehospital potassium administration is discussed, but dismissed for lack of technology to make field measurements of serum potassium levels.

Oxygen Enrichment of Bag-Valve-Mask units During Positive Pressure Ventilation: A Comparison of Various Techniques

CAMPBELL TP, STEWART RD, KAPLAN RM, et al

Annals of Emergency Medicine 17(3):232-235, 1988

The delivered oxygen concentration from a Laerdal bag resuscitator was tested during ventilation of a mechanical test lung at high (0.1) and low (0.01) compliances with ventilation rates 12 and 20 per minute. Oxygen concentration was measured with an on-line analyzer. At 12 ventilations per minute, rapid refilling by spontaneous bag expansion and slow refilling over a 3-4 second period was employed. At 20 per minute, only rapid refilling could be used due to the limited time between ventilations. Oxygen enrichment to the intake of the bag was made by three different methods - supplemental oxygen supply at 15 L/min with a 100 ml reservoir tube, a 2.5 L reservoir bag or attachment of a demand valve resuscitator directly to the bag refill port. In their results, compliance and tube reservoir size were not significant variables to the delivered oxygen concentration. At 12 ventilations per minute, delivered oxygen concentration was 82% with the tube reservoir, 100% with the reservoir bag and 100% with the demand valve. The demand valve consumed less oxygen from the cylinder than the other methods. The authors found the slow bag refill technique to increase the delivered oxygen concentration when using a tube reservoir, but assert that the inconvenience should not be imposed upon field clinicians. They recommend that the 2.5 L bag reservoir or the demand valve be used. Further, caution must be used with the demand valve when attached to the bag to prevent inadvertent manual triggering during patient exhalation, as it may cause dangerous levels of PEEP. Reprints: Ronald D. Stewart, MD, FACEP, Department of Emergency Medicine, University of Toronto / Sunnybrook Medical Center, 2075 Bayview Ave., B-G 315, Toronto, Ontario, Canada M4N3M5

Calendar

CALENDAR EDITOR: Steve Gross, REMT-P

The Journal wishes to promote continuing education and other academic events open to the EMS and critical care community by offering free listings of such events in this section. Please submit the name of the event, sponsoring organization, date, time registration information, tuition and a contact person address and a phone number for additional information. Calendar items must be received no later than 45 days prior to our quarterly publication dates on the first of January, April, July and October to appear in the next issue. Send items to the Calendar Editor, Tampa Bay EMS Journal, P. O. Box 280173, Tampa, Florida 33682 or call 813/988-0115.

April 5, 1988

Trauma Care: Thoracic and Abdominal Injuries

Orlando, Florida - Best Western Catalina Inn, 3401 L.B. McLeod Rd. Tuition $94. For addtional information, contact Health and Education Council, Inc., 7201 Rossville Blvd., Baltimore, MD 21237, (301)686-3610.

April 15, 1988

Controversies in Critical Care Pharmacology

Jacksonville, Florida - Park Suite Hotel, 9300 Bay Meadows Rd. Tuition $94. For additional information, contact Health and Education Council, Inc., 7201 Rossville Blvd., Baltimore, MD 21237, (301)686-3610.

April 20, 1988

The Acutely Ill Child

Orlando, Florida - Best Western Catalina Inn, 3401 L.B. McLeod Rd. Tuition $94. For addtional information, contact Health and Education Council, Inc., 7201 Rossville Blvd., Baltimore, MD 21237, (301)686-3610.

April 23-24, 1988

Advanced Cardiac Life Support (AHA)

Polk Community College, 999 Ave. H, NE, Winter Haven, Florida 33880. For further information, contact Craig Story, (813)297-1000.

April 29-May 1, 1988

Conference for Hazardous Materials Resource Teams

Bethesda, MD - Mariott Hotel. Information - Cpt. Mary Beth Michos, Fir/Rescue Training Academy, 10025 Darnes Town Rd., Rockville, MD 20850

May 5-8, 1988

Emergency '88

Clearwater Beach, FL - Cotact Medical Education Department, Suncoast Hospital, P.O. Box 2025, Largo, FL 34294 (813)586-7103

(Postponed - New date to be announced) May 6-7, 1988

1st Annual National Symposium on Prehospital Medical Control and Continuing Education

Tampa, FL - For additional information, contact the Acute Care Foundation, P. O. Box 280173, Tampa, FL 33682, (813)988-0115.

May 7, 1988

Advanced Cardiac Life Support Provider Course

USF College of Medicine Medical Center Cafeteria - 7:30 a. m., For further information, contact The Center for Emergency Medical Education, Inc., Harbourside Medical Tower, 4 Columbia Dr., Suite 810, Tampa, Florida 33606, (813)251-6911.

May 9, 1988

Arterial and Mixed Venous Blood Gases: Advanced Concepts

Orlando, Florida - Best Western Catalina Inn, 3401 L.B. McLeod Rd. Tuition $94. For addtional information, contact Health and Education Council, Inc., 7201 Rossville Blvd., Baltimore, MD 21237, (301)686-3610.

May 18-22, 1988

Response '88 - 17th Annual Conference of the National Association of Search and Recovery

Salt Lake City, UT - Contact Peggy McDonald, NASAR, P.O. Box 3709, Fairfax, VA 22038 (703)352-1349

May 20-22, 1988

Conference on Citizen CPR

Cincinatti, OH - Westlin Hotel. Contact the Conference Corporation, P.O. Box 805, Solana Beach, CA 92073 (619)481-5267

June 1-4, 1988

National Association of Emergency Medical Technicians 11th Annual Educational Conference

Reno, Nevada - Bally's Hotel. Contact NAEMT, 9140 Ward Parkway, Kansas City, MO 64114 (816)444-3500

June 10-12, 1988

4th Annual Conference of the National Association of EMS Physicians

Washington, DC - Hyatt Regency, Capitol Hill. Contact NAEMSP, 190 Lothrop St., #113, Pittsburg, PA 21201 (301)328-3930

June 10, 1988

Crisis Intervention Skills for Emergency Department Personnel

Orlando, Florida - Best Western Catalina Inn, 3401 L.B. McLeod Rd. Tuition $94. For addtional information, contact Health and Education Council, Inc., 7201 Rossville Blvd., Baltimore, MD 21237, (301)686-3610.

July 23-24, 1988

Basic Trauma Life Support

Polk Community College, 999 Ave. H, NE, Winter Haven, Florida 33880. For further information, contact Craig Story, (813)297-1000.

Tampa Bay EMS Journal

Volume 1, Number 4
April - June, 1988

Editorial

Organizational Culture as a Medical Control Instrument

The topic of medical control and one of its components, retrospective quality assurance, has been getting more attention lately by the EMS community. This is a very positive trend. However, I am concerned about how EMS systems approach this very important issue.

There is tendency, particularly in bureaucracies (like EMS agencies), to inadvertently emphasize form instead of function. In most cases, form is easier to deal with. Function can be rather difficult to define and therefore difficult to assess.

In the case of EMS medical control, quality assurance programs have focused on review of the field report or "run ticket." While that is perfectly legitimate and worthwhile, investing an agency's entire medical control effort in it can satisfy the "bean counters" of the bureaucracy in doing something tangible and generating lots of paperwork, but it can also lead to a very false sense of security about the quality of care delivered in the system.

To illustrate the point of potentially misplaced emphisis on field report audits, consider the all too common case of large multiple victim scenes where things were totally out of control, disorganized, and very poor patient care was delivered as a direct result. Occasionally, I have had opportunity to see the reports that were filed on such calls. Some of them depicted the scene and events with little or no resemblance to the actual situation. These "buffed" reports portrayed the scene as the perfect picture of order, control, efficiency and exemplary patient care.

The term "buffing a chart" was popularized in a not so fictional novel about medical residency training where the quality of care was not judged by patient outcome, patient satisfaction, or direct observation of clinical performance - it was judged solely on the basis of documentation in the charts, even though the charts did not reflect the actual condition or treatment of their patients.

In real life, a good paramedic, in the terms of an errant medical control system based primarily on field report audits, is one who can write a "clean" report. A clean report can be a realistic account of a well managed call. Or, it can be a more contrived representation of what should have happened, but maybe did not in reality - It has been "buffed clean." Buffing is learned skill. The buffer learns what the medical auditors are looking for, regardless if the auditor is a paramedic supervisor or a physician medical director. A skilled buffer can present the facts in such a way that appeases the known sensitivities of the auditors. They may even stroke the auditors by including things they know the auditor likes to see in the report. The line between buffing and outright falsification of medical records is very thin. Some techniques for buffing avoid the falsification issue. By not keeping track of times and events as they occur during the call, one can simply call the dispatcher to get on-scene times and extrapolate times and events with literary license to the best of one's recollection. This allows the buffer freedom to recall things in a way that looks good on paper. If a q5m epinephrine schedule was to be maintained during a code, a sly buffer will recall times with several 5 and a few 4 or 6 and even a rare 7 minute interval between doses.

I do not mean to imply that this is a common phenomenon. I hope it isn't. I have no way of knowing how widespread it is or isn't. Retrospective review of field reports is necessary. My point is that retrospective review of field reports is only one component of good quality assurance and comprehensive EMS medical control program. Don't allow your medical control program to rely too heavily on the written reports just because they are the primary documentation of the incident. Form is important, but only as much as it is an accurate reflection of function. The buffers can exploit a misdirected medical control effort, such that the paramedic you think is your best may indeed be your worst in terms of actual patient care. Even in the case of paramedics who are not intentionally buffing their reports, the typical approaches to documentation of field care are grossly inadequate and can result in very misleading impressions.

The solution? One could start by looking to technology by which documentation in a field environment could become more practical. Verification by direct observation of field operations by paramedic supervisors and medical directors with notation of the events taking place and comparing them to the reports that are filed may be a step in the right direction. However, in practical terms, the technology for making documentation easier can probably be manipulated by the intentional buffer. If the buffer is aware of observers, their tracks will be hidden from view. Besides, only a small percentage of calls can possibly be monitored by such third party observers.

What I think may be the most effective measure may also be the slowest and most difficult to implement. Nonetheless, it would be very worthwhile. It is bringing the influence of the medical control system and the medical director to bear on the professional attitudes of the paramedics. Medical directors for EMT and paramedic training programs must make sure that a deep sense of ethics, professionalism and personal accountability becomes instilled into each student. That doesn't happen now. The organizational "culture" of the EMS agency should be developed in such a way that buffing or anything else short of total professionalism and clinical excellence is not acceptable to the standards of the medical director, or perhaps more influential, one's colleagues. The higher quality of care cannot be mandated, it must be inspired. That also doesn't happen now. This approach might be very effective when coupled with a peer review medical audit program. By peer review, I do not refer to paramedic supervisors, but to the direct participation of field paramedics in the audit process.

The organizational culture, by shaping the basic attitudes of field personnel towards their own self-image as professionals, fostering professional growth and self-actualization, encouraging traits of compassion and a sincere desire to clinically perform to the best of one's potential ability, is perhaps the best instrument for effective medical control. Unfortunately, its the most neglected one.

Michael R. Gunderson, REMT-P
Editor

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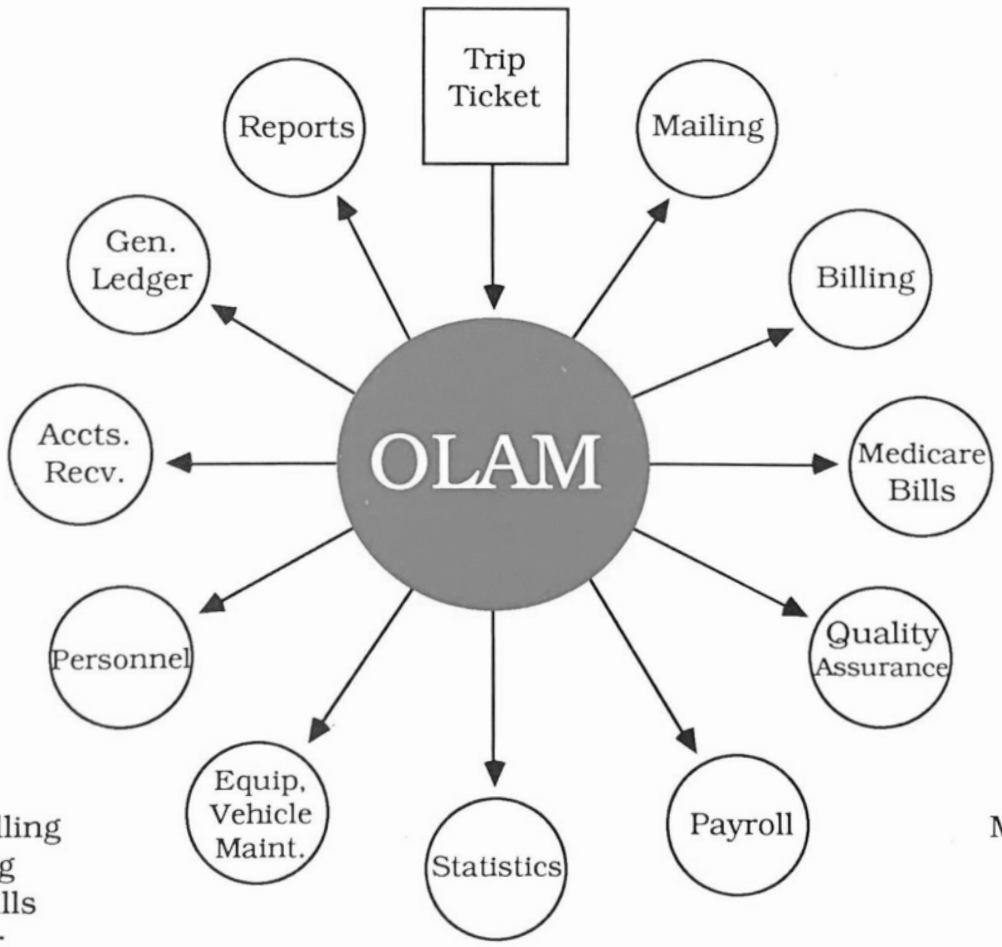

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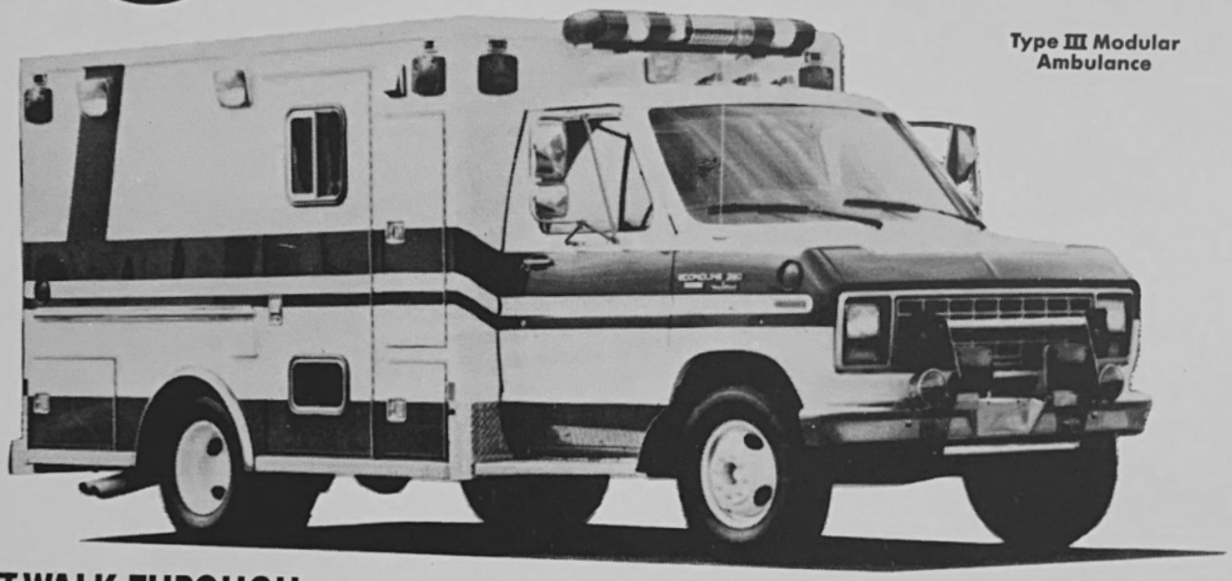

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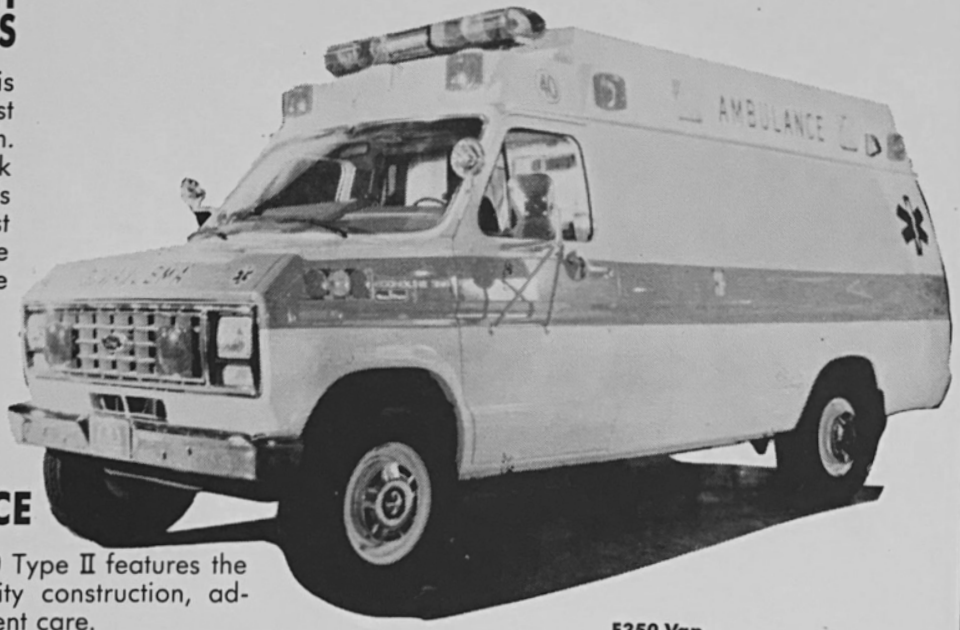

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