

HISTORY TAKING, VITAL SIGNS AND DIAGNOSTICS

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

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

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of Manitoba**

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Disclaimer

These documents were developed for improved accessibility to “An Alternative Route to Maintenance of Licensure” for all paramedics in Manitoba. Regional implementation of Alternate Route is at the discretion of the local EMS Director.

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

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

This package is to be used in conjunction with accepted models for education delivery and assessment, as outlined in “An Alternative Route to Maintenance of Licensure”.

This document was designed to encompass all licensed training levels in the province Technician, Technician-Paramedic, Technician-Advanced Paramedic. Paramedics are encouraged to read beyond their training levels. However, the written test will only be administered at the paramedic’s current level of practice.

All packages have been reviewed by the Paramedic Association of Manitoba’s Educational Subcommittee and physician(s) for medical content.

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

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

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

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Introduction

This module deals with history taking, vital signs and diagnostics. Components of history taking, procedures for assessing vital signs and the procedures of various diagnostic tests will all be discussed in this document.

Conventions Used in this Manual

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

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

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

HISTORY TAKING

As part of a thorough secondary assessment, it is important to expand your knowledge of the patient's current medical problem and medical history by questioning the patient directly or, if the patient is unable to respond, by questioning the family or other bystanders. Elements of effective history taking are as follows:

Questioning Techniques

Your questioning process should result in the patient feeling comfortable and confident in your care. If possible, position yourself at eye level and give the patient's requests and concerns a high priority. To gather the patient history, you can use open-ended or closed-ended questions. Open-ended questions allow the patient to explain how he or she feels rather than simply giving "yes" or "no" answers. For example, "Describe the pain in your chest." Closed-ended questions limit patient response. For example, "Are you on any medications?" Choose either type of questioning technique that suits your purposes, but do not use questions that suggest answers such as, "Is your chest pain a crushing pain?" It is important to record what the patient says, rather than your interpretation of what you think they mean.

Patient Identifiers

Obtain the patient's full name, address, age and gender. You should ask the patient how he or she wants to be addressed and use it frequently during your assessment. If an unaccompanied patient is disoriented or unconscious, you should look in his or her wallet or purse for a driver's license or other piece of identification that will tell you the patient's name. For your own protection it is suggested to have a third party witness this procedure. At the same time, you should check for a medical alert bracelet, necklace, anklet, shoelace tag, etc.

Chief Complaint

The reason for EMS presence at the scene is the chief complaint. When asked the question, "What is the problem?" the signs and symptoms that the patient reports is the chief complaint. What you see may also be included in the chief complaint. If the patient is experiencing significant difficulty breathing, "difficulty breathing" should also be included in the chief complaint as if the patient had reported it verbally. While generally this is how the chief complaint may present, keep in mind possible deviations may include history of the present illness and secondary causes to the mechanism of injury.

To assist you in investigating a chief complaint fully, use the mnemonic OPQRST.

Onset: What were you doing when the problem began? Look for the mechanism of injury to assess if the problem is caused by trauma or if it is medical in nature. Inquire about the activities of the patient prior to the problem, e.g. food intake or shoveling snow, and note the environment where the patient was found.

Provocation What makes the problem better or worse? Factors such as motion, pressure, jarring, ingestion of solids or fluids, rest or sleep, breathing and positioning may be considered.

Quality How would you describe the problem or pain? Quote the patient's descriptors in your report.

Radiation Does the pain radiate, or are there any associated problems? Try to locate the specific location or region of pain. Determine if the pain is occurring independently; or is tender to palpation.

Severity How intense is the pain on a scale from 0 to 10, with "0" being absence of pain and "10" being the worst pain ever experienced. Factors to be considered include: can the patient be distracted, is there writhing, constant grimacing, eyes remain closed, or is there resistance to touch?

Time How long ago did the problem begin? Were there previous episodes and if so how long were their durations? Is the pain intermittent? Query the onset of pain, provocation and time between episodes. How does this one vary in length or severity from earlier ones?

Pertinent Negatives

A pertinent negative is the absence of a finding that might be expected to be associated with the patient's problem. For example, if a patient complains of shortness of breath but denies chest pain and cardiac history, record this as a pertinent negative finding on your report form. Also note any element of the history or physical assessment that does not support a suspected or possible diagnosis.

SAMPLE History:

Obtaining a history may take place prior to or following treatment of the chief complaint. As part of the assessment of every patient, you should ask the following questions, using the word SAMPLE as a guideline:

Signs and Symptoms – Note the patient's signs and symptoms. A sign is something you can observe directly through sight, feel, smell or measurement. Wounds, external bleeding, marked deformities, respirations and pulse are all signs. A symptom is a problem or feeling that the patient reports to you. "I feel dizzy," "My leg hurts," or "Ow, that hurts a lot!" are examples of symptoms. See page 6 for picture/illustration.

Allergies – Is the patient allergic to any medication, food or other substance? What is the patient's reaction to any of them? Knowledge of the patient's allergies may prevent additional complications during emergency treatment especially if the patient becomes disoriented or unconscious.

Medications – What prescriptions, over the counter medications, or herbal remedies is the patient taking? When was it last taken and what is the dosage and frequency? A

sound knowledge of pharmacology can be beneficial in offering additional information regarding the patient's medical history. The patient's medications may be brought with you to the hospital or documented as to dosage and frequency prescribed.

Pertinent Past History – Does the patient have any history of medical, surgical or trauma occurrences? Has the patient had a recent fall, accident or blow to the head? Was the patient unconscious at any time before or since the incident occurred? Look for the presence of scars.

Last oral intake - When, what and how much did the patient last eat or drink? The type of food consumed may reflect a possible problem such as fatty food for a patient with gall bladder problems or peanuts consumed by a patient with a peanut allergy. Equally important is the lack of food intake by the diabetic patient. Should the patient require surgery this information would be valuable as well. Include questions as to if the patient has consumed alcohol?

Events leading to the injury or illness – Determine if you are dealing with a medical and/or a trauma call. A fall may appear to be a trauma call but it may have been precipitated by a medical problem. For example, was the vehicle accident the result of an underlying medical condition (M.I.)? Consider factors such as hypoglycemia, cardiac conditions, emotional stress, recent surgery and exertion. Note the correlation of any significant life event with the beginning or progression of the illness or trauma.



A: *A symptom is a condition that the patient feels and tells you about.* **B:** *A sign is a condition that you can observe*

Vital Signs

Neurological Assessment

To assess level of consciousness, judge the patient's level of orientation through response to questioning. As the level of consciousness drops, the patient will often lose orientation to time first, becoming unable to identify the day of the week, month, year, and time of day.

If the level of consciousness continues to slip, the patient will lose orientation to place. The patient may neither know where he/she is nor be able to recognize familiar or

otherwise recognizable surroundings. The patient may also exhibit a decline in orientation in relation to the event. He/she may be unaware of how the injury took place. In addition, the patient may be unable to recall key events leading up to the incident. The downward progression of consciousness continues with loss of orientation to person, and close friends or relatives.

He/she may recognize names once said, but will not be able to remember the name without hearing it.

As the patient moves toward unconsciousness and coma, you can further evaluate the patient objectively by observing physical responses to stimuli. Patients may respond by moving their extremities or opening their eyes, when you shout the patient's name or issue a loud verbal command (verbal stimuli). They may speak, but the communication is incoherent, garbled, or unintelligible. As the level of consciousness continues to diminish, the patient who no longer responds to verbal stimulation may still respond to painful stimulation. If the patient responds by moving away from the pain or by brushing your hand away, the response is called purposeful. If the hand and the forearm move, but not effectively, the response is called purposeless. The patient who is completely unconscious and unresponsive will fail to move to any stimuli. This is identified as unresponsive and is reflective of coma. In cases of severe brain injury (trauma or medical), the patient may respond with either decerebrate or decorticate posturing. Decerebrate posturing is present when the arms and legs extend and the back bows forcefully. Decorticate posturing differs only in that the upper extremities flex rather than extend. Either posturing may be present continuously or may occur with painful stimuli. Determine if the patient has lost consciousness or orientation at any time since the event. If unconsciousness occurred, increase the index of suspicion for serious cerebral insult. Watch any patient with this history very carefully for any change in level of orientation.

Glasgow Coma Scale

The Glasgow Coma Scale provides a system to evaluate the neurological status of a patient. It consists of three areas of assessment (eye-opening, motor response, and verbal response) and the allocation of points for the best patient response achieved. The resulting value can give an indication of the status of the patient's central nervous system (CNS) function. A score of 15 is the maximum and most common finding. A score of 9 or above is indicative of consciousness; anything below 7 is coma. Note that the lowest score obtainable is 3. Employ this system repeatedly during your care of the patient. See chart below.

Glasgow Coma Scale	
Eye Opening	
Spontaneous	4
To Voice	3
To Pain	2
None	1
Verbal Response	
Oriented	5
Confused	4
Inappropriate Words	3
Incomprehensible Words	2
None	1
Motor Response	
Obeys Commands	6
Localizes Pain	5
Withdraw (Pain)	4
Flexion (Pain)	3
Extension (Pain)	2
None	1

There are many ways to describe level of consciousness. However, items such as obtunded, semi-conscious, and confused have different meanings for different people. A more conscious and objective classification of a patient's level of consciousness is represented by the mnemonic AVPU, which stands for Alert, responds to Verbal stimulus, responds to Painful stimulus, and Unresponsive. This tool is designed to be used in the order given. A level of consciousness that is less than Alert on the AVPU scale may indicate an emergent or an already serious problem. A patient with an impaired mental status may have lost, or be in danger of losing the ability to protect his / her airway. Take immediate steps to protect the patient's airway by positioning, use of airway adjuncts, or intubation, as appropriate. Provide oxygen to any patient with diminished mental status, and seek out the cause.

Respiration

Since oxygen and carbon dioxide exchange is essential to human life, respiration must occur continuously. You will have evaluated respiration briefly during the initial (primary) assessment, but you will reassess it to determine the exact rate, relative tidal volume and subtle signs of distress. Determine the respiratory rate over 30 seconds by placing a hand on the chest and counting each breath. Multiply the number by 2 and the result is breaths per minute. The rate should be regular. Also, assure that the breaths are full and that no extraneous sounds or signs of difficult breathing exist. Repeat this assessment often to ensure the airway remains unobstructed and breathing is adequate in rate and volume.

Though airway and breathing separately make up the A and B of the ABC's, evaluate them together. Breathing does not occur without an airway; conversely, a patent airway cannot be confirmed unless air moves through it. Look, listen, and feel to find out if the patient has an open airway and adequate breathing.

Pulse

Each time the heart beats, the arteries expand and contract with the blood that rushes into them. The pulse is the pressure wave generated by the heartbeat. It directly reflects the rhythm, rate and relative strength of the contraction of the heart. It can be felt at any point where an artery crosses over a bone or lies near the skin. When you take a pulse you should note the following:

- rate
- rhythm (regularity)
- quality (strength)

Count the number of beats for 15 seconds and multiply by 4 to obtain the number of beats per minute. The pulse should be counted for 1 minute if irregular. The normal heart rate per minute for an adult is 60-100 beats. The pulse should be assessed frequently as it is a valuable indicator of circulatory function.

You can use various pulse points to approximate the patient's systolic blood pressure. As the pulse wave travels away from the heart and the central circulation, it weakens. The radial pulse normally disappears when the systolic pressure drops below 80 mm Hg. Between 70 mm Hg and 80 mm Hg the femoral pulse disappears. The carotid pulse usually remains until the systolic pressure drops below 60 mm Hg.

Blood Pressure



Blood pressure is the amount of pressure the surging blood exerts against the arterial walls. It is an important index of the efficiency of the whole circulatory system. In part, it indicates how well the organs and tissues are getting the oxygen they need. Contraction of the heart forces blood through the arteries, which is called systole. Between contractions when the heart relaxes, is called diastole.

Blood pressure normally varies with the age, gender, fitness level and medical history of the patient. The table below illustrates normal blood pressure ranges for children and adults. For gender variants, both the systolic and diastolic pressures are about 10 mm Hg lower in the females than in the males. Blood pressure is reported as systolic over diastolic (for example, 122/78).

See chart below.

Normal Blood Pressure Ranges

Patient	Systolic	Diastolic
Child up to ~ 12 years old	2 x patient's age + 80	50 to 80 mm Hg
Adult	Patient's age + 100 (up to 150 mm Hg)	65 to 90 mm Hg

Measuring Blood Pressure

There are two methods of obtaining blood pressure manually with a blood pressure cuff. One is by auscultation, or by listening for the systolic and diastolic sounds through a stethoscope. The second method is by palpation, or by feeling for the return of the pulse as the cuff is deflated.

For both methods of obtaining blood pressure, it is important to choose the proper sized blood pressure cuff. It must be able to encircle the arm so that the Velcro on opposite ends meets and fastens securely. The cuff's bladder should cover half the circumference of the arm. If it covers less, it will not compress the blood vessels properly. If it covers more, it will suppress the pulse too quickly. The cuff should fit snugly with the lower edge at least two to three centimetres above the antecubital space (the hollow, or front, of the elbow) and the bladder centered over the brachial artery. It should not be too tight. You should be able to place one finger easily under its bottom edge.

Measuring Blood Pressure by Auscultation

1. Apply the appropriate size cuff and inflate rapidly. At the same time, palpate the radial pulse until it can no longer be felt. Make a mental note of the reading. Without stopping, continue to inflate the cuff to 30 mm above the level where the pulse disappeared.
2. Apply the stethoscope over the brachial artery just above the hollow of the elbow. The bell may be held with the thumb.
3. Deflate the cuff at approximately 2 mm per second. Watch the mercury column or needle indicator drop.
4. As soon as you hear two or more consecutive beats (clear tapping sounds of increasing intensity), record the pressure. This is the systolic pressure.
5. Continue releasing air from the bulb. At the point where you hear the last sound, record the diastolic pressure. Continue to deflate slowly for at least 10 mm. Remember that slow pulses require slower-than-normal rates of deflation. With children and some adults, you may hear sounds all the way to zero. In such cases, record the pressure when the sound changes from clear tapping to soft, muffled tapping.
6. Record on which limb the blood pressure was taken. Record the position of the person when the blood pressure was taken.
7. Remove blood pressure cuff.

Measuring Blood Pressure by Palpation

When it is too noisy for you to hear well enough to measure by auscultation, palpate the blood pressure.

1. Apply the appropriate size cuff and inflate rapidly. As you do so, palpate the patient's radial pulse.
2. Make a mental note of the level at which you can no longer feel the pulse.
3. Without stopping, continue to inflate the cuff another 30 mm Hg. Then slowly deflate it.
4. Note the pressure at which the radial pulse returns. This is the systolic pressure.
5. Record it as a palpated systolic pressure (for example, 120/P).

When repeated blood pressure readings are obtained, watch for changes, as this may indicate changes in the patient's condition. Record the blood pressure when you measure it, as well as the time it was taken.

A decrease in the blood pressure may indicate one of the following:

- loss of blood or its fluid components
- loss of vascular tone and sufficient arterial constriction to maintain the necessary pressure even without any actual fluid or blood loss
- a cardiac pumping problem

When any of these conditions occur and result in a small drop in circulation, the body's compensatory mechanisms are activated, the heart and pulse rates increase, and the arteries constrict. Normal blood pressure is maintained, and by decreasing the blood flow to the skin and extremities, available blood volume is temporarily redirected to the vital organs so that they remain adequately perfused. However, as shock progresses, and the body's defence mechanisms can no longer keep up, the blood pressure will fall. Decreased blood pressure is a late sign of shock and indicates that the critical decompensated phase has begun. Any patient with a markedly low blood pressure has inadequate pressure to maintain proper perfusion of all the vital organs and needs to have his or her blood pressure and perfusion restored immediately to a normal level.

When the blood pressure becomes elevated, the body's defences act to reduce it. Some individuals have chronically high blood pressure from progressive narrowing of the arteries that occurs with age, and during an acute episode, their blood pressure may increase to even higher levels. Head injury or a number of other conditions may also cause blood pressure to rise to very high levels. Abnormally high blood pressure may result in a rupture or other critical damage in the arterial system.

Non-Invasive Blood Pressure (NIBP) Monitoring

Non-invasive blood pressure monitoring uses the oscillometric is a mechanical method for determining mean arterial pressure, systolic pressure and diastolic pressure. These devices use a special blood pressure cuff that detects oscillations (or movement) in the arterial walls that are created by cardiac contractions. These oscillations are then transmitted by the cuff hose to a microprocessor within the monitor that uses cuff pressure information as well as the oscillation amplitudes to determine the patient's blood pressure. In the prehospital setting, BP readings by NIBP can be inaccurate during transport due to bumpy road surfaces.

As you evaluate the blood pressure, look to the differences between the systolic and diastolic readings. This value, called the pulse pressure, reflects the effectiveness of the cardiac output against the flexibility of the arterial system. Up to a point, the wider the pulse pressure, the better the state of the circulatory system. A narrow pulse pressure may indicate pericardial tamponade or tension pneumothorax. It may also be an early finding of shock.

Skin

Assessment of the skin temperature, color, and condition can tell you more about the patient's circulatory system.

Skin Temperature

The normal body temperature is 37 °C. You may get a general impression of the patient's temperature by touching the patient's skin with the back of your hand. This is called relative skin temperature. It does not measure exact temperature, but you can tell if it is very high or low.

Changes in skin temperature can alert you to certain injuries and illnesses. A patient whose skin temperature is cool, for example, may be suffering from shock, heat exhaustion, or exposure to cold. A high temperature may be the result of fever or heat stroke. Body temperature can also change over a period of time, and it can be different in various parts of the body. Circulatory problems may be indicated by a cold arm or leg, for example. An isolated hot area could indicate a localized infection. Be alert to changes and record them.

Skin Color

Skin color can tell you a lot about problems in a patient's heart and lungs and other problems as well. For example:

- pallor may be caused by shock or heart attack. It may also be caused by fright, faintness, or emotional distress, as well as impaired blood flow
- redness (flushing) may be caused by high blood pressure, alcohol abuse, sunburn, heat stroke, fever, an infectious disease, or in some cases, ingestion of a caustic substance where there is redness around the mouth and accompanying history
- blueness (cyanosis) is always a serious problem. It appears first in the fingertips and around the mouth. Generally, it is caused by reduced levels of oxygen, as in shock, heart attack, or poisoning
- yellowish (jaundice) color may be caused by a liver disease
- black-and-blue mottling is the result of blood seeping under the skin. It is usually caused by a blow or severe infection. Also look for black tinges around nostrils and facial pores which may indicate smoke inhalation burns

If your patient has dark skin, be sure to check for color changes on the lips, nail beds, palms, earlobes, whites of the eyes, inner surface of the lower eyelid, gums, and tongue.

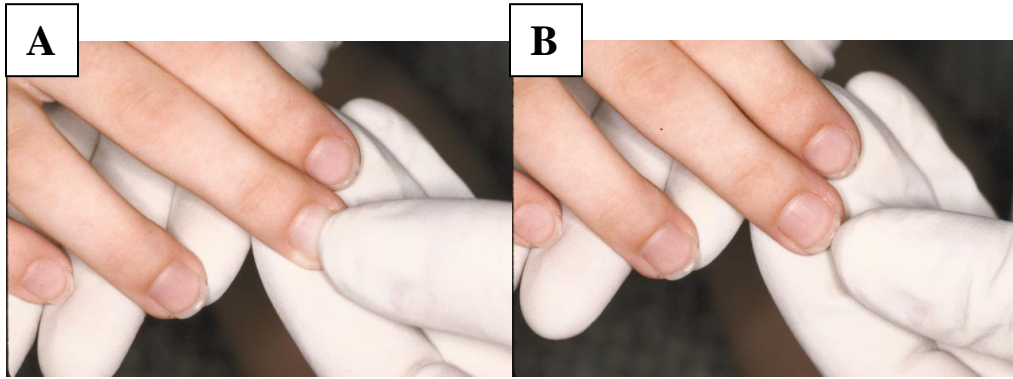
Checking the patient's nail beds is called assessing capillary refill. This procedure is performed by squeezing a fingernail or toenail. When squeezed, the tissue under the nail turns white. When you let go, the color returns to the tissue. To assess capillary refill,

you have to measure the time it takes for the color to return under the nail. Two seconds or less is normal. If refill time is greater than two seconds, suspect shock or decreased blood flow to that extremity.

Capillary refill may be checked in infants by squeezing the palm of the hand or the sole of the foot and watching for color to return.

Note that when you recheck capillary refill in the ongoing assessment, you must be sure to do it at the same place. Different parts of the body may have different refill times.

See illustration below.



A: *To test capillary refill, gently compress the fingertip until it blanches.*
B: *Release the fingertip, and count until it returns to its normal pink color.*

Skin Conditions

Normally, a person's skin is dry to the touch. When a patient's skin condition is wet or moist, it may indicate shock, a heat-related emergency, or a diabetic emergency for example. Skin that is abnormally dry may be a sign of spinal injury or severe dehydration.

Pupils

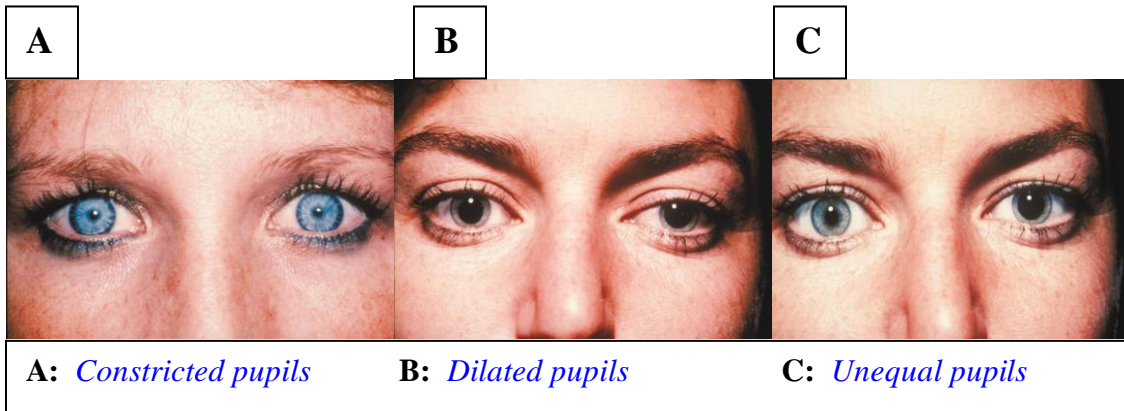
Normally, pupils constrict (get smaller) when exposed to light and dilate (enlarge) when the level of light is reduced. Both pupils should be approximately the same size (although 1 mm difference may be a normal variance) unless a prior injury or condition changes this.

With these normal responses in mind, assess a patient's pupils. Shine your penlight into one of the patient's eyes and watch for the pupil to constrict in response to the light. Also look for the return of dilation when the light source is removed. If you are outdoors in bright light, cover the patient's eyes and observe for dilation of the pupils. Do not expose the patient's eyes to light for more than a few seconds, as this can be very uncomfortable to the patient.

Abnormal findings for pupils include the following:

- pupils that do not react to light
- pupils that remain constricted (This may be caused by a drug overdose)
- pupils that are unequal (This may be an indication of a serious head injury or stroke)

See illustration



Diagnostics

Pulse Oximetry

Indications for Use

EMS personnel can use the pulse oximeter as an adjunct to routine patient care. It is not meant to replace any aspect of standard patient assessment. The pulse oximeter is particularly useful in identifying unrecognized cardiorespiratory problems that result in inadequate oxygenation and ventilation. An abnormal pulse oximeter reading may identify the need for support of the cardiorespiratory system. Ideally pulse oximetry monitoring should be done on all transports especially in the following situations:

- cyanotic patient
- signs and symptoms of respiratory distress
- in conjunction with EKG monitoring
- unconscious patient
- trauma patient

The pulse oximeter provides EMS personnel with a continuous monitor of the patient's oxygenation and ventilation status. It can alert EMS personnel to subtle changes in the patient's condition. It can also identify a change in the effectiveness of any oxygenation or ventilation intervention being made by EMS personnel, such as loss in supplemental oxygen delivery.

EMS personnel recall that oxygen saturation readings are averaged over time (5-15 seconds or more). As a result, oximeter readings will not drop immediately after patient oxygenation and ventilation changes.

Factors Affecting Pulse Oximetry

A number of factors can affect the pulse oximeter's ability to display accurate arterial oxygen saturation levels. While the oximeter may display a reading, it may be unreliable or false under certain circumstances. Pulse oximeters are calibrated using healthy human volunteers as test subjects. The volunteers have normal or near-normal oxygen saturation values, and calibration can be accurate in normal or near-normal oxygen saturation ranges. When saturation values decrease below 70-75%, the values are not considered to be accurate because there are no control values to permit accurate calibration at these low values.

Carbon Monoxide

Carbon monoxide poisoning leads to erroneously normal or near-normal oxygen saturation values. When carbon monoxide is bound to hemoglobin, carboxyhemoglobin is the result. Carboxyhemoglobin does not bind oxygen and does not carry any oxygen to the cells or tissues. However, carboxyhemoglobin absorbs the same wavelength of light as does oxyhemoglobin. The photodetector cannot distinguish between oxyhemoglobin and carboxyhemoglobin. The result is a falsely normal oxygen saturation reading yet the body's cells and tissues are not receiving any adequate oxygen.

Poor Peripheral Perfusion

Poor peripheral perfusion creates problems for the pulse oximeter. When peripheral perfusion is poor, inadequate amounts of fresh oxygenated arterial blood reach the small blood vessels in tissue beds. The pulse oximeter is unable to distinguish between freshly oxygenated arterial blood and the venous blood. Typically, the pulse oximeter will display an erratic reading or fail to give a reading at all. In order to get a reliable reading, the underlying cause of poor peripheral perfusion should be treated. Caution with blood pressure taken on same side as where probe is located as this may result in false readings.

Hypothermia

Hypothermia impedes the pulse oximeter's ability to obtain an accurate reading because there is limited or no blood flow to the peripheral circulation. When the body is cold, peripheral vasoconstriction takes place. This limits the amount of freshly oxygenated arterial blood reaching small blood vessels in tissue beds. Again, the pulse oximeter reading will be erratic or fail to give a reading at all. Repositioning the probe to a more central site (earlobe) may result in a more accurate reading.

Hypovolemia

Hypovolemic shock also causes difficulties for the pulse oximeter, and can lead to misleading oxygen saturation values. The red blood cells are responsible for carrying oxygen to the body's cells and tissues. When there is significant blood loss, the body loses red blood cells. This decreases the total amount of oxygen that can be carried to

the body's cells and tissues. The pulse oximeter may display a normal oxygen saturation because the red blood cells are well saturated with oxygen, but there are fewer red blood cells to carry oxygen to the cells and tissues. The net result is a decrease in total oxygen delivery to the body's cells and tissues.

Anemia

Anemia can also lead to misleading oxygen saturation values. Like hypovolemic patients, patients with anemia have fewer red blood cells to carry oxygen to the body's cells and tissues. Even though each red blood cell is near fully saturated with oxygen, there is an overall decrease in total oxygen delivery to the body's cells and tissues.

CPR

The poor or absent perfusion associated with cardiopulmonary resuscitation (CPR) results in unreliable pulse oximeter readings. A pulse oximeter has no place in a cardiac arrest.

Bright Light

The pulse oximeter's photodetector is sensitive to certain wavelengths of light. Bright light sources or strong ambient light can lead to inaccurate pulse oximeter readings. EMS personnel can minimize or avoid this source of error by covering the probe with an opaque material (towel, blanket).

Pigments and Dyes

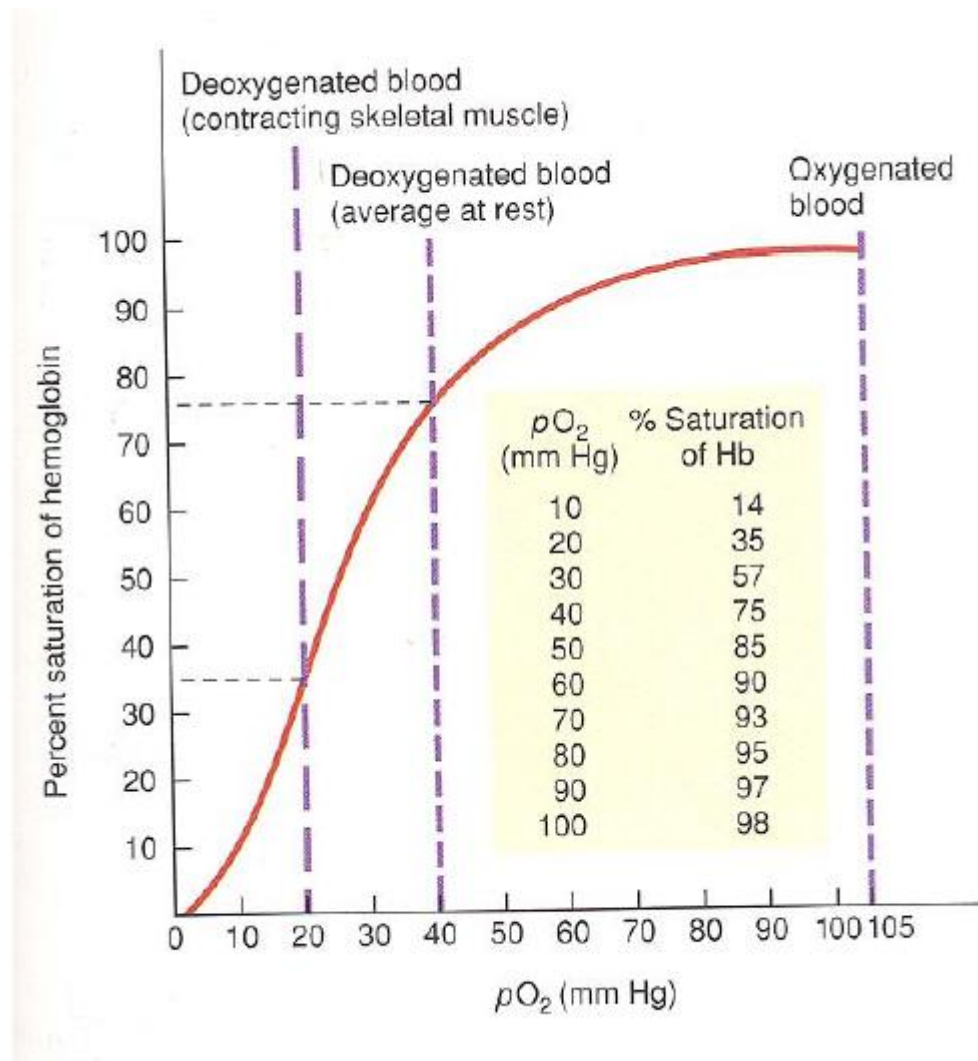
Pigments and dyes can interfere with the probes transmission and detection of light. The resulting decrease in the pulse oximeter's signal quality affects the accuracy of the value displayed. Examples of pigments or dyes include nail polish, skin dyes, tattoos, burns, bruises, hematomas, or any other discoloration of the skin or finger nails. If nail polish is a problem, it should be removed or the probe should be relocated to an alternate site.

As a final note, pulse oximeters may take several minutes to indicate a potentially life-threatening drop in oxygen saturation after the patient has been breathing 100% oxygen. If the patient were to stop breathing, the oxygen saturation would not drop for several minutes. The patient's signs and symptoms in conjunction with vital signs must be used as the primary tools for patient assessment.

Oxygen Saturation

When a hemoglobin molecule is carrying its full complement of 4 oxygen molecules, that hemoglobin molecule is fully saturated. If a very large number of hemoglobin molecules are considered as a group, we can determine the overall oxygen saturation in that sample of blood. Under normal circumstances, a healthy person with no cardiac or respiratory compromise will have oxygen molecules bound to 97-99% of all potential oxygen binding sites on the hemoglobin molecules. This average is referred to as the "oxygen saturation". In other words, 97-99% of all oxygen sites on the hemoglobin molecules have oxygen bound to them. The relationship between the oxygen saturation and the partial pressure of oxygen is illustrated by the oxygen-hemoglobin dissociation

curve Note that the curve is not linear. When the partial pressure of oxygen is high, hemoglobin binds with large amounts of oxygen and is almost fully saturated. When the partial pressure is low, hemoglobin is only partially saturated and oxygen is released from hemoglobin. At partial pressures between 60 and 100 mm Hg, hemoglobin is 90% or more saturated with oxygen. When the oxygen saturation drops below 90%, the partial pressure of oxygen drops quickly. This non-linear relation between oxygen saturation and partial pressure of oxygen is important to note when interpreting pulse oximeter readings.



Oxygen-hemoglobin dissociation curve at normal body temperature.

Use of a Pulse Oximeter

The pulse oximeter is a useful adjunct to identify hypoxia. Nevertheless, its use should be deferred if resources are limited or there are more urgent assessment and care priorities that require prompt management. The pulse oximeter does play an important role in patients with cardiorespiratory complaints. Pulse oximetry is needed to determine when high concentration oxygen by mask is sufficient or if assisted ventilation is also required. The decision to provide assisted ventilation is dependent primarily on clinical factors, but a low oxygen saturation measurement suggests it may be required. When

assisted ventilations are provided, the pulse oximeter can be used to judge the effectiveness of oxygenation and ventilation provided. EMS personnel are reminded to review the applicable Emergency Treatment Guidelines regarding ventilatory assistance.

Steps in pulse oximeter use:

1. Set up the pulse oximeter:
 - place oximeter where the display can be observed
 - ensure the pulse oximeter is well secured to avoid it being dropped as the patient is moved or transported
 - connect the sensor cord to the monitor
 - clip the sensor over a fingertip (or other appropriate location)
 - avoid using the thumb because it often causes sensing difficulties due to its size
 - in patients with poor peripheral perfusion, the earlobe or bridge of the nose may be used suitable probes are available
 - in infants, the toe or lateral aspect of the foot may be used

2. Initiate monitoring of oxygen saturation:
 - turn the pulse oximeter on
 - when the sensor is positioned properly and there is adequate perfusion to the site being monitored, the signal quality indicator should display “good” (or similar, such a green light)
 - if the sensor is not properly located over the vascular bed or there is inadequate perfusion, the signal quality indicator will indicate an inadequate signal. Reposition the sensor until the display indicates good sensing

3. Interpret pulse oximeter readings:
 - once proper sensing has been confirmed, there will be a delay of 3 – 6 seconds before the pulse rate and oxygen saturation are displayed
 - as long as the sensor remains properly placed, readings will be displayed
 - the pulse oximeter will display readings that are averaged over 5 – 15 seconds
 - any rapid change in oxygen saturation will take at least this long to register and be displayed

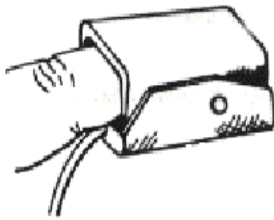
4. Equipment malfunctions:
 - most pulse oximeters are designed to provide either no reading or an unintelligible reading if any component fails
 - while this reduces the chance that an unrecognized malfunction will cause inaccurate readings, it does not eliminate the possibility
 - pulse oximeter readings should be compared regularly with a reference or other reading to ensure proper functioning
 - this can be done by comparing the readings obtained with those obtained by another pulse oximeter
 - pulse oximeters should be checked after they are dropped, damaged, found to provide inconsistent readings, or according to manufacturer’s recommendations

5. Documentation:

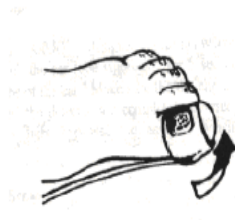
-if a pulse oximeter is used, its results must be documented on the patient care report

The following is the mandatory minimum information that must be recorded every time a pulse oximeter is used:

- initial reading
- any improved or deteriorating value during treatment and transport
- any change in patient management based on pulse oximeter readings
- any pulse oximeter difficulties or malfunction
 - times of each documented reading
 - license number of medic performing the pulse oximetry



Finger Probe



Toe Probe (adult)



Toe Probe (neonate)

There are several different types of sensors. Typically they are as illustrated here; a clip like probe which attaches to the finger or toe, and is designed to exert the proper amount of pressure to obtain a good signal.

Oxygen Saturation Values

Oxygen Saturation	Interpretation	Management
97 – 100%	Normal	Oxygen should be administered if patient complains of dyspnea or exhibits signs and symptoms of shock
92 – 96%	Low	May require supplemental oxygen via nasal cannula or simple mask – patient should be monitored closely to determine whether oxygen saturation improves
<92%	Very Low	Oxygen is to be administered via non-rebreathe mask – patient may require manual assistance of ventilation using high-flow oxygen

(Consider what is normal for patient i.e. COPD patient)

End Tidal CO₂ Monitoring

End tidal CO₂ detectors are designed to help verify tube placement and to recognize esophageal intubation. They can also provide a non invasive estimate of alveolar ventilation, CO₂ production, and arterial CO₂ content. Two types of CO₂ detectors are the colorimetric device and the electric monitor.

Colorimetric CO₂ detectors contain a non toxic chemical strip that responds to exhaled air. The exhaled air contains CO₂ that changes the colour of the strip from purple to yellow with each breath. No colour change indicates that tube placement is in the esophagus. The detector should only be used on intubated patients that have a perfusing rhythm. CO₂ detectors have shown inconsistent results on patients in cardiac arrest.

The electric device uses an infrared analyzer to measure the percentage of CO₂ at each phase of respiration. This information is displayed as a waveform on a monitor or printout.

Glucometry

Indications for Blood Glucose Testing

Patients with altered level of consciousness (some of the common causes of altered level of consciousness are listed below).

- A = Acidosis, alcohol
- E = Epilepsy
- I = Infection
- O = Overdose
- U = Uremia
- T = Trauma, tumor
- I = Insulin (hypoglycemia, or diabetes ketoacidosis)
- P = Psychosis
- S = Stroke

Procedure and Equipment Required

1. Determine that the patient meets the indications for blood glucose testing.
2. Gather the equipment and explain the procedure to the patient.
3. Prepare lancet or lancing device, such as Glucolet or Penlet.
4. Insert a test strip, (thereby turning on glucometer). Avoid touching test strip with bare hands.

5. Clean the fingertip that will be used to gather the blood sample with an alcohol swab and dry thoroughly. Alternative sites for pediatric patients include the toe or heel.
6. If using a lancet, grasp the lancet fairly close to the point so as to control the depth of the puncture. Then, using a quick and controlled motion, prick the prepared fingertip. Immediately dispose of the lancet in a sharps container as it is now considered a contaminated sharp.

If using a lancing device, press it firmly against the selected site and trigger the spring release mechanism. These devices normally work very well, but occasionally you may come across patients with very thick skin that the device may not penetrate. In these situations you may have to use the lancing insertion as you would a regular lancet. Some of the lancing devices have depth regulators that may overcome this problem. This requires assessment of each patient's skin prior to lancing so as to determine the appropriate setting. The lancing device inset should be immediately disposed of in a sharps container.

7. After the fingertip has been pricked, gently squeeze the finger proximal to the puncture site to increase the amount of blood presented. Once the necessary amount of blood is available, apply it to the test strip.

There are two common types of test strips used. One requires the blood droplet to be placed on the strip while in the other type the end of the test strip is inserted into the blood, which is automatically drawn into the strip. Different glucometers may require a different amount of blood to acquire accurate readings. Getting enough blood the first time avoids having to redo the test unnecessarily. **KNOW YOUR EQUIPMENT.**

8. Once the sample has been obtained, cover the puncture site with sterile gauze. It will take approximately 30-60 seconds for the glucometer to give its reading. This is a good time to reassess your patient.
9. If the patient was treated with glucose administration and transport time is over 10 minutes, then a second test would be in order. This would check the efficiency of the glucose treatment and may indicate that more glucose should be administered.

Blood Glucose Values

The body tries to keep glucose in the blood within certain levels to maintain homeostasis. In patients with certain infections, diseases, or physiologic states these levels can fluctuate over a wide range. See table below.

Blood Glucose Levels As Provided by Manitoba Health

0.0-2.9 mmol/l	Very Low	Signs and symptoms of hypoglycemia will likely be present. Patient requires glucose administration.
3.0-3.9 mmol/l	Low	Signs and symptoms of hypoglycemia may be present. Monitor patient carefully.
4.0-7.0 mmol/l	Normal	
7.1-19.9 mmol/l	High	May exhibit some signs or symptoms of hyperglycemia at higher levels.
Above 20.0 mmol/l	Very High	Signs and symptoms of hyperglycemia will likely be present ranging from dehydration to coma. Patient requires definitive care at hospital

Documentation

When blood glucose testing has been done, certain documentation is required:

- patient's condition prior to testing
- blood glucose level, recorded as mmol/l
- any treatment rendered based on readings
- the patient's response to treatment
- any difficulties encountered during or after testing
- subsequent readings must be recorded as well as the times for all treatments
- License number of the medic performing the assessment

Phlebotomy

Phlebotomy is defined as an incision into a vein. It is one of the oldest medical procedures, dating back to the early Egyptians. Hippocrates believed that an excess of

body fluids caused disease and that removal of the excess would return the body to a healthy state. Currently, a much more important role for phlebotomy is the collection of blood for laboratory analysis to diagnose and monitor conditions. This process is also referred to as venipuncture. Venipuncture is often performed in the field for the purpose of fluid or drug administration however, the acquisition of blood samples for laboratory analysis is rare.

Listed below are some examples of blood tests that can be performed using blood samples.

Test:	Function:
Acid Phosphatase	elevated levels may indicate prostatic cancer
Albumin	decreased levels may indicate liver or kidney disorders or malnutrition
Alcohol	elevated levels indicate intoxication
Ammonia	elevated levels may indicate severe liver disorders
Amylase	elevated levels may indicate pancreatitis
Arterial Blood Gases (ABG)	determine the acidity or alkalinity and gas pressures in blood
Bilirubin	elevated levels may indicate liver or hemolytic disorders
Blood Urea Nitrogen (BUN)	elevated levels may indicate kidney disorders
Cholesterol	elevated levels indicate coronary risk
Creatine Kinase (CPK)	elevated levels may indicate myocardial infarction or other muscle damage
Creatinine	elevated levels may indicate kidney disorders
Electrolytes	evaluate body fluid balance and kidney disorders
Glucose	elevated levels may indicate diabetes mellitus
High Density Lipoprotein (HDL)	assesses coronary risk
Lactic Dehydrogenase (LDH)	elevated levels may indicate myocardial infarction or lung or liver disorders
Lipase	elevated levels may indicate pancreatitis
Low Density Lipoprotein (LDL)	assesses coronary risk
Protein	decreased levels associated with liver or kidney disorders
Triglycerides	assesses coronary risk
Uric Acid	elevated levels may indicate kidney disorders or gout
Complete Blood Count (CBC)	helps determine the presence of an infection, bleeding disorders, anemia or leukemia

Arterial Blood Samples

Arterial blood is drawn for the assessment of blood gases, abbreviated as ABGs. The composition of arterial blood is uniform throughout the body, whereas the composition of venous blood varies as it picks up waste products from different areas of the body. Testing of ABG's measures the ability of the lungs to exchange oxygen and carbon dioxide by determining the partial pressure of oxygen (PO₂) and carbon dioxide (PCO₂) present in the arterial blood, and the pH of blood. Under normal conditions, arterial blood will have a higher PO₂ than PCO₂, because oxygen enters the arterial blood flowing through the lungs and carbon dioxide released from the tissues accumulates in the venous blood.

Some conditions requiring the measurement of blood gases include chronic obstructive pulmonary disease, cardiac or respiratory failure, severe shock, and diabetic coma. Patients requiring blood gas determinations are usually critically ill.

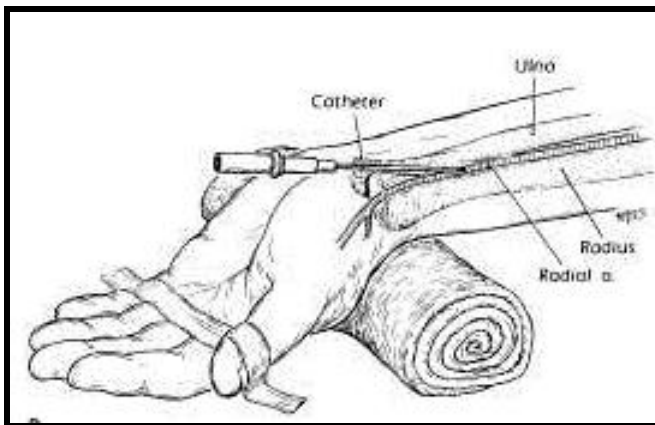
Arterial Blood Gas Values
Normal Adult Range

pH	7.35 – 7.45
PO ₂	80 – 100 mmHg
PCO ₂	35 – 45 mmHg
HCO ₃	20 - 24 mEq/L

Base excess and base deficit are also reported values.

Arterial blood gas samples can be obtained via radial artery puncture or via arterial line access. Arterial blood is collected in a heparinized syringe to avoid coagulation and is then sent to the lab for analysis of ABG's.

The risk of infection is higher in arterial puncture than venipuncture. Other complications include arteriospasm, hemorrhaging and nerve damage.



Core Temperature Monitoring

The body always tries to maintain a core temperature of 37 °C. A slight variance can mean that significant events are going on within the body. In emergency medical service a temperature is taken either orally or tympanically to approximate a core temperature.



A core temperature of 30 °C to 35 °C is considered to be mild/moderate hypothermia and a core temperature < 30 °C is considered severe hypothermia. A patient who is hypothermic may present with lethargy, confusion, and hallucinations, decreased or absent respirations, decreased blood pressure, decreased/irregular or absent heart rate. Increased cardiac irritability occurs at < 29.4 °C. Accurate measurement of temperature on the hypothermic patient is critical and should be done with a low reading thermometer (28.9 °C – 42.2 °C).

Hyperthermic patients are those with temperatures above 37 °C. A core temperature of > 41 °C is a grave prognostic sign. Patients may present with disorientation, convulsions, increased heart rate, and increased respiratory rate whereas blood pressure is not normally affected.

Symptoms in hypothermia and hyperthermia may mimic symptoms of other complications such as heart disease, diabetes, stroke or other metabolic derangements. Acquisition of core temperatures will assist in ruling out hypo or hyperthermia as the cause of the symptoms present.

Central Venous Access and Monitoring

Central Venous Access

Obtaining access to the venous and arterial circulation enables the administration of drugs, crystalloid and blood products and the measurement of central venous and arterial pressures.

Central Venous Access is performed:

- when rapid delivery of cardiac medications to the coronary circulation is required during cardiopulmonary resuscitation
- for venous access when peripheral veins are inadequate
- when measurement of Central Venous Pressure monitoring is

desired

A variety of sites and techniques are available to access the central circulation. Most commonly, the catheter is placed in the superior vena cava via the internal jugular or subclavian vein, less commonly via the external jugular vein. The femoral vein may also be used but it requires subsequent immobilization of the leg to maintain catheter placement and the procedure poses a higher risk for complications.

Monitoring

Central Venous Pressure (CVP) reflects right ventricular end diastolic pressure or preload. It is a poor indicator of left ventricular function.

CVP monitoring is useful in the following settings:

- to monitor initial volume resuscitation
- to evaluate right ventricular function after right ventricular infarction
- cardiac tamponade
- pulmonary embolism

CVP monitoring of cardiac response to blood volume changes requires extreme caution particularly in treating heart failure. In general, a hypotensive patient with a CVP < 5mmHg may be given fluid safely, and fluid must be given with particular caution if the CVP is > 15mmHg. Because CVP is an unreliable guide to volume status or left ventricular function, Pulmonary Artery Catheterization is considered if cardiovascular instability persists after initial therapy.

Complications

Complications of central venous catheterization may include hematoma formation, phlebitis, thrombosis, cellulitis and pneumothorax.

Pulmonary Artery Cannulation and Monitoring

Pulmonary Artery Cannulation

A Pulmonary Artery Catheter (PAC) is helpful in the monitoring of critically ill patients with acute myocardial infarction. Most important, a PAC can help to differentiate between shock due to intravascular volume depletion and that due to extensive left ventricular dysfunction.

The PAC or Swan Ganz catheter is inserted into the common sites used in central venous catheterization (subclavian or internal jugular veins). However, in Pulmonary Artery Cannulation, the catheter is passed further by continuing from the superior vena cava into the right atrium, through the tricuspid valve into the right ventricle. It is then advanced across the pulmonary valve and finally into a branch of either the left or right pulmonary artery where a balloon on the tip of the catheter may be inflated for a short period of time.

Pulmonary Artery Catheter Monitoring

When the inflated balloon tip of the catheter is wedged in a branch of the pulmonary artery, the pressure measured by the catheter corresponds to that in the left atrium. Left

atrial pressure (which equals left ventricular filling pressure) is an excellent indication of the adequacy of fluid resuscitation. If the pressure is < 12mmHg additional fluid is indicated. If the pressure is > 20 mmHg, additional fluids are unlikely to improve cardiac performance. Inotropes and vasopressors are among some of the treatments that should then be considered. Although the PAC can yield useful diagnostic information, the distinction between the need for more fluids and the need for more left ventricular support is its most useful application during resuscitation.

Complications

Cardiac dysrhythmias and right bundle branch block may occur as the catheter traverses the heart. Other potential complications include pulmonary embolism or infarction, knotting of the catheter, infection, and rupture of pulmonary artery structures.

Electrocardiograms (ECG's)

There are two types of cells in the heart.
Myocardial cells – which are the mechanical cells that contain contractile filaments.
Pacemaker cells – are responsible for the spontaneous generation of a stimulus and also specialize in the conduction of electricity.

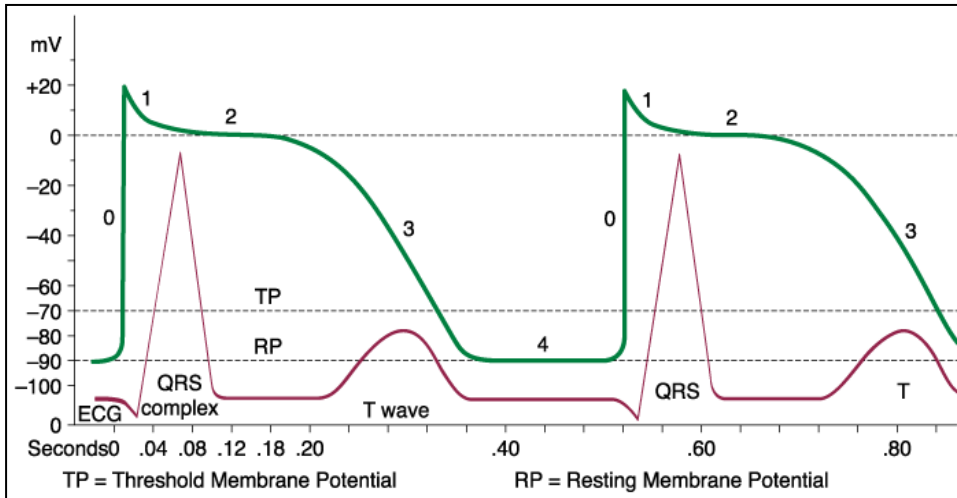
Electrical impulses are the result of a brief and rapid flow of ions back and forth across the cell membrane. This exchange of ions creates electrical activity.

The major ions that cause this affect are:

- Sodium
- Potassium
- Calcium

There is normally a slight excess of positively charged ions outside the membrane and negatively charged ions on the inside of the cell when a cell is at rest. The stimulation of myocardial cells, as evidenced by a change in the membrane electrical charge that subsequently spreads across the myocardium is known as action potential. A series of events causes the electrical charge inside the cells to change from its polarized (resting) state to a depolarized (stimulated) state and return them back to a repolarized (resting) state. The action potential curve is an illustration of these events.

During depolarization, the inside of the cells become more positive due to an influx of positive ions. It is important to remember that depolarization is an electrical phenomenon and not a mechanical event as can be evidenced by pulse less electrical activity (PEA). Once the cells have depolarized, they must return to their resting state whereby the inside of the cells become negatively charged.



Action Potential Curve

Action Potential of a cardiac cell consists of five phases.

Phase 0 – Depolarization

The inside of the cell become positively charged when sodium ions rush in. The cell depolarizes causing mechanical contraction to begin. On the electrocardiogram (ECG) depolarization of the atria is depicted by the P wave and depolarization of the ventricles is depicted by the QRS complex.

Phase 1 - Early Repolarization

This is an early and brief period of repolarization where the inside of the cell becomes less positive due to a shift in ions.

Phase 2 – Plateau Phase

Repolarization is underway but slowly. During this phase the ST segment is produced.

Phase 3 – Rapid Repolarization

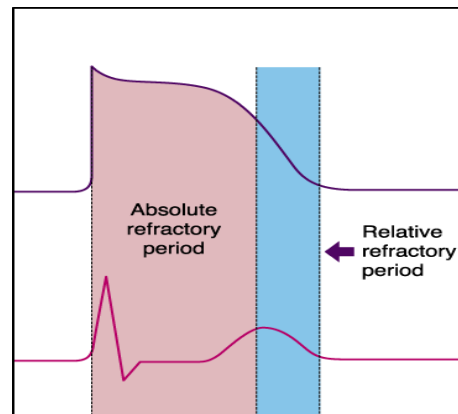
The cell quickly becomes more negative on the inside and also becomes more sensitive to external stimuli. The T wave corresponds with this phase on the ECG.

Phase 4 – Repolarized

The cells are now in their complete resting state and are ready for another stimulus.

Refractoriness

Refractoriness refers to the extent to which a cell is capable of responding to a stimulus. The Absolute Refractory Period is at the onset of the QRS complex to approximately the peak of the T wave. This means that no matter how strong a stimulus is conducted, cells in the absolute refractory period will not depolarize. During the Relative Refractory Period, cells can be depolarized even though they are not completely repolarized, by the stimulus that is strong enough. The relative refractory period corresponds with the down slope of T wave.



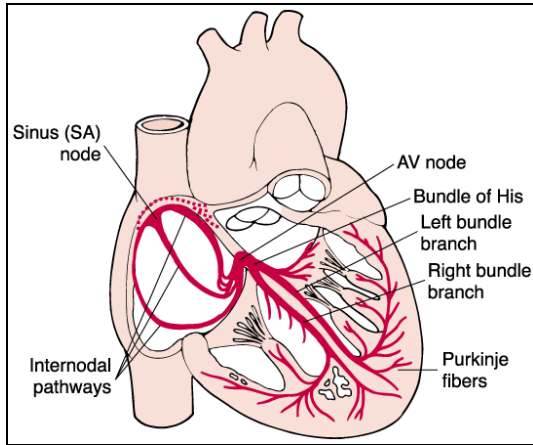
Refractory Periods

Properties of Cardiac Cells

Cardiac cells have the ability to generate their own impulses thus do not rely on being stimulated by another source such as a nerve. This is known as automaticity. The muscle cells are excitable and will respond to outside stimuli such as that from a chemical, mechanical or electrical source. Cardiac cells have a conductivity property thereby having the ability to conduct impulses to the adjacent cells. Cardiac cells also have the ability to contract. Fibers shorten in response to an electrical stimulus causing muscle contraction.

The Conduction System

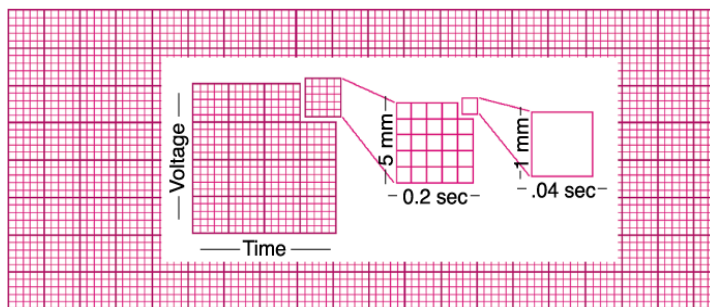
There are specialized pacemaker cells within the hearts electrical system. Normally the pacemaker site with the fastest rate controls the heart. The Sino Atrial (SA) Node is normally the primary pacemaker and it initiates electrical impulses at a rate of 60 – 100 beats per minute (bpm). Impulses leave the SA node and spread from cell to cell across the Atria. The impulse then reaches the Atrio Ventricular (AV) Junction which is located in the AV Node. There is a delay in conduction at this point which allows the atria to empty its contents into the ventricles. The pacemaker cells in the AV Node have the inherent rate of 40 - 60 bpm. The impulse then continues through the Bundle of His and then connects to the Right and Left Bundle Branches. The Right Bundle Branch innervates the right ventricle and the Left Bundle Branch innervates the septum and the left ventricle. The electrical pathway continues to the Purkinje Fibers which have the intrinsic rate of 20 – 40 bpm. See illustration below



Electrical Conduction Pathway

Graph Paper

ECG graph paper is standardized to allow comparative analysis of patterns. The paper moves across the stylus at 25mm/sec. The horizontal axis represents time while the vertical axis represents voltage. The ECG paper is divided into small and large boxes. There are 5 small boxes across 1 large box.



1 small box = 0.04 sec
 5 small boxes (1 large box) = 0.20 sec
 5 large boxes = 1.0 sec

ECG Graph Paper

Leads

Electrodes placed on the skin, detect the total amount of electrical activity occurring within the heart at a given time. A pair of electrodes is referred to as a lead.

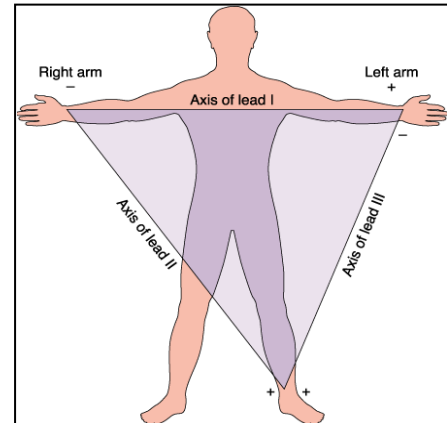
There are three types of leads:

- limb (bipolar) leads
- augmented leads
- precordial (unipolar) leads

3 Lead ECG's

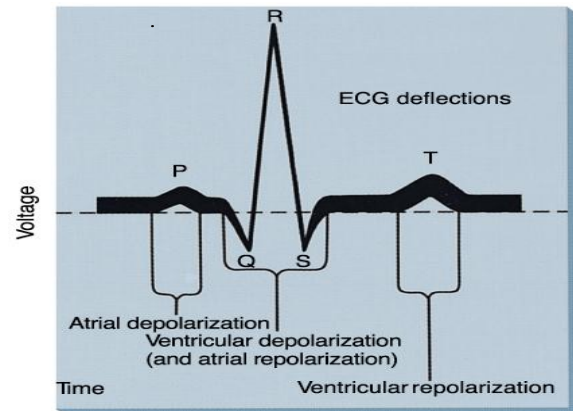
The limb leads are most frequently used for cardiac monitoring in the field. They form a triangle around the heart, referred to as Einthoven's Triangle.

<u>Lead</u>	<u>Positive Electrode</u>	<u>Negative Electrode</u>
I	left arm (shoulder)	right arm (shoulder)
II	left leg (hip)	right arm (shoulder)
III	left leg (hip)	left arm (shoulder)



*3 Lead Placement
Einthoven's Triangle*

On any limb lead, an electrical impulse that moves toward a positive electrode will cause a positive deflection on the ECG paper. An electrical impulse moving toward a negative electrode will produce a negative deflection.



ECG Deflections

Artifact

Artifact causes deflections on the ECG that are produced by factors other than the heart's electrical activity.

Common causes of artifact include:

- muscle tremors
- shivering
- patient movement
- loose electrodes
- 60 cycle interference
- machine malfunction

Calculating Rate

Rhythm Recognition and Interpretation

Rhythm recognition is one of the most important skills learned, as subsequent treatment will be based upon accurate interpretation. The electrocardiogram is a graphic representation of the electrical activity of the heart. It does not provide any information on the mechanical or pumping ability of the heart.

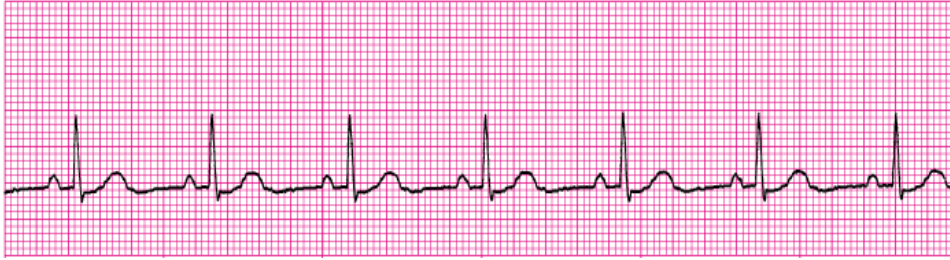
The ECG can provide information regarding:

- the orientation of the heart in the chest
- conduction disturbances
- the electrical activity due to effects of medications and electrolytes
- the mass of cardiac muscle
- the presence of ischemic damage

Interpretation of rhythm strips should be done in a logical and systematic fashion. Attempting to eyeball in a non-analytical way often leads to incorrect interpretation. The following legend shows a systematic approach to ECG interpretation. It also indicates what is considered normal for the adult.

<u>Sequence</u>	<u>Normal Sinus Rhythm</u>
• Rate	60 – 100 bpm
• Regularity	Regular
• Presence and morphology of P waves	occur before every QRS complex, are rounded and upright
• Presence and length of PR interval	0.12 – 0.20 seconds
• Duration of QRS complex	0.10 - 0.12 seconds

See illustration below



Normal Sinus Rhythm

Any deviation from normal is considered a dysrhythmia. Memorization of the rules for each dysrhythmia will help in the interpretation of a rhythm strip should it not fit within the normal. Some dysrhythmias are more significant than others and one should remember to treat the symptoms not the dysrhythmia.

Causes of dysrhythmias are numerous and include:

- myocardial ischemia, necrosis or infarction
- autonomic nervous system imbalance
- distention of the chambers of the heart
- blood gas abnormalities, including hypoxia and abnormal pH
- electrolyte imbalances (Ca⁺⁺, K⁺, Mg⁺⁺)
- trauma to the myocardium
- drug effects and drug toxicity
- electrocution
- hypothermia
- central nervous system damage
- idiopathic events
- normal occurrences (exercise)

Rhythm Rules

RHYTHM	RATE	REGULARITY	P WAVE	PR INTERVAL	QRS
Sinus Bradycardia	< 60	Regular	Upright/Normal	0.12 – 0.20	0.10 – 0.12
Sinus Tachycardia	>100	Regular	Upright/Normal	0.12 – 0.20	0.10 – 0.12
Sinus Dysrhythmia	60 - 100	Irregular	Upright/Normal	0.12 – 0.20	0.10 – 0.12
Sinus Arrest	Normal - <	Irregular	Upright/Normal	0.12 – 0.20	0.10 – 0.12
Wandering Pacemaker	Usually 60 - 100	Slightly Irreg.	Differing Morphology	>, = or < than 0.12 – 0.20	0.10 – 0.12
PAC's ¹	Depends on underlying rhythm	Usually Regular Except for PAC	Occurs earlier than expected	Usually 0.12 – 0.20	0.10 – 0.12
PSVT ²	150 – 250	Regular	Upright/may be hard to find	Usually 0.12 – 0.20	0.10 – 0.12
Atrial Flutter	Atrial 250 – 350 Ventricular varies	Regular	Saw Toothed	Constant	0.10 – 0.12
Atrial Fibrillation	Atrial rate can not be counted	Irregular	No discernable waves	None	0.10 – 0.12
PJC's ³	Depends on underlying rhythm	Usually Regular Except for PJC	Inverted or can't see	< or none	0.10 – 0.12
Junctional Escape	40 – 60	Regular	Inverted or can't see	< or none	0.10 – 0.12
Accelerated Junctional	60 – 100	Regular	Inverted or can't see	< or none	0.10 – 0.12
PSJT ⁴	100 – 180	Regular	Inverted or can't see	< or none	0.10 – 0.12
Ventricular Escape	20 – 40	Regular	None	None	> 0.12
PVC's ⁵	Depends on underlying rhythm	Usually Regular Except for PVC	None	None	> 0.12
Ventricular Tachycardia	100 - 250	Regular	None	None	> 0.12
Ventricular Fibrillation	No organized rhythm	No Organized Rhythm	None	None	None
Asystole	No electrical activity	No Electrical Activity	None	None	None
Paced Rhythm	Set to rate of pacemaker	Regular or Irregular	Varies on pacemaker placement	Varies if present	> 0.12
1st Degree Block	Depends on underlying rhythm	Usually Regular	Upright/Normal	> 0.12 – 0.20	0.10 – 0.12
2 nd Degree Block Type 1	Normal to slow	Irregular	Upright/Normal	Progressively longer until a QRS is dropped	0.10 – 0.12
2 nd Degree Block Type 2	Usually slow	Usually Regular	Upright/Normal More P's than QRS complexes	Constant, may be longer	0.10 – 0.12 or greater
3 rd Degree Block	Atrial normal Vent. 40 - 60	Regular	Normal but no association with QRS	No relationship with QRS	Usually > 0.12

¹ Premature Atrial Contraction ² Paroxysmal Supraventricular Tachycardia ³ Premature Junctional Contraction
⁴ Paroxysmal Supraventricular Junctional Tachycardia ⁵ Premature Ventricular Contraction

12 Lead ECG's

Single lead ECG monitoring was principally designed to detect cardiac dysrhythmias. With the advent of fibrinolytic therapy, early detection of acute myocardial infarction, using a 12 lead ECG, has become very important. A standard 12 lead ECG views the heart from 12 different angles.

The multiple views of the heart in a 12 lead ECG can provide useful information including:

- recognition of bundle branch blocks
- identification of ST segment and T wave changes associated with myocardial ischemia, injury and infarction
- identification of ECG changes associated with certain medication and electrolyte imbalances

Lead Placement

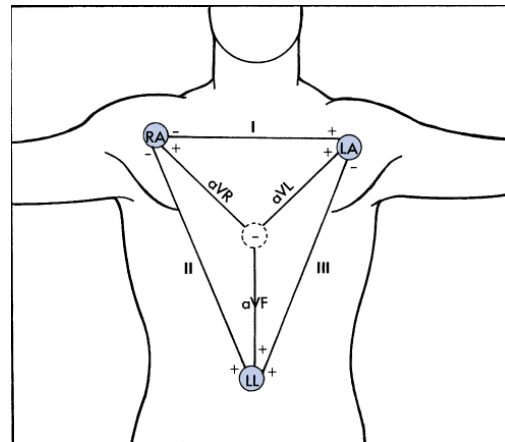
A 12 lead ECG is obtained by placing electrodes in specific locations on the body. Each lead has a positive (+) and a negative (-) electrode. The 12 lead ECG includes all three types of leads.

Limb Leads	Lead I	Lead II	Lead III
Augmented Leads	aVR	aVL	aVF
Precordial Leads	V ₁	V ₂	V ₃ V ₄ V ₅ V ₆

There are only 4 electrodes placed on the skin to achieve the 6 views provided by the limb and augmented leads combined. The electrode placement is the same for that of a 3 lead ECG, but a 4th electrode is placed on the right leg (hip).

The limb leads and the augmented leads together are considered the frontal plane leads. That is, they record the electrical activity of the heart in the frontal plane of the body utilizing electrodes placed on the extremities. They view the heart from the front of the body.

(is a reference # required here?)



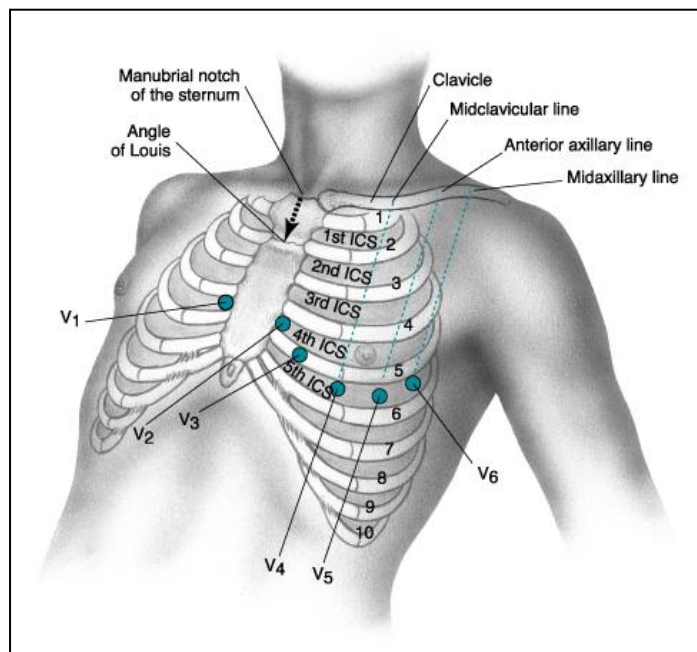
Frontal Plane Leads

The precordial leads provide a look at the horizontal plane of the heart. The horizontal plane leads view the heart as if the body were sliced in half horizontally. The negative

pole for the precordial leads is a common ground arranged electronically within the ECG machine. The precordial leads are considered unipolar.

Lead placement for the Precordial leads is as follows:

- V1 right side of sternum, 4th intercostal space
- V2 left side of sternum, 4th intercostal space
- V3 midway between V2 and V4
- V4 left midclavicular line, 5th intercostal space
- V5 left anterior axillary line, same level as V4
- V6 left midaxillary line at same level as V4



Precordial Lead Placement

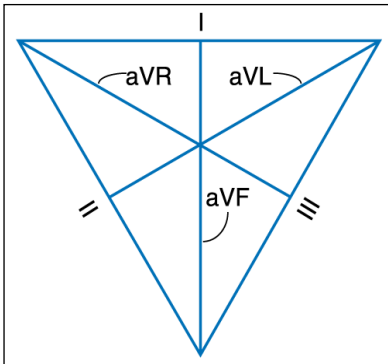
Listed below are the leads of a 12 lead ECG and what portion of the heart they view.

- Lead I views the lateral wall of the left ventricle
- Lead II views the inferior surface of the left ventricle
- Lead III views the inferior surface of the left ventricle
- aVR views the base of the heart, primarily the atria and great vessels. It does not view any wall of the heart
- aVL views the lateral wall of the left ventricle
- aVF views the inferior wall of the left ventricle

- V1 and V2 view the anterior septum
- V3 and V4 view the anterior surface of the left ventricle
- V5 and V6 view the lateral surface of the left ventricle

Vectors and Axis Deviation

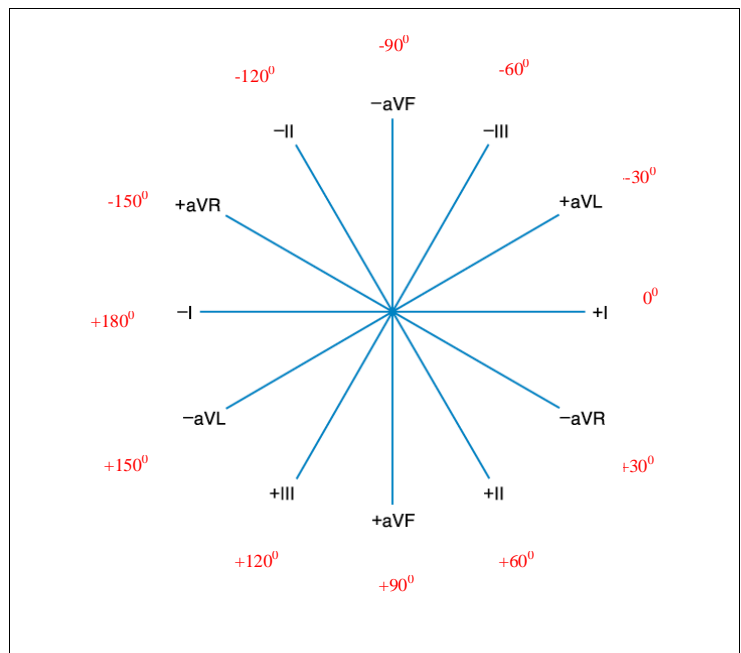
A vector points in the direction of depolarization. A mean vector identifies the average of depolarization waves in one portion of the heart. The mean P vector represents the average magnitude and direction of both left and right atrial depolarization. The mean QRS vector represents the average magnitude and direction of both the right and left ventricular depolarization. The average direction of a mean vector is called the mean axis and is only identified in the frontal plane. An imaginary line joining the positive (+) and negative (-) electrodes of a lead is called the axis. Electrical axis refers to determining direction (angle in degrees) in which the main vector of depolarization is pointed. When the term "axis" is used by itself, it refers to the QRS axis. Because the left ventricle is considerably larger than the right ventricle, right ventricular repolarization forces are overshadowed on the ECG. As a result, the mean QRS vector points inferiorly and to the left. The axes of leads I, II and III form an equilateral triangle (Einthoven's Triangle) with the heart at the centre. If the augmented leads are added to this configuration, they bisect each other in such a way that the result is the hex axial reference system.



Hex Axial Reference System

The hex axial reference system represents all of the frontal plane leads with the heart at the centre. This reference also forms a 360 degree circle around the heart.

Axis Chart



The positive end of lead I is designated 0 degrees. The six frontal plane leads divide the circle into segments each representing 30 degrees. The mean QRS vector (normal electrical axis) lies between 0 and +90 degrees. Current flow to the right of normal is called **right axis deviation** or RAD (+90 to +180 degrees). Current flow to the left of normal is called **left axis deviation** or LAD (-1 to -90 degrees). **Indeterminate axis** is often considered extreme right axis deviation (-90 to -180 degrees).

Leads I and aVF divide the heart into four quadrants. These two leads can be used to quickly estimate electrical axis. The QRS complex is normally positive (upright) in leads I and aVF. If the QRS in either or both leads is negative, axis deviation exists. The following is a quick method that can be used to determine which axis is present.

Axis	Normal Axis	LAD	RAD	Indeterminate
Lead I QRS	positive	positive	negative	negative
Lead II QRS	positive	negative	positive	negative

Right Axis Deviation

Right Axis Deviation may be a normal variant, particularly in young and thin individuals. Other causes of RAD include mechanical shifts associated with inspiration, emphysema, right ventricular hypertrophy, dextrocardia and left posterior hemiblock.

Left Axis Deviation

Left Axis Deviation may be a normal variant, particularly in older individuals and those that are obese. Other causes of LAD include mechanical shifts associated with expiration, a high diaphragm due to pregnancy, ascites, hyperkalemia, inspiration or emphysema, right ventricular hypertrophy, and dextrocardia.

Ischemia, Infarct and Injury

The sudden occlusion of a coronary artery due to a thrombus may result in ischemic injury and or infarct of the area of the myocardium supplied by the artery. The affected area goes through a sequence of events that have been identified as “zones” of ischemia, injury and infarction. Each zone is associated with characteristic ECG changes. It is important to note that the ECG is non-diagnostic in approximately 50% of patients with chest discomfort. A normal ECG does not rule out an acute myocardial infarction (AMI) particularly in the early stages of a coronary artery occlusion.

Ischemia

Myocardial ischemia results when the heart’s demand for oxygen exceeds its supply from coronary circulation. This can occur due to decreased supply or an increased demand of oxygen. Angina Pectoris is a symptom of myocardial ischemia. If the ischemia is not reversed it may progress into injury and eventually infarct. Ischemia can resolve by resting and bringing the heart rate down therefore reducing oxygen demand. Medication such as beta-blockers also have an effect on slowing the heart rate. Another medication used to treat angina is Nitroglycerine, which dilates coronary arteries.

ECG changes in Ischemia.

- ST segment depression
- T wave inversion

ST segment depression is considered significant when it is 1mm or more below the baseline. ECG changes associated with ischemia are usually temporary if treated. If ischemia is present through the full thickness of the myocardium, T wave inversion will be present in the leads facing the affected area. If ischemia is present in the subendocardial layer, the T wave is usually upright because repolarization is unaffected. Repolarization normally occurs from epicardium to endocardium.

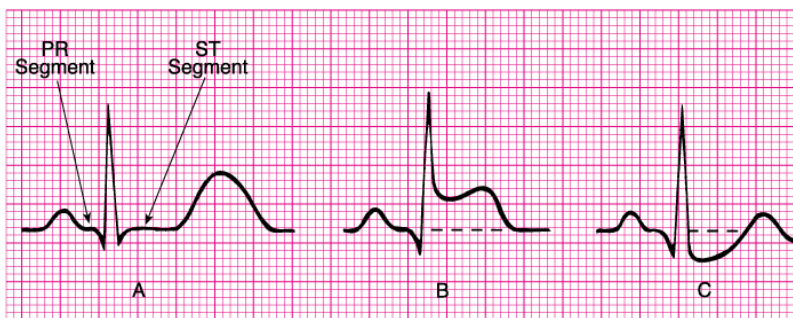
Injury

Myocardial injury occurs following prolonged ischemia. This period is a severe threat to the myocardium because myocardial cells may live or die. Without rapid intervention, the area will become necrotic. Methods to restore blood flow may include administration of fibrinolytic agents, coronary angioplasty or a coronary artery bypass graft (CABG).

Injury ECG changes

- ST segment elevation
- ST segment depression

ST segment elevation is present in leads facing the affected area. If injury is present in the subendocardial layer, the ST segment is usually depressed. ST segment depression or elevation of 1mm or more is considered significant.



ST Segment Elevation (B) and ST Segment Depression (C)

Infarction

Myocardial infarction (MI) is the actual death of injured myocardial cells. MI occurs when there is a sudden decrease or total cessation of blood flow through a coronary artery to an area of the myocardium. A myocardial infarction often begins in the subendocardial area of the myocardium. As the myocardial cells die, their membranes break and leak into the blood stream. The presence of these substances can be measured by means of blood tests thus verifying the presence of an infarction.

Infarct ECG changes

- ST segment elevation

ST segment elevation is present in leads facing the affected area. Elevation of 1mm or more is considered significant.

Location	Leads Involved
Inferior	II III aVF
Septal	V ₁ V ₂
Anterior	V ₃ V ₄
Lateral	I aVL V ₅ V ₆

Localization chart for Ischemia, Injury and Infarct

Bundle Branch Blocks

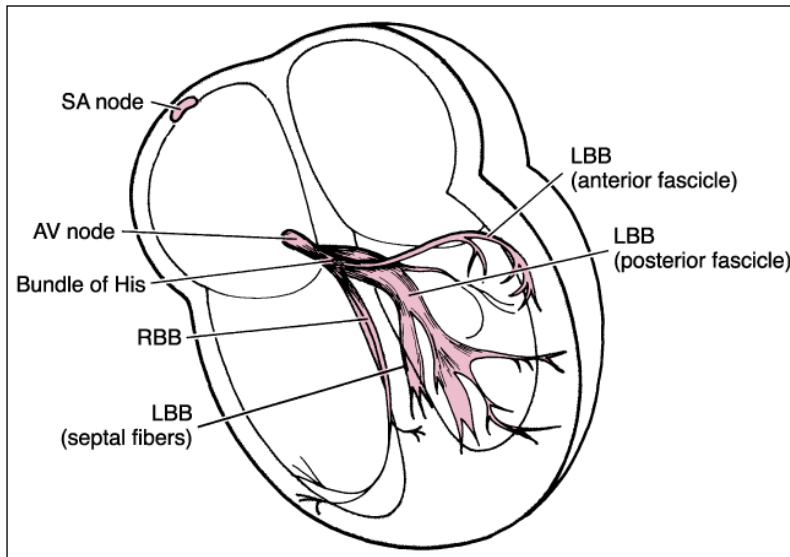
The right bundle branch travels down the right side of the interventricular septum to conduct impulses to the right ventricle. Structurally, the right bundle branch is thin, long and more fragile than the left. Because of its structure, a relatively small lesion may cause a blockage. The left bundle branch begins as a single structure that is short and thick and then divides into three divisions called the anterior fascicle, posterior fascicle and the septal fascicle. The left bundle branch depolarizes the left ventricle.

If a block occurs in one of the branches the ventricles will depolarize asynchronously. The ventricle with the blocked bundle branch is the last to depolarize.

ECG Identification of a bundle branch block

- QRS duration of more than 0.12 seconds
- QRS complexes must originate from supraventricular activity

To differentiate between a right and left bundle branch block; if the last portion (last 0.04 seconds) of the QRS complex is a positive deflection, then a right bundle branch block is present. If the terminal end of the QRS complex is a negative deflection then a left bundle block is likely. See illustration below



Bundle Branches

Diagnostic Imaging

X-ray

In the emergency department, portable x-rays are a standard diagnostic procedure, particularly to assess cardiac and respiratory emergencies. Chest x-rays can assist the emergency room physician with the diagnosis of: pulmonary embolus, pneumothorax, pneumonia, pericarditis, Left Ventricular Hypertrophy, congestive heart failure, aortic dissection, or abdominal aortic aneurysm if ultrasound is unavailable or patient instability excludes CT scan.

X-rays can also be used to assess a multitude of fractures. Portable x-ray devices may assist the ER physician in expediting trauma patients requiring surgical intervention or other diagnostic testing, thereby reducing morbidity and mortality.

Ultrasound

Ultrasound images are created electronically from high frequency sound waves generated by the transducer (or probe), which also receives the reflected waves. The time required for the reflection of each structure determines its depth on the image, and the intensity of the reflection determines its shade on a black-to-white scale.

An important limitation of ultrasound is that even small amounts of air preclude effective visualization distal to the gas. Bone is also poorly imaged by ultrasound compared to plain x-ray.

In areas where available, emergency room ultrasounds should be limited to life-threatening, time-sensitive conditions for which the bedside ultrasound examination

provides rapid, easily interpreted information that is often unavailable in a timely manner by any other means.

Primary indications for emergency department ultrasounds:

Indication	Key sonographic finding
<i>life threatening</i>	
abdominal aortic aneurysm	aortic diameter >3 cm
trauma evaluation	hemoperitoneum
first trimester pregnancy	intrauterine pregnancy
cardiac evaluation	cardiac function, pericardial fluid
<i>non-life threatening</i>	
obstructive uropathy	hydronephrosis
gallbladder disease	gallstones

Abdominal Aortic Aneurysm (AAA): Patients who present to the emergency department with abdominal pain and hypotension are candidates for emergency room ultrasound. Also, the elderly with unexplained back, flank, or abdominal pain should be evaluated for the presence of AAA.

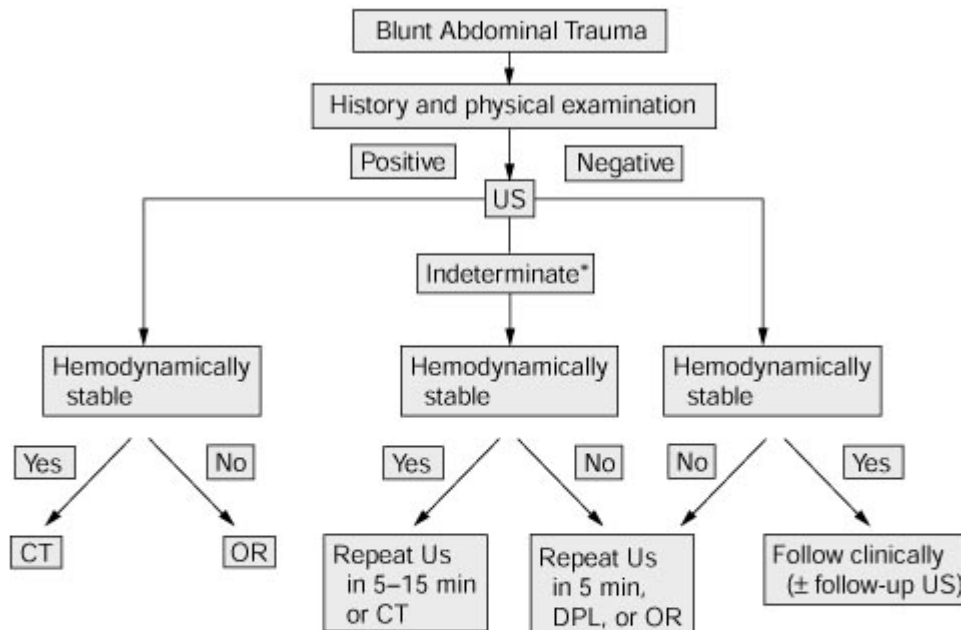
Focused Abdominal Sonography for Trauma (FAST): FAST has proven to be a valuable tool in the evaluation of abdominal trauma. It can be performed in less than 5 minutes with no preparation, no contraindications, and it is non-invasive. This diagnostic procedure is relatively inexpensive and can be easily repeated if required. Computed Tomography (CT) is still the gold standard in the evaluation of abdominal trauma.

US = Ultra Sound

CT = Computed Tomography

DPL = Diagnostic Peritoneal Lavage

OR = Operating Room



Ultrasound utilization in a blunt abdominal trauma patient.

First Trimester Pregnancy: Ultrasound can markedly decrease the possibility of ectopic pregnancy. Pregnant emergency department patients with any abdominal pain or tenderness, vaginal bleeding, or have any risk factors for ectopic pregnancy have a 1 in 10 chance that their pregnancy is ectopic in nature. It is recommended that all patients, presenting to the ER with first trimester pregnancies receive ultrasound evaluation, as it is fast and it has been clinically proven to reduce ectopic rupture thanks to early diagnosis.

Cardiac Evaluation: Similar to FAST, ultrasound is very effective at evaluating myocardial wall activity and pericardial fluid collections. The normal pericardial sac contains 50 ml of fluid, but in the case of tamponade, pericardial fluid may be in excess of 300 ml. A rapid increase of up to 200 ml of fluid causes an abrupt intrapericardial pressure increase and thus, decreased cardiac output.

Generally, emergency department ultrasound is very focused and can be performed on a supine patient within a few minutes. Physicians are able to use patient response to aid in interpretation.

Computed Tomography (CT)

CT uses x-rays and computerized image reconstruction to produce a valuable diagnostic image for a wide range of emergent conditions. The various shades of gray that make up a CT image are determined by the density of a structure and amount of x-ray energy that passes through it. The image information can be manipulated by the computer to display a greater spectrum of densities than can be displayed on conventional x-ray film.

To stress the significance of rapid CT in the United States, the CT scanner is in or adjacent to many emergency departments. This minimizes the necessity for patient transport. The major disadvantage of CT is that it is not as cost-effective as ultrasound and it uses ionizing radiation to produce an image.

CT is the primary imaging study to detect intracerebral hemorrhage due to trauma or aneurysm, and the presence of a CVA. It is also the imaging study of choice for the retroperitoneal cavity, as well as the abdomen and pelvis. In other applications, CT can assist in the diagnosis of acute appendicitis and ureteral calculi. It is useful to assess fractures, including the cervical spine, pelvis, and facial bones, as well as bone pathological conditions.

Areas poorly visualized by CT include the pituitary fossa, posterior intracranial fossa, and spinal cord. These areas are better served by the magnetic resonance imaging (MRI).

Magnetic Resonance Imaging (MRI)

MRI has many advantages over conventional CT scans. MRI is able to visualize a two-dimensional slice in any orientation versus a CT scan, which can only visualize transverse to the long axis of the body. Unlike MRI's, CT's use ionizing radiation, which may have some long-term carcinogenic implications. It is for this reason MRI is the preferred option for the pediatric and childbearing female populations. MRI offers better tissue discrimination versus CT for muscles, tendons, spinal cord, and bone marrow and because of this, has become a major adjunct in the evaluation of neurological and musculoskeletal injuries.

Disadvantages of the MRI include cost, accessibility, and the incompatibility of most basic life supportive equipment including cardiac monitors and ventilators. There are obvious health risks relating to patients with pacemakers or automated implantable cardioverter defibrillators (AICD's), as the magnetic field may place these devices in an asynchronous mode. Steel aneurysm clips may cause brain injury and steel slivers in the eyes of sheet metal workers or welders may damage the eye. Cochlear implants may also be damaged, and as a result, these patients are excluded from MRI.

In application, MRI may replace the head CT based on availability and cost. Currently, it is used extensively to evaluate: the brain, spinal cord (compression), and musculoskeletal system to include the knee, shoulder, and hip in the case of radiographically occult intertrochanteric fractures. In the pediatric population, it is useful to assess fractures around the growth plates.

Currently, MRI is not practical in the emergency room setting. However, technological advances in this field may create more emergent possibilities for magnetic resonance imaging.

Glossary

Ascites:	An abnormal accumulation of fluid
Auscultation:	A method of examination that involves listening for signs of injury or illness
Body Substance Isolation (BSI):	This is an isolation strategy designed to prevent the transmission of potential pathogens between patients. BSI goes a step beyond Universal Precautions and considers all body substances potentially infectious. For example, feces, nasal secretions, sputum, sweat, tear, urine and vomitus would also be considered infectious. In Canada the term Body Substance Isolation is now called, “Routine Practices”, while in the United States the term “Standard Precautions” is to be used
Dextrocardia:	A condition in which the heart is positioned to the right side of the chest
Diastole:	the result of relaxation of the heart between contractions
Hemi Block: branch.	Blockage in one of the fascicles of the left bundle
Hypertrophy:	Enlargement
Idiopathic:	A disease for which no identifiable cause can be determined
Inotrope:	Class of medication given to increase to force of cardiac contractility
Level of Consciousness:	mental status, usually characterized as alert, verbal, conscious to pain, or unconscious (abbreviated as AVPU)
Personal Protective Equipment: (PPE)	Equipment used by a rescuer to protect against injury and the spread of infectious disease
Pulse Pressure:	The difference between systolic blood pressure and diastolic blood pressure

Routine Practices:

Current term used in Canada to replace the isolation strategy called Body Substance Isolation. Routine Practices integrates the major features of Universal Precautions and Body Substance Isolation. This strategy applies to blood and all body fluids except sweat, regardless of whether or not they contain visible blood. Handwashing is recommended after glove removal regardless of whether or not hands are visibly soiled

Systolic Pressure:

The result of a contraction of the heart, which forces blood through the arteries

Vasopressor:

Class of medication that causes contraction capillaries and arteries

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