LUCAS COUNTY

TO: ALL LUCAS COUNTY PARAMEDICS

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Lucas County EMS Continuing Education Program Administrator

DATE: September 17, 2014

SUBJECT: **Continuing Education – October 2014**

In the month of October we will once again review the newer educational material that has been added to the paramedic scope of practice in the State of Ohio:

- Morgan medi-FLOW Lens
- Chest tube monitoring
- Blood product administration
- Blood chemistry analysis
- Positive End-Expiratory Pressure (PEEP)

Using a Jeopardy-style game we will inject some lively competition into each class to cover the above listed topics. I have included educational material for you to review that will aide you with game responses. In addition, hands-on stations will be geared towards commonly used skills in the field.

As a reminder, all who are nationally registered should have created a user account by logging into nremt.org.

If you have any questions or comments please feel free to contact me.

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Morgan Lens

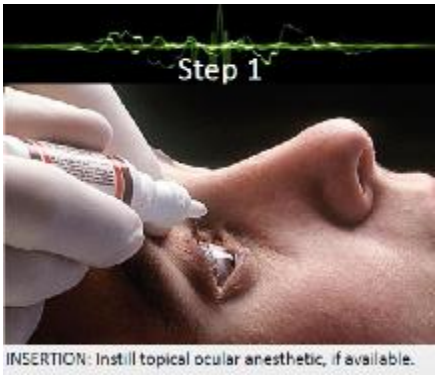
The Morgan Lens was developed during the Vietnam War by Dr. Loran B. Morgan, an ophthalmologist. He believed that something as simple as thoroughly irrigating a patient's eye can keep them from later developing more serious complications. The Morgan Lens is very quick to set up, insert, and requires minimum supervision. It also allows patients to keep their eye closed during irrigation, which is the natural reflex for most patients with ocular injuries, and generally more comfortable.

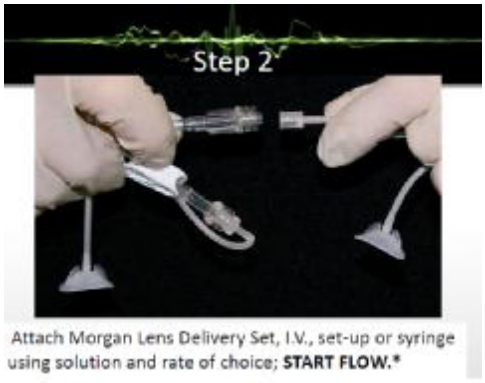
Both the cornea and conjunctiva are flushed by the Morgan Lens. The lens itself does not adhere to the eye rather it floats on the solution it is delivering, and it vaults itself from the cornea. Eye injuries which the Morgan Lens can be used on:

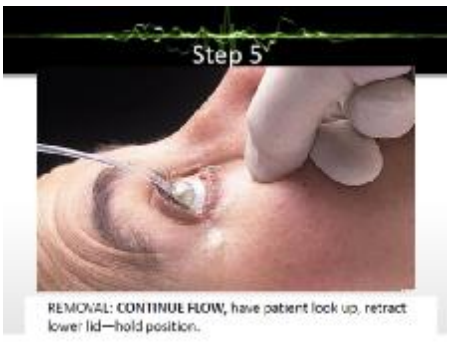
- Foreign body sensation with no visible foreign body,
- Non-embedded foreign bodies,
- Burns from acids or alkali substances, solvents, gasoline, detergents, etc.

Tetracaine can be used prior to insertion of the Morgan Lens, except in the case of eye injuries that penetrate or rupture the globe of the eye. The pediatric and adult dose is one to two drops of Tetracaine per eye.

<u>Inserting the Morgan Lens</u>







Positive End Expiratory Pressure (PEEP)

Positive End Expiratory Pressure, or PEEP, is pressure that remains inside the alveoli after exhalation is complete that is greater than the atmospheric pressure outside the body. PEEP can be generated inside the body (intrinsic) or can come from sources outside the body (extrinsic).

Intrinsic, or "Auto-PEEP", can build up for several reasons including:

- Hyperventilation
- Airway obstruction
- Narrowed airways
- A combination of these factors

All the above factors share a common trait: they interfere with the alveolar ability to empty fully. Gasses become trapped in the lungs, and the pressure inside the chest rises. This can have devastating effects like alveolar collapse, hypoxia and decreased cardiac output.

Generation of Auto-PEEP is often associated with diseases that cause respiratory narrowing/ obstruction including asthma and COPD. Once a patient with negative Auto-PEEP is identified, steps should be taken to correct it. Treatment of the underlying causes - i.e. opening narrowed asthmatic airways with bronchodiliating medications may be all that is needed to reverse the effects of auto-PEEP. However, if corrective treatment is not enough alone, application of extrinsic PEEP may be needed.

Extrinsic PEEP is generated outside the body and may come from several sources, including a mechanical ventilator. Ventilators operate on a closed-circuit system, and are usually positive-pressure. A ventilator will deliver one breath, and then allow the gasses to escape by allowing an exhalation valve to open. PEEP is generated in ventilators by applying pressure to the patient's lungs during exhalation. Extrinsic PEEP helps with alveolar recruitment, by helping keep more alveoli open, and allowing for better gas exchange.

In simple terms, when a person develops auto-PEEP some of their alveoli are collapsed. Air follows the path of least resistance. This means that when ventilating a patient with auto-PEEP, even at an appropriate rate and tidal volume, the alveoli that are collapsed will shunt air to those that are open. This results in simultaneous hyperinflation of open alveoli, and under ventilation of closed alveoli.

PEEP is used on the majority of ventilator patients, usually in the 3-5cm H20 range. Higher levels of extrinsic PEEP >5cm H20 are used to improve hypoxemia and reduce ventilator associated lung injuries, and certain types of hypoxemia-related lung failure.

All ventilators are capable of causing patient complications such as:

- Decreased cardiac output
- Oxygen toxicity
- Fluid volume excess (from oxygen humidification)
- Infection
- GI complications (distention or bleeding from stress ulcers)

With increases in pressure on the lungs other serious complications may arise:

- Pneumothorax
- Tension pneumothorax
- Pneumomediastinum
- Pneumopericardium
- Interstitial emphysema

Patients that are on mechanical ventilators are still capable of developing auto-PEEP and should be monitored closely for:

- Exhalation that continues until the next breath
- Failure of peak airway pressure to change when extrinsic PEEP is applied
- Delay in the beginning of inspiration (Demand Vent)

When auto-PEEP is recognized, the following corrective steps can be used:

- Increasing expiratory time
- Decreasing respiratory time
- Decreasing tidal volume
- Decreasing pain, anxiety, and shivering in patients
- Giving sedation or paralytics as needed

Reduction of any flow resistance is also important. This can be corrected by:

- Using large bore endotracheal tubes
- Frequent suctioning
- Administration of bronchodilators
- Application of extrinsic PEEP

In the field, application of CPAP helps EMS providers treat patients who have respiratory distress from asthma, COPD, or pneumonia in part by reducing their auto-PEEP. CPAP makes breathing easier, reduces the need for intubation, and for most patients reduces their sense of dyspnea. It also improves gas exchange and vital signs. Start these patients at 5.0cm H_2O, and increase to 7.5cm H_20 if needed.

For CHF, CPAP improves cardiac function by changing the dynamics of preload and afterload. Begin CPAP at 10cm H_20 for CHF patients. If the patient cannot tolerate the initial setting adjust the CPAP setting to 7.5cm H_20.

Blood Product Administration

Blood is the only fluid connective tissue and possesses a number of important functions. It delivers oxygen and nutrients to the cells, carries away metabolic waste products for elimination, and facilitates the transport of hormones from endocrine organs to target sites. Blood plays a role in maintaining body temperature, acts as a buffer to combat excessive changes to pH, and sustains adequate fluid volume in the circulatory system by the means of oncotic forces. Finally, the blood also functions as a defense mechanism, possessing the ability to prevent infections, and halt the bleeding process with clotting factors.

The incidents of administering blood products in the field are very rare, except perhaps in the air ambulance setting. However, with the trend of increased patient transfers and specialized health care centers, the frequency with which paramedics are required to initiate and monitor the transfusion of blood products is increasing. As a result, the practitioner must have a strong understanding of the different types of blood products, the importance of ensuring the blood product is administered to the intended recipient, the process of initiating and monitoring blood products and assessing the patient for adverse reactions.

The average male's circulatory system has 5-6 liters of blood traveling through it, while the average female has 4-5 liters. When blood is drawn and spun in a centrifuge, the different components separate. Plasma is a sticky straw-colored fluid consisting of approximately 90% water. Dissolved within the plasma are over 100 different solutes including proteins, nutrients, electrolytes and respiratory gases. Plasma makes up about 55% of the volume of blood. *Erythrocytes* (red blood cells) constitute approximately 45% of the blood's volume and have a dedicated role in the transportation of respiratory gases. *Leukocytes* (white blood cells) make up less than 1% of the entire blood volume and play a major role in defense against infection and disease. *Platelets* (also less than 1% of blood volume) are necessary for the clotting process and circulate in the vasculature, inactive until a blood vessel ruptures or is damaged. Red blood cells, plasma and other blood products collected from volunteer donors are available for transfusion.

Whole Blood

Whole Blood contains all components of blood. However, the clotting factors and platelets quickly lose their function during storage. A unit contains approximately 450 ml of whole blood plus 63 ml of anticoagulant. This product is not commonly available from blood banks, and red blood cells are more commonly used for treatment of anemia and acute blood loss. Whole Blood must be ABO-identical to the recipient's blood group. (Group O is not universal donor for whole blood.) One unit of Whole Blood can increase the patient's hemoglobin by approximately 10g/L. The initial transfusion should be slow (5 ml/min for 15 minutes) while assessing the patient for adverse reactions. In the absence of any reactions, the product can be infused as quickly as the patient can tolerate it. The administration set must have a 170-260 micron blood filter. Whole Blood cannot be left at room temperature for longer than 4 hours. The transfusion should be completed within the 4-hour window. As soon as collection from the

donor is complete, Whole Blood must be stored at 1-6 °C. At this temperature, depending on the anticoagulant used, the red blood cells will retain their function for up to 21-35 days.

Red Blood Cells along with normal saline are more commonly used than Whole Blood for acute blood loss. To process the product, donor blood is centrifuged separating the red blood cells from the plasma. A unit of Red Blood Cells is 240-340 ml and will be more viscous than Whole Blood. However, most Red Blood Cell components today have an additive solution mixed with the Red Blood Cells (eg. AS-3). With an additive solution, Red Blood Cells will have the same flow rate as Whole Blood. Red Blood Cells have minimal amounts of plasma (and ABO antibodies) so can give ABO-compatible blood rather than only ABO-identical. Group O is universal donor for Red Blood Cells. Red Blood Cell units are administered to patients requiring increased oxygen carrying capacity by increasing the circulating red blood cell mass. The initial infusion should be slow to assess for adverse reactions, then administered as quickly as the patient tolerates. A unit of Red Blood Cells must be administered within 4 hours and the administration set must have a 170-260 micron blood filter. Depending on the anticoagulant and additive solution used, Red Blood Cell units have a shelf life of 21-42 days. They must be stored at 1-6 °C.

Platelets are produced from centrifuging Whole Blood. The platelets are then suspended in 40-70 ml of the original plasma constituting one unit. Platelets are indicated for patients with bleeding due to a decreased platelet production or abnormally functioning platelets. A standard 170-260 micron blood filter must be used when administering platelets and the infusion time must be less than 4 hours. For optimal survival of the platelets, they must be stored at 20-24 °C and gently agitated to prevent the formation of aggregates. The shelf life under these conditions is 5 days.

Fresh Frozen Plasma (FFP) is separated from Whole Blood by centrifugation or sedimentation and must be frozen within 8 hours of collection. A unit of fresh frozen plasma (FFP) contains approximately 250 mL (minimum 100 mL) of anticoagulated plasma. FFP is indicated for patients requiring plasma coagulation factors, patients on Coumadin requiring emergency invasive procedures before Vitamin K can reverse its effects, or patients with plasma protein deficiencies. FFP can be stored up to 12 months at temperatures –18 degrees C and for 24 hours at 1-6 °C once thawed. FFP should be thawed in a water bath at 30-37 °C (in a water tight protective plastic overwrap using gentle agitation); this may take 20-30 minutes. Once thawed, FFP must be used immediately and cannot be refrozen.

Prior to a *transfusion* of blood products, it must be determined that the donor's blood will be compatible with the recipient's plasma or serum. Pre-transfusion testing includes the following:

- Blood Typing
- Antibody Detection (and antibody identification if antibody screen is positive)
- Crossmatch

A requisition for a crossmatch will be completed specifying the order for blood and a specimen will be drawn from the patient. Care must be taken to correctly identify the patient prior to collection of the specimen and the specimen must be correctly labeled immediately after collection. Pre-transfusion testing is done by a department in the laboratory called the *blood bank lab*. Most hospitals have blood bank services; there may be 2 units or over 200 RBC units in stock depending on the needs of the hospital.

Blood Typing

Red blood cells have many different *antigens*. During a transfusion if a red cell antigen is seen as foreign, antibodies that the patient has to that antigen will attach to the red cells. This may cause hemolysis of the red cells or a slower removal of the sensitized (coated with antibody) red blood cells from the system (*immune hemolytic transfusion reactions*).

The *ABO blood typing* is the most important test done prior to transfusion. This is because those people, whose red cells lack the A and/or B antigen, will naturally form an antibody to the antigen they lack. Anti-A and anti-B can cause immediate hemolysis of red cells. If the ABO blood group is done incorrectly or on an improperly identified specimen, the resulting transfusion could lead to patient fatality.

Blood Type	Antigen(s) on Red Cells	Antibody(ies) in Plasma
A	A	Anti-B
B	B	Anti-A
AB	A and B	Neither anti-A or anti-B
O	Neither A or B	Anti-A and anti-B

If unable to determine the patient's blood group prior to transfusion, only group O red blood cells and group AB plasma components should be transfused.

The *Rh (D) type* of the patient must also be determined. Approximately 80% of Rh (D) negative patients exposed to Rh (D) positive red blood cells through transfusion or pregnancy will develop anti-D. In emergency situations, Rh negative RBCs should be given preferentially to children and women of childbearing age.

Antibody Detection

Because of previous transfusion or pregnancy, the patient may have been exposed to other foreign red cell antigens and formed antibodies. Antibody screening is done to detect unexpected clinically significant red cell antibodies. These are antibodies, which are known to cause hemolytic transfusion reaction, shortened survival of transfused red blood cells or Hemolytic Disease of the Newborn (HDN). If the antibody screen is positive, the antibody must be identified. RBC units that are negative for the antigen would be provided for transfusion.

Crossmatching is the process of determining the compatibility of blood from a donor with that of the recipient before transfusion. RBC units are selected and compatibility with the patient is determined. A label or tag is applied to the unit identifying that unit for the intended recipient.

Infectious Disease

Despite careful donor screening and blood testing, there is still a risk of transmitting an infectious disease. Blood donations are tested for diseases such as HIV, Hepatitis B and C, syphilis and West Nile Virus, among others. Even with negative results, there is a small risk of transmitting these diseases to the recipient.

Bacterial Contamination

Any patient experiencing chills, high fever or hypotension during or following a transfusion should give rise to the suspicion that the blood product may have been contaminated. This can be a life-threatening event and must be treated aggressively with fluids and vasopressors if necessary. The transfusion must be discontinued, and the remaining blood product and bag be returned to the blood center for investigation.

Febrile Reactions – Nonhemolytic

Febrile nonhemolytic reactions (FNHTR) occur in approximately 1% of all transfusions. It is believed that it is a result of *cytokines* being released by leukocytes.

Allergic Reactions

In approximately 1% of all transfusions, the recipient may present with an allergic reaction. Wheezing, *urticaria*, *angioedema* may be present in these patients. Recipients presenting with an *anaphylactoid reaction* may present with severe bronchospasm and laryngeal edema. The transfusion must be stopped and the patient treated as per symptoms.

Transfusion Related Acute Lung Injury (TRALI)

Transfusion Related Acute Lung Injury (TRALI) is condition where the patient develops non-cardiogenic pulmonary edema. The cause for this condition is believed to be the presence of antibodies in the donor's blood to the recipient's leukocytes. The patient's leukocytes aggregate in the pulmonary vasculature causing a release of mediators, which increase capillary permeability leading to pulmonary edema. If detected in patients receiving blood products, stop the transfusion and treat the patient accordingly.

Circulatory Overload

As with any fluid administration, excessive volumes or excessively rapid administration can lead to pulmonary edema. Administration of blood products should generally be no faster than 2-4 ml/kg/hr unless indicated for significant blood loss.

Immune Hemolytic Reactions

Unfortunately there are times when recipients are given blood products that react with their circulating antibodies. The consequences can be devastating resulting in intravascular *hemolysis*. Signs and symptoms that may be present are lumbar pain, fever, hypotension and *hemoglobinuria*. *Disseminated intravascular coagulation (DIC)* and renal failure are later complications of acute hemolytic reaction. Delayed hemolytic reaction is also immune-mediated but by non-ABO antibodies. The reaction can take days to occur and results in the extravascular sequestration and early destruction of the donor red cells. As with all transfusion reactions, the blood product administration must be stopped, the bag and tubing kept for the blood bank lab, and a normal saline line must be attached to the intravenous site. Aggressive IV therapy and diuresis is indicated with the goal of maintaining urine output at 100mL/hr.

The most serious adverse transfusion reactions can be due to the administration of a blood product to an unintended recipient. *Transfusion record tags* are used to minimize the potential of this error occurring. The tag should include the following information:

- Patient's last name, first name
- Patient's PHN and hospital record number
- Product type
- Product unique unit number, pooled unit number or lot number
- ABO and Rh of the patient for blood components
- ABO and Rh of the blood product

In order to transfuse blood products at an adequate rate, a minimum of an 18-gauge IV catheter should be used for the adult patient. For pediatric patients, a 23 gauge catheter or larger should be used. Once the blood product is matched with the intended recipient, the contents should be visualized for any abnormalities including, but not limited to clumps and clots, cloudiness and leaks. Follow the blood administration set manufacturer's instructions for attaching and charging the line. The blood product administrations set must incorporate a 170-260 micron filter and be free of any defects. Using aseptic technique, the administration set must be attached to the blood product bag and a previously inspected bag of normal saline. Use the normal saline to charge the blood administration line and attach it to the IV. For RBC units, mix the blood product by turning it over end-to-end in your hands to re-suspend the cells. Initiate the transfusion of the blood product at a rate of no faster than 5 ml/min for the first 15 minutes while assessing the patient for any adverse reactions. In the absence of any reactions,

adjust the flow to the desired rate; usually 2-4 ml/kg/hr. Continually reassess the patient. If any adverse reaction is observed, stop the blood product transfusion immediately and attach an IV line of normal saline to the site. Save the blood product and administration set so it can be returned to a blood bank lab for investigation, and carefully document the reaction witnessed. Treat the patient accordingly following local protocol.

Blood product administration requires careful documentation on the Patient Care Report. Be sure that the blood bank lab that issued the blood product is informed of the final status of each unit ASAP (i.e. whether you transfused the unit or gave it to the receiving hospital, if you are on a transfer.) The following information should be included:

- Type of blood product
- Unit number
- Volume administered
- Date and time of initiation
- Date and time of completion
- Amount of Normal Saline administered
- Vital signs
- Treatment evaluation
- Description of adverse reactions
- Name and position (Paramedic, Physician, RN) initiating transfusion
- Name and position (Paramedic, Physician, RN) completing transfusion

Emergency Transfusion

The safest transfusion is transfusion of group-specific blood that has been found to be compatible by crossmatch. For stable patients with *anemia* resistant to pharmacological treatment, this is the normal situation. However, for some patients, blood may be needed quickly, as in a case of trauma or gastrointestinal bleed. If there is not time for a crossmatch prior to transfusion, the next best alternative is for the lab to determine the patient's blood type and release group-specific blood. The lab would continue with the compatibility testing while the transfusion is started. If there is no time to start testing, group O Red Blood Cells can be released. Preferably the red cells would be Rh negative especially if the patient is a child or woman of childbearing age. If plasma components are to be given, only group AB plasma can be released.

Whenever an emergency transfusion of *uncrossmatched blood* is required due to life-threatening situations, a properly labeled specimen for crossmatch purposes must be drawn prior to starting the transfusion. If the person's identity is unknown, a special identification system should be used. This usually consists of a fictitious name (eg. John Doe) and unique identification number used on the patient's armband.

Prior to giving unmatched blood, a signed statement from the requesting physician must be obtained which indicates that the clinical situation was sufficiently urgent to require release of the blood components prior to completion of compatibility testing. If possible, consent from the patient should also be obtained.

Which Patients Require a Transfusion?

It is a decision that should made on a case-by-case basis with consideration of established protocols. The risks versus benefits must be weighed for each patient, as with other medical treatments. In pre-hospital care, we usually do not have our patient's hemoglobin level. That is just as well, as the hemoglobin level does not reflect the amount of blood loss until we replace the fluid volume with crystalloids anyway. Often it is too difficult to accurately estimate blood loss. Our patient who benefits from an RBC transfusion will likely have a mechanism of illness or injury consistent with a serious hemorrhage. Most patients will compensate well for a small to moderate amount of blood loss. The RBC transfusion is an attempt to prevent or treat *hemorrhagic shock* only when the situation warrants it.

Pre-Hospital Transfusions

In pre-hospital care, we must carry only Group O Red Blood Cells. They should be Rh Negative. As explained above, never transfuse a female of childbearing age or younger with Rh Positive blood. The risks of transfusing uncrossmatched blood include the risk of an immune hemolytic transfusion reaction. It would be prudent to be sure the reasons for the transfusion are clear from the patient care report.

Tracking Blood Products

It is very important to have the final disposition of all blood products recorded by the blood bank lab that issued the blood. For example, let's say a patient is to be transfused during transfer. The EMS crew might take 4 units of blood along, transfuse 3 and give the other 1 to the receiving facility. This needs to be communicated back to the original blood bank, along with each unit identification number ASAP. (The receiving facility may or may not accept the unit into their stock; it may end up being discarded.)

Summary

Paramedics will encounter transfusions in a variety of situations. One is the transfusion of uncrossmatched O Rh Negative Red Blood Cells in a pre-hospital care setting. Another setting is the interfacility transfer with an ongoing transfusion of blood that has probably been crossmatched. Whatever the circumstances, unexpected events may arise and there are always several risks involved. The paramedic who encounters blood products must be familiar with the process of initiating, monitoring and documenting blood product administration. This module is designed to give the Paramedic an overview of the challenging subject of blood product transfusions.

Blood Chemistry Analysis

Blood Gas Analysis and Regulation

Blood Gas Analysis is done from an arterial sample (ABG). The most common sample site is from the radial artery in the wrist, though the femoral and brachial arteries can be access as well. Several different blood gas values are then analyzed from the sample. Blood Gas Analysis is most often used in critically ill patients and gives vital information about the patient's respiratory and metabolic status. A normal body will strive for a pH range between 7.35-7.45. Staying within this range is important as a change of 0.4 or greater will result in death. When the pH goes out of this range the body should compensate.

Compensating mechanisms for pH include:

- Chemical Buffers- react very quickly (less than a second)
- Respiratory Regulation- slower reaction (seconds to minutes)
- Renal Regulation- Slowest reaction (minutes to hours)

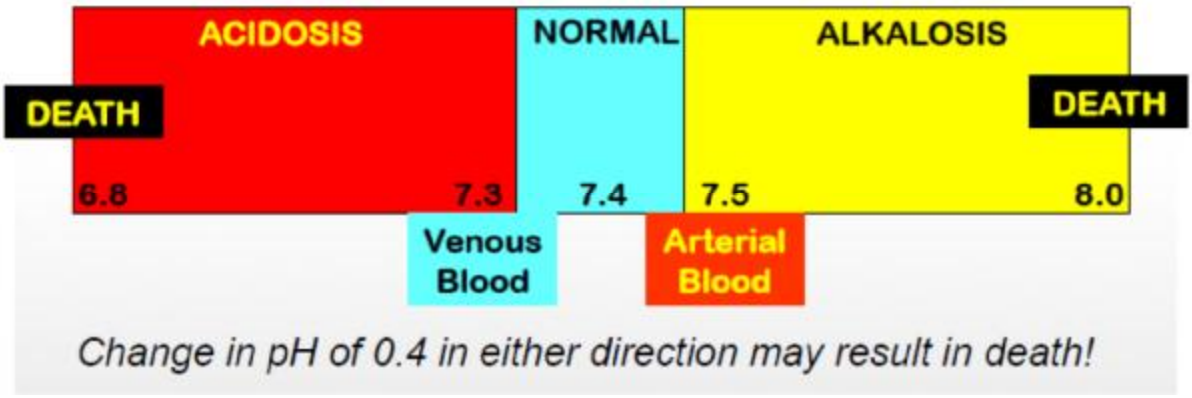
Blood gas analysis looks at several blood components to help determine what the nature of a patient's illness is and also how to best treat them. In essence when the body's pH is off it generally stems from a respiratory or metabolic disorder. For example, if the pH comes from a metabolic disorder, like DKA, the respiratory system can help compensate for a time by increasing respiratory rate. This compensation mechanism produces Kussmaul respirations in a hyperglycemic patient. On the other hand, if the respiratory status of the patient is compromised, the metabolic system will attempt to compensate. Careful analysis of the different blood gas values gives insight into the overall function of the respiratory and metabolic functions of the body, and also how to best treat any problems.

Blood Gas Values

Determining ABG values is a three step process. Think of it as trying to determine a person's full name- first, middle, and last. The first part of an ABG's name is compensated or decompensated, its middle name will come from metabolic or respiratory, and the last name will be from the patient's pH status- normal, acidosis, or alkalosis.

pH

pH is The measurement of the concentration of hydrogen ions in the blood sample. We'll look at pH first to give us our "last name". If the sample is < 7.35 then the last name is acidosis. If the sample is > 7.45 then the last name is alkalosis.
The pH value also gives us our "first name". If the pH is in the normal range its "compensated," if it isn't, it's "uncompensated."
Remember, if the regulation mechanisms are functioning correctly the pH will be normal, but that doesn't mean there isn't an issue, because those mechanisms will eventually fail.



The "middle" name requires us to look at two other values.

First the partial pressure of CO_2 (PCO_2). A Normal PCO_2 range is 35-45mmHg.

- Increased PCO_2 values could mean:
  - Respiratory acidosis
  - Compensated metabolic alkalosis
- Decreased PCO_2 values could mean:
  - Respiratory alkalosis
  - Compensated Respiratory Acidosis

Next look at the Bicarbonate (HCO3-) values. Normal HCO3- range is 22-26 mEq/L.

Remember that CO_2 dissolved in the blood produces a weak acid. Bicarbonate is one of the chemical buffers mentioned previously and helps reduce acidosis.

Finally, we look at the Base Excess (BE), which also tells us about the patient's metabolic status, and whether or not the body is compensating. A normal BE range is -2 to +2 mEq/L.

- Base excess- indicative of metabolic alkalosis
- Base deficit- indicative of metabolic acidosis

Bringing it all together

The human body requires a stable environment to function. When a respiratory problem arises the metabolic system works to oppose that problem. When the metabolic system starts to err respiration can check that problem.

So just remember it's all about balance- what one side does the other will directly oppose to achieve balance.

- Metabolic acidosis
    - Accumulation of abnormal acids in blood- decreased pH
    - Compensatory respiratory alkalosis- increased respiratory function
- Metabolic alkalosis
    - Excess metabolic base of loss of normal acid- increased pH
    - Compensatory respiratory acidosis- decreased respiratory function
- Respiratory acidosis
    - CO_2 retention (hypoventilation or intrinsic lung diseases) leads to increased PCO_2 -decreased respiratory function
    - Compensatory metabolic alkalosis- increased pH
- Respiratory alkalosis
    - Blowing off CO_2 (hyperventilation, potentially serious diseases may be responsible) -increased respiratory function
    - Compensatory metabolic acidosis- decreased pH

When looking at ABG's try to follow a standard interpretation sequence.

- Check the pH- Is the pH normal, acidic or basic?

- Check the PCO_2-
    - High PCO_2 indicates respiratory acidosis in the presence of a low pH
    - Low PCO_2 indicates respiratory alkalosis in the presence of high pH

- Check the pH
    - High HCO3 indicates metabolic alkalosis in the presence of a high pH
    - Low HCO3 indicates metabolic acidosis in the presence of a low pH

Again, pH may stay within the normal range if the body can keep up. If it can't different lab values combinations will result:

- Decreased pH with decreased HCO3-: Acidosis
- Increased pH with increased HCO3-: Alkalosis
- Decreased pH with increased PCO_2: Acidosis
- Increased pH with decreased PCO_2: Alkalosis

Blood Chemistry

A Basic Metabolic Panel (BMP) provides critical information about the status of one's blood chemistry. There are eight specific lab values commonly obtained in this test:

- Sodium (Na+)
- Potassium (K+)
- Chloride (Cl-)
- Bicarbonate (HCO3-)
- Calcium (Ca+)
- Blood Urea Nitrogen (BUN)
- Creatinine (Cr)
- Glucose (BGL)

The first five of these are ions; the last three are metabolic byproducts.

Sodium (Na+)

An electrolyte that is essential for life Sodium is needed for normal muscle function (including cardiac muscle) and the transmission of nerve impulses by generating an electrical charge when interacting with Potassium. Sodium also helps to regulate blood volume, water volume, and pH levels. (Normal range 135-145 mEq/L.; Life threatening <120 or >155)

When Sodium levels drop below <115 mEq/L the brain begins to swell due to the electrolyte imbalance. This swelling increases ICP and the patient will begin suffering the signs and symptoms of that no differently than if the increased ICP were from a CVA or TBI.

Potassium (K+)

An ion that is essential for the function of all living cells. Potassium is necessary for the transmission of nerve impulses. Depletion of Potassium in humans and animals results in various cardiac arrhythmias. About 98% of the body's potassium is found inside cells. (Normal range is 3.5-4 mEq/L; Life threatening <2.5 or >6.5).

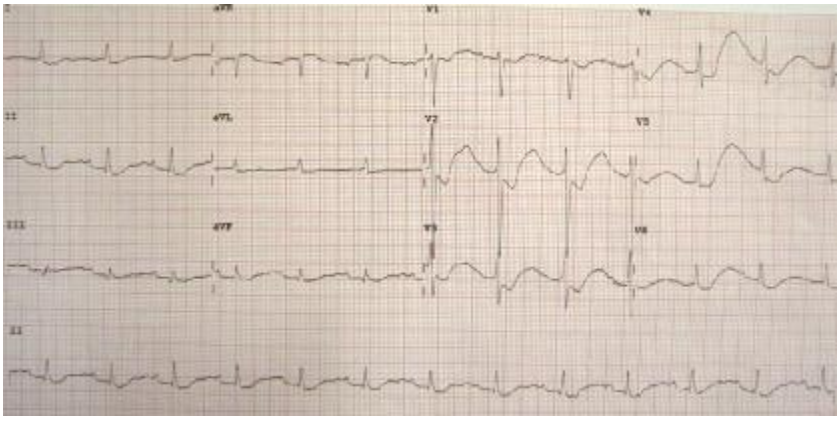
DKA causes a special type of potassium loss. Not only is potassium lost due to polyuria, it's actually needed to help the body excrete ketones that develop. Patients in DKA for an extended length of time are likely to have a critically low potassium level.

Because potassium is required for the proper contraction of all types of muscle, many of hypokalemia's signs and symptoms relate to the dysfunction of muscle including:

- Muscle weakness/ pain/ cramps
- Constipation
- Flaccid paralysis/ slow reflexes
- Rhabdomyolysis
- Respiratory depression from severe impairment of skeletal muscle function

Hypokalemia will also produce characteristic EKG changes:

- Peaked T waves
- Widening of QRS
- Loss of P wave
- ST segment depression
- Bradycardia
- Ventricular arrhythmias



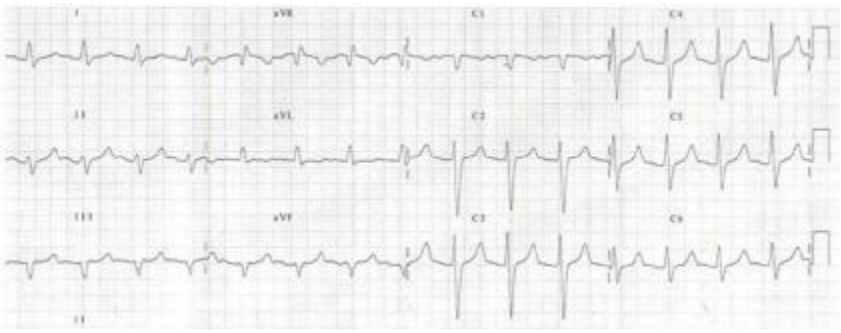
Life-threatening arrhythmias can also develop if a person's potassium levels are too high. Causes of hyperkalemia include:

- Acidosis
- Renal Failure
- Muscle Necrosis
- Blood Transfusions
- Hemolysis

Remember that almost all of the potassium in the body is stored inside its cells. If a significant number of cells die hyperkalemia will result. Be highly suspicious of this in crush injuries and significant burns.

EKG changes that occur due to hyperkalemia include:

- Peaked T waves
- Widening of QRS
- Loss of P wave
- ST segment depression
- Bradycardia
- Ventricular Arrhythmias



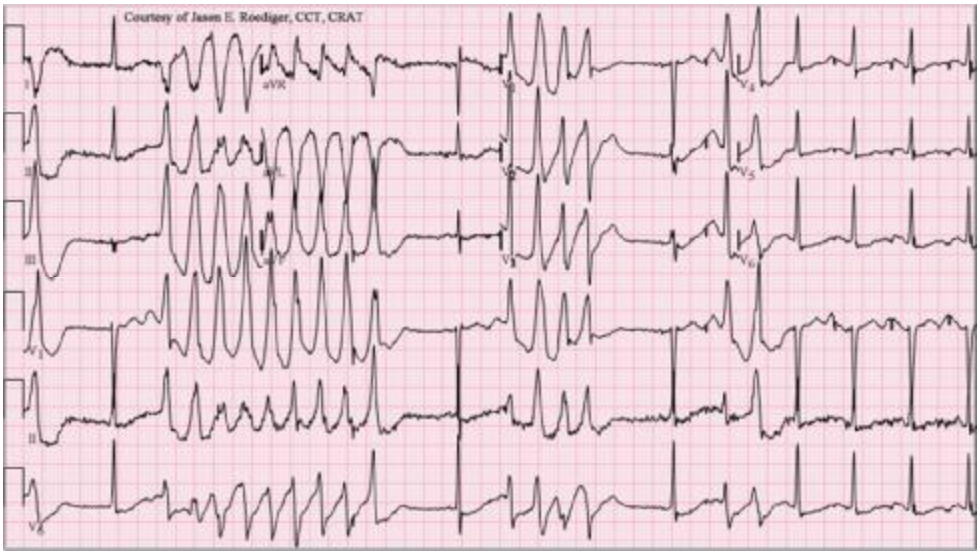
Chloride (-Cl)
It is an essential electrolyte located in all body fluids. Chloride is responsible for maintaining acid/base balance, transmitting nerve impulses, and regulating fluid in and out of cells. The treatment of hypo/hyper-chloremia focus' on fixing the underlying cause of it. (Normal Range is 95-105mEq/L)

Bicarbonate (HCO_3-)
An ion that is a vital component of the body's acid-base balance. Bicarbonate is a buffering agent. (Normal: 20-26 mEq/L)

- Increased in Metabolic Alkalosis and Compensated Respiratory Acidosis
- Decreased in Metabolic Acidosis and Compensated Respiratory Alkalosis

Calcium (Ca+)
Necessary for muscle contraction, and neurotransmitter release, calcium is an essential ion. In cardiac muscle calcium allows for a longer duration of muscle contraction. Most patients with a calcium aberration are afflicted with a chronic condition that causes it. (Normal: 8-11 mg/dl; Critical values <7mg/dl or >12mg/dl)

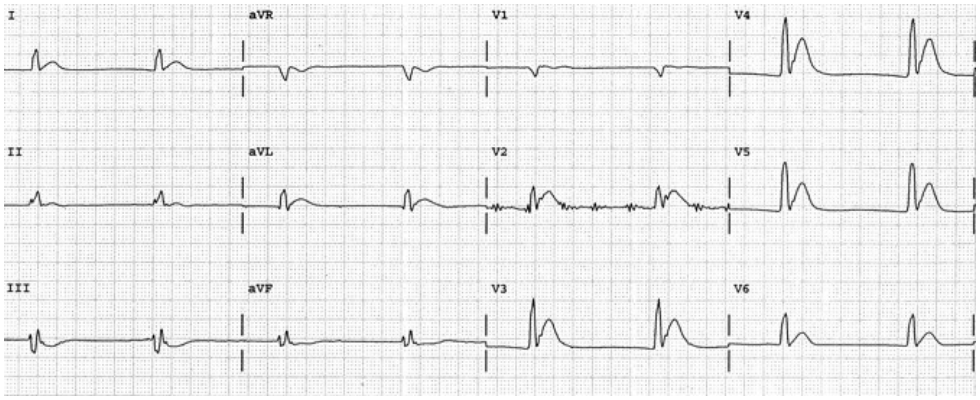
Hypocalcaemia creates a prolonged QT interval on an EKG. A prolonged QT interval, from any cause, can lead to the development of Torsades des Pointes or V-Fib.

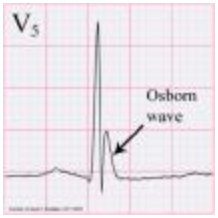


Treatment of Hypocalcaemia focuses primarily on the treatment of the underlying condition. In crisis IV Calcium Gluconate, or Calcium Chloride may be administered, but only with close monitoring and caution. Patients who have chronic hypocalcaemia often acclimate to a degree, and raising their levels too quickly may be fatal.

Hypercalcaemia can also cause significant EKG changes, which include:

- Abnormal heart rhythms
- Short QT interval
- Widened T wave
- Osborne Wave
- Significant hypercalcaemia can cause ECG changes mimicking a STEMI





The primary treatment of Hypercalcaemia focuses on correcting the underlying problem. Administration of IV fluids concurrently with Loop diuretics may also help the body be rid of excess calcium.

Blood Urea Nitrogen (BUN)

BUN is produced by the liver as part of the digestion of protein. BUN is an indicator of renal health. (Normal: 5-20 mg/dl)

Creatinine

Creatinine is a byproduct of muscle metabolism, and its excretion is an important measurement of renal health. (Normal: 0.5 – 1.5 mg/dl)

Glucose

The form of sugar used by the body to produce energy glucose is essential to life. High or low levels may lead to a life-threatening emergency. (Normal: 60-115 mg/dl)

Chest Tube Monitoring

Chest tubes are used for a number of different reasons most of which are significant pathologies. They restore the normal pressures within the alveoli and the pleural cavity, which are essential to adequate expansion and reinflation of the lung. They are designed to remove air, fluid or both from the affected lung field. The tube(s) are connected to a closed system in order to accomplish this. Chest tubes are indicated when the normally airtight pleural space has been penetrated by trauma or surgery. Without them in this situation, the lung would collapse and mediastinal shift would occur with associated consequences. Following are a list of the common indications for the use of chest tubes.

- Pneumothorax – spontaneous or traumatic
- Tension pneumothorax
- Hemothorax
- Hemopneumothorax
- Pleural effusion
- Post-operative cardiothoracic surgery
- Thoracotomy
- Resection
- Decortication (Surgery to remove the outer layer of an organ)
- Pericardial window
- Thoracoplasty

Heimlich™ Valve

The *Heimlich™ chest drain valve* is a one-way flutter valve that can be used to drain the pleural cavity within the chest. The Heimlich™ valve can be connected to a chest tube and allow fluid and air to exit through the flutter valve while preventing any return flow of air. The valve is functional in any position and does not require clamping of the chest tube. The valve can be attached to a collection system or be left open to the atmosphere. The use of the Heimlich™ valve can be used to allow brief disconnection of the patient from a chest tube drainage system should it be necessary to facilitate transfer of the patient (stretcher to bed etc.).

Heimlich™ Chest Drain Valve

Heimlich™ Chest Drain Valve

Drainage System

There are different types of chest tube drainage systems used in today's hospitals. These can range from using an underwater seal with one or multiple bottles to a self-contained system such as the *PLEUR-EVAC™ chest tube drainage system* (most common to inter-facility transfers). Regardless of the type or manufacturer, each chest tube drainage systems will have three basic components:

- Collection chamber
- Water seal chamber
- Suction Control

Collection Chamber

The collection chamber is connected to the patient's chest tube with extension tubing. Drainage from the chest accumulates in the collection chamber. It is marked in milliliter increments to enable measuring the drainage volume. All tubing connections must be sealed with tape.

Water Seal Chamber

The water seal chamber or air leak chamber is a one-way 2 cm water seal preventing air from entering the *pleural space*. It also acts as a *manometer* measuring the amount of negativity in the patient's chest cavity and allows for observation of air leakage. The water level in the water seal chamber normally rises up and down as the patient breaths (this is called *tidaling*). If suction has been applied, tidaling will not be present. If the tidaling stops, it may indicate the tubing is blocked, kinked, the lung is fully expanded or a tension pneumothorax has developed.

Suction Control

The suction chamber is usually filled to a level of 20 cm H_2O. Once filled, replace the muffler (atmospheric vent cover) that is attached to the suction control chamber. This muffler allows air to enter the suction control chamber, which minimizes the chance of a tension pneumothorax developing. The suction control chamber has tubing to be connected to a suction source. If suction is not being used, the tubing should be left unclamped and uncapped to allow for air to exit, again avoiding the possibility of a tension pneumothorax developing.

Responsibilities of Monitoring the Patient with a Chest Tube Drainage System

It is necessary to ensure anyone who is responsible for the care of a patient with chest tubes is familiar with the purpose of the tubes, the tube placement and the system it is attached to. A complete report of the situation prior to accepting a patient with chest tubes is essential. This should include the physician's preference for patient positioning during transport. The following is a list of the important checks to perform while caring for a patient with a chest tube and drainage system in place.

- Ensure the chest drainage system is below the level of the patient's chest.
- Check the tubing for kinks and ensure there are not dependent loops.
- Make note of the depth of the chest tube at the patient. It should not change during your care.
- Note the amount of drainage.
- Assess for tidaling at the water seal chamber.
- If suction is being used, assess for leakage at the water seal chamber.
- If leakage is suspected by witnessing persistent, unexplained bubbling at the water seal chamber, using padded clamps, clamp the tubing as close to the patient as possible for 1-2 seconds. If the bubbling stops, the leak is on the patient side. Remove the clamp and ensure the chest tube has not been dislodged and attempt to make a better seal at the insertion site. If the bubbling continues, the leak is on the chest drainage side. Seal all connections with tape.
- Ensure suction is set at the prescribed level.

A *dependent loop* is any sag or loop in the thoracic tubing between the patient and the drainage system. This would allow fluid drained from the pleural space to accumulate in the thoracic tubing resulting in occlusion.

Milking is the act of pinching and releasing the chest tube with fingers along the length of the tubing between the patient and the collection system. This procedure can generate 40-50 mmHg of pressure. Milking, although discouraged as regular practice, can be used to break up clots should the thoracic tubing become occluded. Proper positioning of the chest tube drainage system below the level of the patient and ensuring there is no dependent loop in the thoracic tubing will avoid the formation of clots.

Stripping is the act of occluding the chest tube or thoracic tubing with one hand near the patient and then compressing the tubing with the other hand quickly sliding the fingers along the length of the tubing toward the drainage system and then releasing the hand occluding the tube near the patient. This allows the thoracic tubing to spring open and create a sudden negative pressure to extract the blockage toward the drainage system. IMPORTANT! – This procedure should never be attempted as it can generate up to 400 mmHg of pressure, which can cause significant damage to tissues.

Documentation

Careful and thorough documentation of your evaluation and care of the patient is required. In addition to the overall state of the patient during transport the following items should be documented and given in your verbal report on arrival at the receiving facility.

- Site, size and depth of chest tube
- Drainage amount and description
- Amount of suction used
- Presence or absence of tidaling
- Presence or absence of air leaks
- How patient tolerated the transfer
- Full set of vital signs just prior to arrival

Summary

The majority of paramedics do not get exposed to patients with indwelling chest tubes and chest drainage systems on a regular basis. However, with the encroachment of paramedics into the hospital work environment, the frequency of having to care for these patients will rise. As a result, the practitioner must have a strong understanding of the equipment used and the requirements of the patient to provide competent care.