PCP Autonomous IV Program
Module 2
PRECOURSE PACKAGE

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Purpose

This module will instruct Primary Care Paramedics, through a combination of take home packages, in class practical, and in hospital practical training, how to establish intravenous access. The paramedic taking the IV/IO access module will learn medical directives, indications, complications, anatomy, physiology, and become practically proficient in IV cannulation.

Components

1. Theoretical: This component will consist of a take home package, which the paramedic will have to be intimately familiar with on the first day of class. It will also contain a take home theoretical test, to self-test his or her knowledge prior to attending class.

2. Theoretical testing: On the training day, the paramedic will be tested on his or her knowledge of the take home package. The Passing mark is 80%. Those not achieving 80% must return to a future class and will not be able to continue that day.

3. In Class Practical: This consists of theory review and practical instruction using IV practice limbs.

4. In Hospital Practical: This is the practical component where paramedics use their knowledge to initiate IV cannulation in Day Surgery, Emergency Departments and other clinical settings to gain practical knowledge and experience.

Certification

As with other skills, yearly certification of IV cannulation will be required by the Medical Director. This may be achieved through a skills inventory (database review) and/or include writing a pre-test, and starting an IV with BHP assessment.

OBJECTIVES

In completing this module, the PCP will:

EFFECTIVE

Maintain a patient's dignity at all times

Use appropriate language

Maintain patient confidentiality

Demonstrate ethical behaviour

Function as a patient advocate

Function within the scope of practice defined by provincial regulating agencies and local medical control

Explain to the patient, when asked, "patient rights", and be mindful of those rights on the role of provider

Work collaboratively with other members of the healthcare team

Accept and deliver constructive feedback

Demonstrate reasonable and prudent judgement

Practice effective problem solving skills

COGNITIVE

Be familiar with the anatomy and physiology of both upper and lower extremities, as related to IV cannulation.

Identify pathophysiology of the immune and cardiovascular system, hypovolemia, hypo perfusion and shock.

Be able to relate factors that affect vasodilation.

Relate indications and contraindications for IV cannulation.

Describe the properties of Normal Saline (NS), its uses and overdose symptomology

Describe circumstances where a "bolus" of NS may be required

Have knowledge of Base Hospital policies and provincial ALS standards with regard to IV cannulation.

PSYCHOMOTOR

SIMULATED

Demonstrate the selection of appropriate equipment for given situations

Demonstrate proper technique in "flushing" an IV line with normal saline

Identify criteria for vein selection

Demonstrate aseptic techniques required for IV infusions

Identify steps required to secure IV cannula and IV tubing

"Troubleshooting" difficult IVs including removing air bubbles, and checking for IV patency.

Demonstrate competence in administering infusions under pressure

Calculate IV "drip rates"

Identify "interstitial" IVs

Demonstrate the skill of infusing non-colloids and volume expanders

CLINICAL

Demonstrate proper technique in intravenous access

Rights of the Patient

Any patient may refuse any treatment for any reason at any time.

Some patients may refuse simply because they are afraid of needles or for complex reasons such as religious beliefs. The paramedic must balance the need for an IV with the person's wishes. If the patient refuses because of a fear of needles, and the IV is a necessity, it is best to talk the patient into the treatment with reasoning such as it "only lasts a moment" or the "needle part" does not stay in, or "the cannula that stays in is soft and flexible".

People with religious objections may require further assurances. Religious orders such as Jehovah's Witnesses object to the introduction of whole blood, packed red cells, white blood cells, plasma or platelets. They will accept non-blood replacement fluids like hetastarch and crystalloids. If questioned, the fluid being instilled is normal saline, a non-blood product (see composition of NS in equipment section of this package).

Implied consent with the unconscious Jehovah's Witness patient has been ruled on by the Ontario Supreme Court. Jehovah's Witnesses carrying a dated, witnessed card stating their intentions are to be honoured even after unconsciousness.

Anatomy Relevant to Intravenous Starts

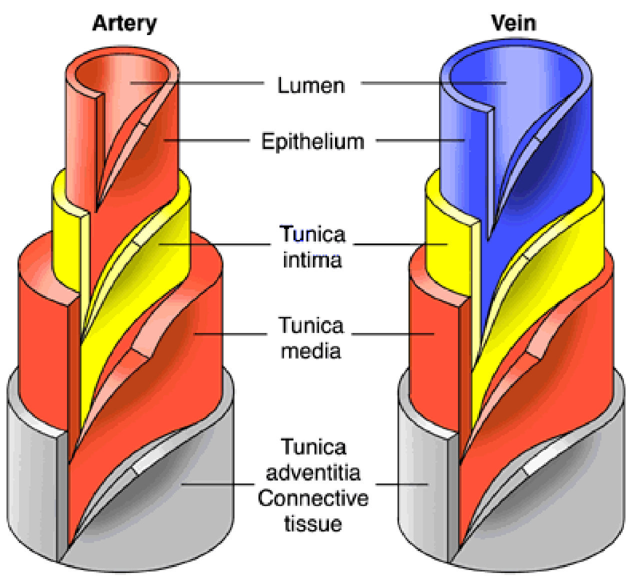
Definitions

An intravenous refers to the cannulation of a vein in order to introduce *fluid*, *blood* or *medication* in to the circulatory system

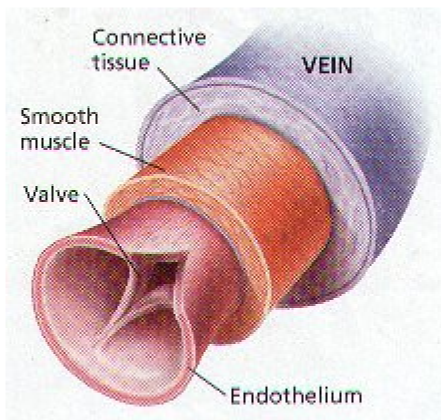
VEINS, by definition transport blood (at relatively low pressures) towards the heart and lungs for oxygenation and circulation.

Veins are superficial in nature, typically located just below the subcutaneous tissue, making them ideal for cannulation. On successful cannulation of a vein, blood should look dark and flow slowly into IV cannula "window" or flash chamber.

ARTERIES, by definition, transport blood (at a higher pressure than veins) away from the heart, to deliver oxygenated blood (except the pulmonary artery) to the body. Arteries are thick walled, deeply inset vessels that should not be cannulated by prehospital care providers. If cannulated, the blood will appear bright red and fill the IV cannula flash chamber rapidly. If inadvertently accessed, remove the cannula; apply a sterile dressing with firm pressure over the site for five minutes.



VALVES: medium to large veins use a structure called a valve to help move blood against gravity, toward the heart. These valves consist of folds in the tunica intima, which act in the same manner as the semi lunar valves in the heart. The valves overlap, and when blood attempts to flow backward during diastole, the valves occlude the vein. There are many valves in a section of vein, and the number of valves generally increases with need (The number of valves in the lower extremities are greater than the number in the upper extremities).



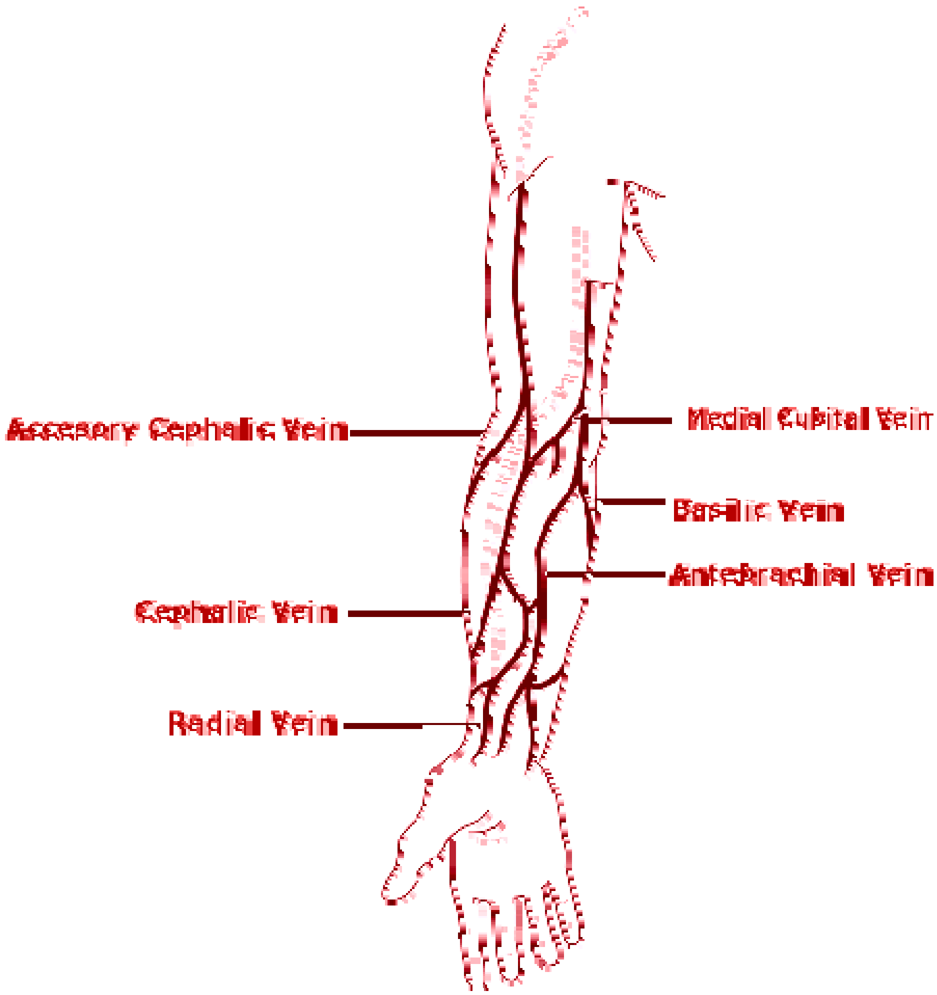
With age, these valves can become "incompetent", resulting in backflow and damage to the distal structures. This is called a varicose vein. The area is generally reddened and edematous. With sufficient damage, the vein can develop stagnant areas, and blood clots may develop. Therefore, cannulating a varicose vein should be avoided.

Valves can also become "stenotic". They do not open or close fully. It allows blood to flow backward and impedes distal blood flow. The paramedic cannulating a vein distal to a stenotic valve will find it difficult to advance the cannula past it, and if the cannula stops short of the valve, the flow of IV fluid will be diminished or blocked. A stenotic valve can generally be identified as a small (1-2 mm) raised and enlarged section in the vein. When palpated, it is harder than the rest of the vein.

Veins of the Upper Extremity

Proximal Cephalic, Basilic and Median Cubital Veins

- Most commonly referred to as “antecubital veins”
- Are large and usually very prominent, even without a tourniquet
- Normally reserved for venipuncture and emergency IV infusions (e.g. necessity to give large quantities of fluid or blood products due to burns, hypovolemia, and shock states) or irritating medications
- Reserve for short term/emergency use, due to it being at a moveable joint
- Readily accepts large # 14, 16, 18 IV catheters
- Care should be taken not to cannulate the brachial artery or damage any of the numerous nerve endings in the area
- Site most successfully cannulated **during** transport



<u>Distal Basilic Vein</u>

- Runs along the ulnar aspect of the arm
- Large and prominent in males
- Often overlooked due to its location on the underside of the arm
- This vein is prone to “rolling”, making cannulation more difficult
- Best cannulated with the arm in an “arm wrestling stance”
- Best cannulated with # 18, 20 catheters

Distal Cephalic Vein

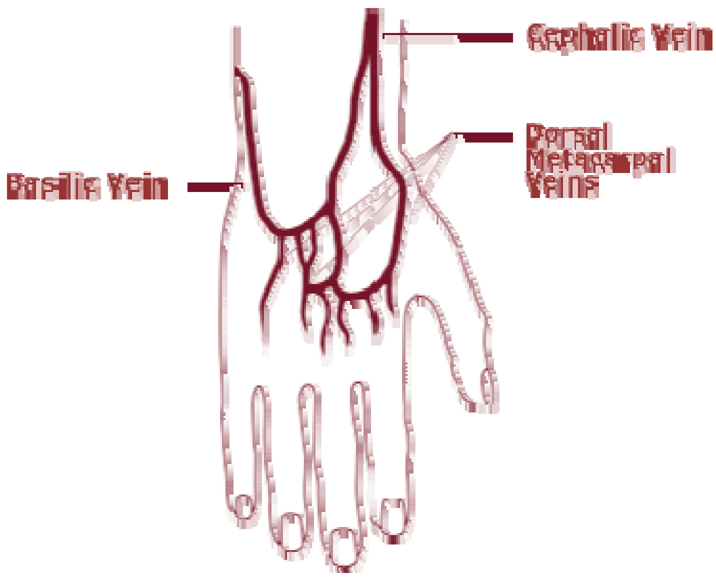
- Runs along the radial aspect (thumb side) of the arm
- Bones of the forearm provide natural splint
- Is a medium sized vein; ideal, for example, for long term infusion of antibiotics, non emergency cardiac medication
- Sometimes difficult to cannulate due to its tendency to roll, and the need to cannulate around the thumb and thenar prominence
- Best accessed with a #18, 20 catheter

Medial Ante Brachial Vein

- Runs down the center of the anterior aspect of the forearm
- Medium sized vein
- Easily visualized, difficult to palpate
- Does not tend to roll
- **DO NOT** cannulate the extreme distal end of this vein due to the numerous nerve endings, the wrist is a moveable joint (impossible to secure) and extreme pain caused
- Appropriately cannulated with a #18, 20 catheter

Metacarpal Veins

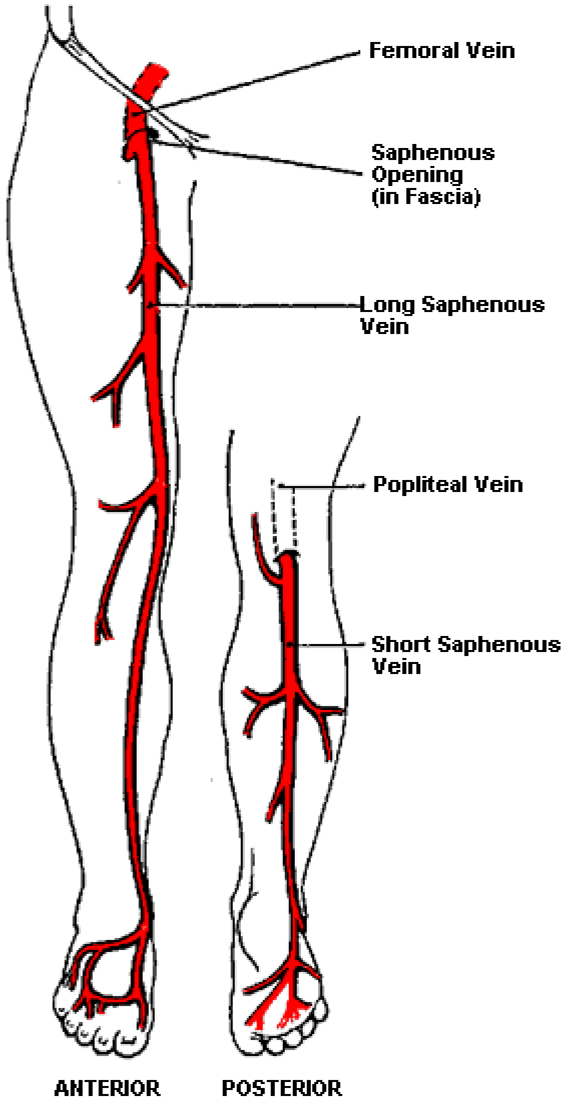
- Located in the back of the hand
- Small to medium sized veins
- Ideal for long term TKVO therapy
- Positional IV if catheter is located too far back on the hand/wrist
- Best cannulated with a #18, 20 or 22 catheter



Digital Veins

- Small veins, located in the fingers (not generally used in the prehospital setting)
- Area of last resort as it is positional, painful and difficult to secure
- Cannulated with a small #22 catheter

Veins of the Lower Extremities



Great Saphenous Vein

- Mid calf to the internal malleolus
- Large vein with numerous valves
- Cannulation limits patient’s mobility
- Moderate risk of deep vein thrombosis (DVT)
- Risk of impaired circulation in the lower leg and foot

Dorsal Venous Network

- Located on the dorsal surface (top) of the foot
- Medium sized to small veins
- Painful access
- Increased risk of DVT

Factors Influencing Vasodilation/Vasoconstriction

There are many factors, which influence vasoconstriction and vasodilation, all of which affect the pressures inside the blood vessels. Manipulating the pressure upward, creates vasodilation, and makes IV cannulation easier. Natural influences can conversely make IV starts more difficult through vasoconstriction or collapse.

Vasodilation

- *Tourniquet* - application of a tourniquet constricts the flow of blood at the afferent end of the vein, mechanically enlarging and expanding the vessel. A tourniquet may consist of a blood pressure cuff or a soft rubber band.
- *Gravity* – lowering the limb below the level of the heart dilates veins as the force of gravity pulls blood into dependant areas. Use this in conjunction with a tourniquet.
- *Mechanical Stimulation* – “flicking” fingers or gentle “slapping” with 2 fingers over the venipuncture site produces a short lived venous dilation.
- *Muscular Activity* – opening and closing the fist is the most popular method.
- *Application of Heat* – applying heat for 10 minutes will increase blood flow to the area, causing vasodilation of arteries and veins in the area.

- *Volume Loading* – patients in CHF or women during pregnancy have increased intravascular blood volume. Patients with these conditions generally do not require further mechanical methods.

<u>Vasoconstriction</u>

- *Gravity* – raising the limb above the level of the heart reduces the blood flow and induces vasoconstriction. This factor is already employed by the paramedic as a means to control bleeding.

- *Cold* – Application of cold packs reduces flow to the affected region, and induces vasoconstriction. This is useful to the paramedic wanting to reduce the swelling of missed IV attempts, and the prevention of a hematoma. Hypothermic patients should be warmed prior to attempting IVs due to the difficulty in cannulating a shivering, vasoconstricted patient.

- *Hypovolemia & Shock* – the body's natural mechanism in dealing with a decreased circulating blood volume is to shunt blood from the periphery to the core, making cannulation of a peripheral vein difficult. The paramedic should recognize the need to increase circulating volume rapidly and attempt to cannulate a large, antecubital vein.

- *Vasovagal Response* – fear or anxiety may trigger a vasovagal response, resulting in an undesirable vasodilation, drop in BP and syncopal symptoms. Pain and anxiety from further IV attempts may increase these symptoms. Patients may identify this at first contact, saying "People have a hard time getting blood from me". This may be reversed with decreasing their anxiety, confidence shown by the paramedic, and a calm demeanour.

Physiology Relevant to IV Starts

There are some basic principles, which affect the flow of blood through the circulatory system. It is the interrelationships between these factors, which regulate blood pressure, blood flow, and play a vital role in the function of the circulatory system.

- *Viscosity* – viscosity is the measure of the resistance of a liquid to flow. In other words, as the viscosity of liquid increases, so does the pressure required to force it to flow. The viscosity of blood is largely influenced by the amount of hematocrit (blood cells e.g. RBCs, WBCs).

- *Laminar and Turbulent Flow in Vessels* – laminar flow describes the flow of blood, or a fluid, through a smooth walled vessel. It flows slowest where the blood makes contact with the vessel wall, and fastest toward the center (where there is little resistance). Laminar flow is interrupted, and becomes turbulent, when it comes into contact with a constriction, sharp bend in a vessel or a rough surface. Turbulent blood flow is what makes it possible to auscultate a blood pressure (the paramedic hears the turbulent blood flow over the antecubital fossa when the vessels are compressed with a BP cuff).

- *Blood Pressure* – BP is a measure of the force blood exerts against the vessel walls. It can be measured by auscultating an occluded blood vessel, or by inserting a cannula into an artery and connecting an electronic pressure transducer to it. This commonly referred to as an ART (or arterial) line.

Rate of Blood Flow – The rate of blood flow is measured by the amount of blood that passes through a specific blood vessel (or organ) per unit of time, and is usually measured in Litres per Minute.

Poiseuille's Law

According to Poiseuille's law, the flow of a fluid is directly proportional to the radius of the vessel to the 4th power. The flow of blood therefore is dramatically increased when the radius of the blood vessel is increased. Conversely, a small decrease in the size of a blood vessel, results in a dramatic decrease in blood flow. Additionally, an increase in viscosity, or an increase in vessel length decreases blood flow.

Law of LaPlace

The Law of LaPlace helps to explain the phenomenon known as Critical Closing Pressure. The law states that the force that stretches the vascular wall is proportional to the diameter of the vessel, times the blood pressure. As the pressure in the vessel decreases, the vessel wall size also decreases. Some minimum pressure is required to keep the blood vessel open; if the pressure falls so that it is below the minimum required, the vessel will collapse. Conditions causing collapse may include shock states.

Conversely, the development of an aneurysm may be explained. As the diameter increases, the force applied to the vessel wall also increases, even with a constant pressure. If an artery has a weakened wall, and it develops a "bulge", the force applied to that area is greater than any other section of the artery, because the diameter is larger. A negative feedback loop follows (i.e. the larger the weakened area becomes, the more force that is applied to it, resulting in a larger bulge, resulting in more force being applied…)

Vascular Compliance

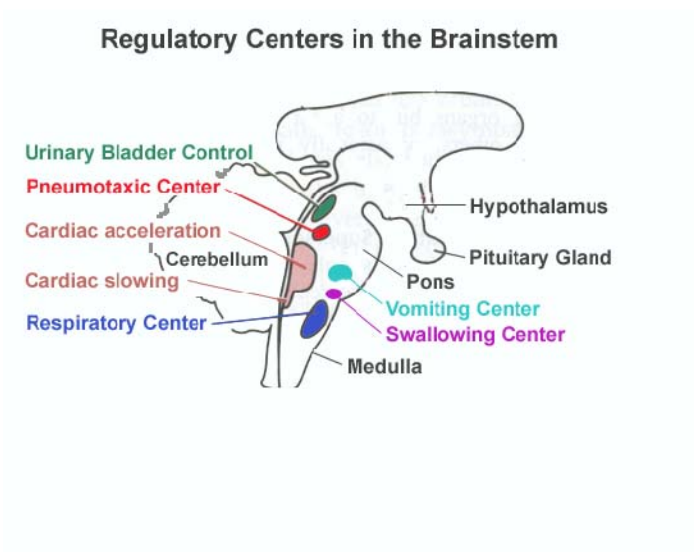
Vascular compliance is the tendency of the blood vessel volume to increase as the pressure increases. Venous compliance is greater than arterial compliance by a large margin. This high compliance results in the body using the venous system as a storage area.

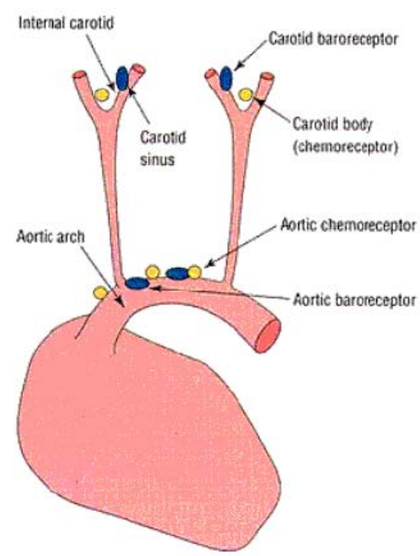
Systemic Circulation

System circulation will, depending on vessel type, location, and size, have different pressures in them. Also, because the heart is pulsatile in nature, the pressure will vary during systole and diastole.

The aorta is the first vessel to receive blood pumped by the left ventricle. Under normal circumstances, the systolic pressure is approximately 120 mmHg and the diastolic pressure is maintained at 80 mmHg. These pressures ensure that there is enough fluid flow to circulate through all arteries, capillaries and veins. The pressures progressively decrease towards 0 mmHg, as it returns to the right atrium.

Blood pressure is centrally regulated by the nervous system; namely the vasomotor center of the Medulla Oblongata. Baroreceptors, Pressoreceptors and Chemoreceptors in major vessels in both the arterial and venous circulatory systems are sensitive to stretch, shrinkage and blood gases. The ever changing environment initiates impulses that are transmitted to the cardio-regulatory and vasomotor centres to make moment by moment changes in vessel diameter and fluid flow.





In the case of a low BP, receptors stimulate a sympathetic response which increases the heart rate and vasoconstricts peripheral vessels.

An increased BP results in, cardio regulatory centres in the medulla, being notified. Vasodilation and increased parasympathetic vagal innervation of the heart results. The heart rate slows and blood pressure decreases.

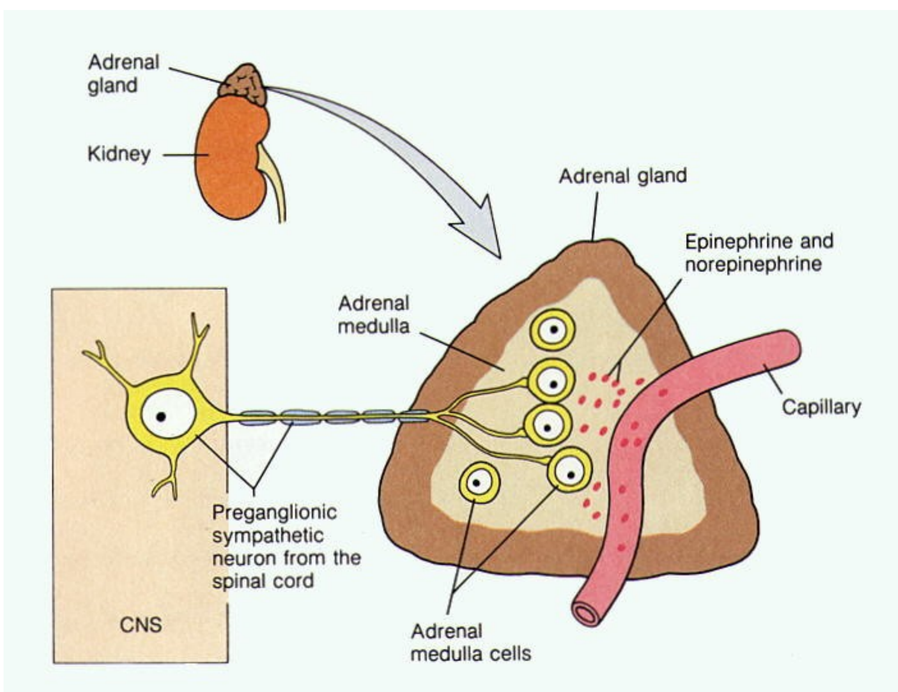
Chemoreceptors react to low oxygen levels, high levels of carbon dioxide or abnormal blood pH. These act under “emergency” conditions, most notably, if BP falls below 80 mmHg or oxygen levels in the blood falls markedly.

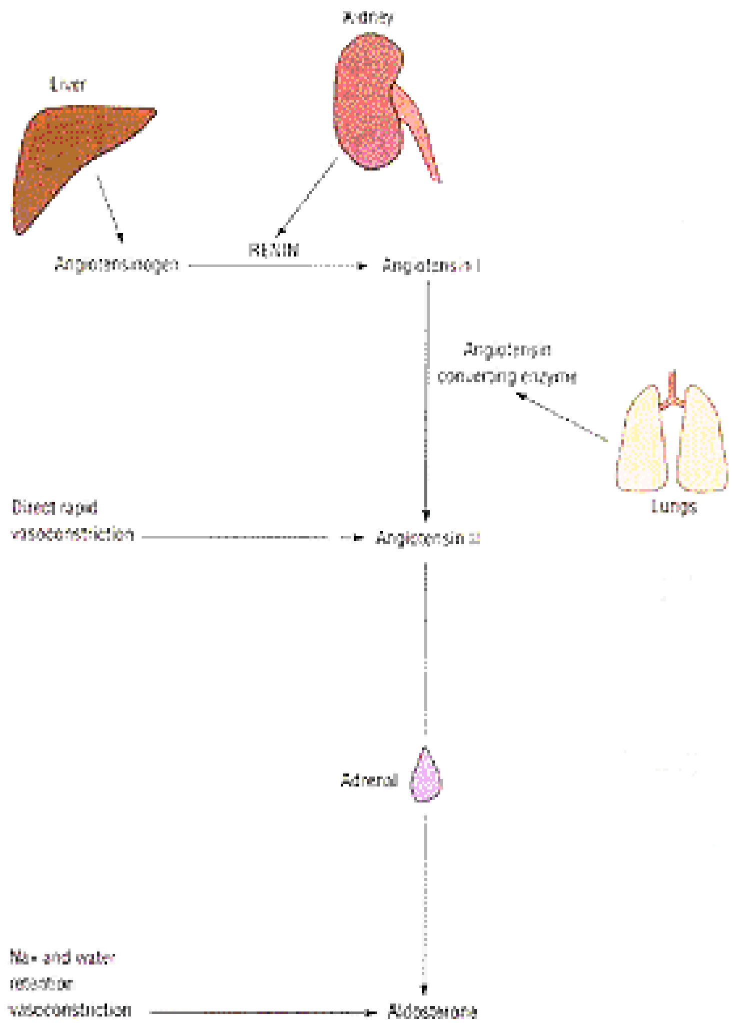
In addition to nervous regulation of arterial pressure, four hormonal mechanisms also have influence on blood pressure.

1. Adrenal Medullary Mechanisms – Sympathetic nervous stimulation also acts on the adrenal medulla. Epinephrine and Norepinephrine are secreted, affecting the cardiovascular system by increasing heart rate and causing vasoconstriction.

2. Renin/Angiotensin/Aldosterone Mechanism – On sensing low blood pressure, the kidney secretes an enzyme called "Renin" from juxtoglomerular apparatuses. **Renin** acts on a plasma protein called Angiotensinogen, splitting it up.

One of the resultant fragments is called "Angiotensin I". Other enzymes in the lung further act to change Angiotensin I into a chain of amino acids called Angiotensin II. Angiotensin II causes vasoconstriction of arteries and, to some degree, in veins causing blood pressure to rise.





Angiotensin II also stimulates Aldosterone release from the adrenal medulla. Aldosterone decreases the production of urine that again raises blood pressure by retaining volume in the vascular system.

Angiotensin II also stimulates the sensation of thirst, increased salt appetite, and anti diuretic hormone secretion.

3. <u>Vasopressin Mechanism</u> – with low BP or an increase in plasma concentration the neurophypophysis increases the amount of anti diuretic hormone, or vasopressin secreted. The result is vasoconstriction and a decrease in the rate of urine production.

4. Atrial Naturetic Mechanism – Elevated atrial BP results in a release of Atrial Naturetic factor from the atrium of the heart. The substance increases the rate of urine production, decreasing circulatory blood volume, resulting in a lower blood pressure.

Fluid Components — Intravascular

Intracellular

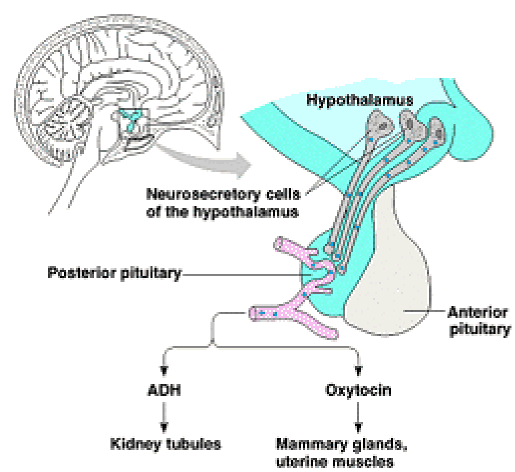
Interstitial

Circulation - Arteries → arterioles

- Vein → Venules

Capillaries – are the place where waste products and nutrients are exchanged in the process called diffusion. Nutrients are pulled from the capillaries and diffuse into the interstitial spaces while waste products are drawn into the capillaries for eventual removal. There are several forces that assist this to happen. Since blood borne proteins tend to be large, they remain within the capillaries, drawing fluid back into the arterial side of the capillaries. This is called Colloidal Osmotic Pressure. Pushing fluid into the interstitial (or 3rd space) is the hydrostatic pressure (or the force – Blood pressure – exerting pressure from inside the blood vessel itself). The third force exerting influence on fluid balance in capillaries is a slightly negative (in the normal/healthy person) interstitial pressure. The lymphatic circulation creates this.

Edema is the result of decreased plasma protein concentration (resulting in a lack of "pull" of fluid back into the capillaries). It can also result in an increased capillary permeability, resulting in plasma proteins being lost into the interstitial spaces. This pulls more fluid from the capillaries,



increasing edema. Edema can also be a result of an increased BP in the capillaries; Hydrostatic Pressure. This last cause may for example result from Cor Pulmonale or a rapid transfusion of fluid.

<u>Fluids & Electrolytes</u>

Body fluids contain dissolved chemicals which are divided into 2 categories – Electrolytes and Non Electrolytes. Non-Electrolytes are mostly organic compounds like glucose, urea and creatinine. Electrolytes are inorganic compounds (e.g. acids, bases & salts), which have the ability to bind together. They are either positively or negatively charged.

Electrolytes have 3 general functions. Many are essential minerals. Secondly, they control movement of water (osmosis) between components (osmosis pulls water from areas of low concentration to areas of high concentration). Finally, they help maintain acid base balance.

The major electrolytes are Sodium (Na^+), Chloride (Cl^-), Potassium (K^+), Calcium (Ca^{++}), Phosphate ($HP0_4^{--}$) and Magnesium (Mg^{++}).

<u>Sodium</u> is the most abundant positively charged *extra*cellular electrolyte (about 90%). The normal range of sodium in the blood is 136 – 142 mEq/L. It is necessary for the transmission of impulses through nervous and muscle tissue. It also plays a significant role (depending on its concentration) in fluid & electrolyte balance by contributing most of the osmotic pressure. The kidneys regulate the amount of sodium in the blood stream – excreting excess sodium and conserving it during periods of low concentrations.

High levels of sodium (possibly from large amounts of “Normal Saline” IV fluids, or dehydration) lead to cellular dehydration. Signs and symptoms include thirst, fatigue restlessness agitation and eventually coma states.

<u>Chloride</u> is the most abundant negatively charged *extra*cellular electrolyte. Normal blood concentration is 95 – 103 mEq/L. It moves easily between extracellular and intracellular compartments, making it an important component in regulating vascular osmotic pressure.

It also combines with hydrogen to form hydrochloric acid in the gastric mucosal glands.

The kidneys indirectly regulate chloride, as it tends to follow sodium through a natural bonding process.

Potassium is the most abundant positively charged *intra*cellular electrolyte. Normal blood concentration of potassium is maintained within a very narrow range, typically between 3.8 – 5.8 mEq/L. Potassium is the key element in the functioning of nervous and muscle tissue. Abnormal serum levels affect neuromuscular and cardiac function. Intracellularly, it helps maintain fluid volume within the cell. The movement of potassium out of cells is replaced by sodium and hydrogen. This shift of hydrogen ions helps to regulate the pH.

The mechanism of potassium regulation in the kidney is exactly the opposite to that of sodium. The hormone that regulates both electrolytes is Aldosterone. When Aldosterone is secreted from the adrenal cortex, sodium is retained and potassium is excreted.

Hypokalemia (or low serum levels of potassium) may result from vomiting, diarrhea, high sodium intake, kidney disease or some types of diuretic therapy. Symptoms include cramps, fatigue, flaccid paralysis, nausea, vomiting, mental confusion, increased urine output, shallow respirations and changes in the ECG (lengthening of the QT interval and flattening of the T-wave).

Calcium 98% of calcium is found in the skeleton and teeth, combined with phosphate. The serum calcium is found both extracellularly and intracellularly (in skeletal muscle). It functions in coagulation, neurotransmitter release, neuromuscular conduction, maintenance of muscle tone and excitability of nervous and muscle tissue.

Low levels of Calcium (hypocalcemia) may be due to calcium loss, reduced calcium intake, elevated phosphate levels (as phosphate levels elevate, calcium levels decrease). Symptoms include numbness or tingling of the fingers, hyperactive reflexes, muscle cramps, tetany and convulsions. It may cause laryngeal muscle spasms that can cause death by asphyxiation.

Phosphate Primarily found combined with calcium in bones. The remaining amount combines with other substances and structures for many purposes. It is a necessary component in forming nucleic acids, and high-energy compounds, as well as substances that serve as buffers (“The phosphate buffer system”).

Magnesium activates enzymes involved in the metabolism of carbohydrates and proteins and triggers a mechanism called the “sodium/potassium pump”. It is also important in neuromuscular activity, neural transmission and myocardial functioning.

Movement of Fluid

Fluid movement between the vascular compartment and interstitial space occurs across capillary membranes. Basically, fluid movement depends of 4 different pressures.

1. Blood hydrostatic pressure
2. Interstitial fluid hydrostatic pressure
3. Blood osmotic pressure
4. Interstitial fluid osmotic pressure

Blood Hydrostatic Pressure – is the “blood” pressure within the walls of the capillaries, exerted outward; forcing fluid, plasma and electrolytes into the interstitial spaces.

Interstitial Fluid Hydrostatic Pressure – is the pressure exerted outward by the accumulation of fluid in the interstitial spaces against the capillaries and cells.

Blood Osmotic Pressure – is the “pulling” pressure the plasma proteins exert on fluid in the interstitial spaces. It pulls fluid back into capillaries.

Interstitial fluid Osmotic Pressure – is a “pulling” pressure that electrolytes and other s ubstances exert to pull water into the interstitial spaces.

Fluid movement between the Interstitial and Intracellular compartments

Under normal circumstances intracellular and interstitial osmotic pressures are the same.

Is normally controlled with the movement of Na^+ and K^+into and out of the cell.

Concentration changes of Na^+ and K^+ can result in fluid imbalance.

Over hydration of cells is disruptive to nerve cell function.

Severe over hydration or water intoxication produces neurological symptoms ranging from disorientation to death.

Acid Base Balance

Acid/Base balance is accomplished by controlling the hydrogen concentration of body fluids.

Normal extra cellular pH is 7.35 – 7.45.

Keeping this narrow range possible is essential to survival.

The responsibility for maintaining a normal pH depends on 3 major mechanisms.

1. The Buffer system
2. Respirations
3. Kidney Excretion

Buffer systems

Acts as a subtle agent to balance pH using electrolytes, proteins and organic materials to manipulate hydrogen ions.

Examples are the *Carbonic Acid/Bicarbonate Buffer System*, the *Phosphate Buffer System*, the *Hemoglobin / Oxyhemoglobin Buffer System*, and the *Protein Buffer System*.

Respirations

An increase in an individual's respiratory rate decreases the amount of carbon dioxide concentration in body fluids, therefore raising the blood pH (making it more basic).

A decreased respiratory rate increases serum CO_2 concentration, decreasing the pH (making it more acidic).

This is regulated by the respiratory center in the medulla, sensing either an increase or decrease in hydrogen ions (accumulating CO_2 leads to a hydrogen ion increase and low CO_2 levels lead to a low hydrogen ion level).

Kidney Excretion

The kidney can directly excrete hydrogen ions in the urine (distal portion of the nephron).

Through dissociation, bicarbonate ions and sodium ions can be reabsorbed and transported back into the extra cellular fluid; raising the body pH.

If the pH of the body increases, the rate of hydrogen secretion into the nephron decreases. Excess bicarbonate ions are then excreted and as a consequence, the pH decreases.

Normal Saline – an isotonic crystalloid solution

Actions Increases circulating volume

Source of Na^+, Cl^- & H_20

Considerations -Head injury

- Dilutes/warms blood
- Main line for blood transfusion
- To restore intravascular volume

- Initial fluid electrolyte replacement in hypovolemia, dehydration (Na^+ & Cl^- depletion) & burns
- Irrigation, cooling burns (external use)
- Dilutent and a vehicle for reconstitution, injection or infusion of most drugs
- Ketoacidosis, diabetes, septic shock, fresh water drowning, crush injuries

Adverse Affects

- Large infusions cause volume overload, e.g. pulmonary edema or exacerbation of CHF

Electrolyte dilution and acid/base imbalance following large infusions

Precautions

- Renal impairment
- CHF
- Pulmonary edema
- Room temperature fluid may induce hypothermia with multiple infusions

Contains

- 900 mg NaCl / 100 ml
- pH 5.0

Na^+ 154 mmol/L

- Cl^- 154 mmol/L

Supplied

250 ml bags, 500 ml bags and 1000 ml bags

Priming IV Tubing

1. Select the appropriate IV tubing. Inspect the tubing, the roller clamp, the injection ports & the luer lock connector for cracks, use and sterility.
2. Select the appropriate sized IV bag. Inspect for cloudiness, precipitate and cracks/leakage. Check the expiry date, and ensure the fluid is the proper type (Normal Saline or 0.9% saline).
3. Close the roller clamp.
4. Remove the cap covering the spike on the IV tubing closest to the drip chamber. Maintain sterility! Remove the plastic tab on the IV bag. Insert the spike completely into the bag with a straight forward, non-twisting motion.
5. Squeeze and release the drip chamber to fill it ½ full.
6. Open the roller clamp slightly to allow the fluid to advance under gravity down the tubing.
7. When the fluid approaches an injection point, invert the port and strike the port, forcing air out and fluid in. Repeat as many times as needed.
8. Continue to advance the fluid to the end of the tubing, but not beyond. Close the roller clamp having expelled all the air from the tubing.

<u>IV Equipment</u>

- Gloves
- Tourniquet
- Alcohol swabs

- IV cannula
- IV tubing
  - Micro drip
  - Macro drip
  - Blood tubing
  - Buretrol
- Saline lock
- Occlusive dressing
- Tape
- 2 x 2 gauze
- Sharps container

Gloves are an essential part of infection control

IV Catheter

Most needles are made of stainless steel, while the outer cannula is made of teflon coated plastic that resists clot formation. The "sharp", or inner stainless steel trochar is used for ease of insertion. After signs of the needle being in a vein, the trochar is withdrawn and the teflon catheter advanced and left indwelling in the vein. The teflon cannula is radio opaque, meaning the cannula shows up as a ghost image on x-ray, in case of loss of part of the cannula in the patient's circulation. Sizes typically range from the largest, 14 and 16, to medium sized catheters 18 and 20 to the smallest sized 22 and 24 gauge (note – the smaller the number – the larger the diameter of the catheter).

IV Tubing

The infusion tubing drip chamber achieves the maximum flow rate when suspended approximately one metre above the IV site. This is due to the force of gravity

- **Micro drip** – a micro drip (60 drops = 1 ml) is an IV set which is designed to precisely deliver small volumes of solution over a long time. Eg. using a microdrip set to control the infusion in a CHF patient.

- **Macro drip** – is an IV set used to deliver moderate volumes of solution over long periods of time. Because of a larger drop size, the time between drops is longer (than a micro drip), the risk of clot formation of the tip of the IV cannula is greater at TKVO rates. The number of drops, depending on the manufacturer, may be 10, 15 or 20 drops = 1 ml.

- **Blood Tubing** – is an IV set with 2 IV ports, one for a crystalloid to prime and maintain flow after blood administration; the other is a port for the blood product. It also contains a large flexible drip chamber with a screen to filter out clots formed in the blood product.

- **Buretrol** – A buretrol is an IV set with a large chamber with a measurement scale printed on the side to precisely control fluid or medication administration. IV tubing with a buretrol has an additional roller clamp between the IV fluid bag and the buretrol to deliver a set amount of fluid into the chamber and no more. The buretrol chamber can be refilled periodically as the medication or fluid is administered.

- **Saline Lock/Heparin Lock** – These locks are used when a continuous infusion is not required, but occasional infusion of IV medications is desired. This lock consists of a short plastic tube (filled with saline or diluted heparin to prevent clotting) and a multi access injection point.

- **Occlusive dressing** – an occlusive dressing is applied over the site of the IV insertion to provide a barrier to infection. It may consist of a 2 x 2 gauge, a band-aid or a clear adhesive film.

- **Tape** – the cannula, once in place, requires securing. Hypoallergenic tape (eg. silk or plastic) should be used to secure the cannula and IV tubing to the patient's arm/hand/foot.

- **Alcohol Swabs** – should be used to disinfect the potential IV site. Allow a few seconds for the alcohol to dry prior to venipuncture, as isopropyl alcohol is for external use only.

- **2 x 2 gauze** – depending on the site, some "propping" may be required at the cannula site (usually digital or metacarpal IVs). They are also useful for cleaning the site of any blood that may prove disconcerting to the patient.

- **Tourniquet** – The tourniquet is rubber band (non-latex) applied around the arm or leg. It takes advantage of venous circulation to mechanically enlarge the vein making cannulation easier. Remove the tourniquet following the initial penetration of the vein and prior to the removal of the stainless steel IV trochar.

- **Sharps Container** – Immediate disposal of the trochar is essential to reduce the risk of accidental needle stick injury to paramedics. Needle stick injuries need to be reported immediately to:

  a) Paramedic Supervisors

  b) The same ER department that the patient has been admitted to

Treatment and/or testing should occur as soon after the exposure as possible.

<u>Guidelines for Catheter Size</u>

# 14 and 16	-	Adolescents & adults only
	-	Critical Trauma/Burns
	-	Pt's requiring large amount of fluids
# 18	-	Adolescents & adults only
	-	Fluid resuscitation
	-	Colloid Infusion
# 20	-	Children, adults & adolescents
	-	Most infusions requiring medication, TKVO lines
	-	Smallest size for colloid infusion
# 22 and 24	-	Infants, toddlers, children, adolescents & adults (especially elderly patients
	-	TKVO infusions

- Minor medication needs

IV Starts

1) Attempt IV cannulation (depending on the severity of the patient's problem) distally and work your way proximally.
2) Critical patients, requiring rapid infusions or viscous medications need IVs placed in large veins.
3) For TKVO infusions, be selective about site selection. Examine the skin integrity as well as palpate and inspect the vein for size and accessibility and for "valves", crooked veins, or otherwise poor quality veins.
4) Avoid attempting an IV in a vein over a joint for TKVO and potential long-term infusions.
5) Avoid veins in injured arms. Do not start IVs in the same side as radical mastectomies or dialysis fistulas.
6) Elderly patient's hands can have thin, easy tearing skin. They also can have sclerosed, crooked veins due to a loss of connective tissue. If so, avoid the back of the hand and try to cannulate veins above the wrist.

IV Starts

1) *Prepare the patient* – explain the need for the IV to the patient, and the brief discomfort that will be encountered. A patient may refuse treatment at any time.
2) *Select the equipment* – prime an IV line with a bag of saline or prepare a saline lock. Select the proper size cannula.
3) *Select a site* – apply a tourniquet. Use proper vasodilation techniques and ensure plenty of light. Ensure patient comfort. Choose an appropriate site.
4) *Don appropriate PPE*

5) *Prepare the site* – cleanse the site in a circular manner at least 5 cm diameter with an alcohol swab. If necessary, shave the area.

6) *Inspect the cannula* – If there are any imperfections, discard the needle. Separate the cannula and trochar slightly to ensure smooth movement.

7) *Insert the cannula* – at a 30 - 45^{o} angle and slightly to one side of the vein, insert the needle (bevel up). When the end of the trochar enters the vein, a "pop" should be felt, followed by dark coloured blood filling the cannula flash chamber.

8) *Release the tourniquet*

9) *Advancing the cannula* – Decrease the angle of the needle until parallel with the skin. Holding the needle hub securely, advance the teflon cannula over the needle into the vein. **If you feel resistance, do **NOT** force the cannula*

10) *Apply an occlusive dressing to secure the cannula*

11) *Withdraw the needle* – with firm pressure approximately the length of the catheter proximal to the site (and with the IV tubing close), withdraw the needle. Dispose of the trochar immediately in a sharps container.

12) *Connect the IV tubing to the hub of the catheter* – Open the roller clamp and assess fluid flow in the drip chamber. Check the connections for fluid leakage. Set the flow rate.

13) *Secure the IV tubing (with tape)*

Complications and Troubleshooting IVs

Complications at the IV site

Extravasation/Interstitial IV – is an IV whose cannula has come out of the vein. The fluid leaks out of the IV site and into the interstitial spaces. It is identified by a slowed IV drip rate, a puffy appearance surrounding the IV site, (due to the accumulation of fluid), pain at the site (as reported by the patient), fluid leaking from the IV site (not the connection of IV tubing & IV cannula) and blanching of the skin at the site.

IVs can also be checked for patency by momentarily lowering the IV container below the level of the IV insertion site. Blood appearing in the IV tubing indicates a patent IV site/cannula. Interstitial IVs need to be removed and re-started.

Phlebitis is an irritation and inflammation of the vein and surrounding structures. This may indicate the presence of an infection. IVs with redness and swelling at the site should be restarted. These symptoms are normally seen in long term IV therapy (> 72 hours).

Systemic Complications

Septicemia, Bacteremia and Septic shock may occur if signs of local phlebitis are ignored. Watch for large areas of redness involving arms, fever, nausea, vomiting, headache and shock-like states.

Pulmonary Embolism – may occur if a blood clot slips from the IV site and follows the circulatory system to the pulmonary artery. Signs of pulmonary embolism include chest pain, blood tinged sputum, shock.

Air Embolism – occurs when approximately 10 ml of air inadvertently enters the vascular system, reaches the heart and produces cardiac arrest. Smaller amounts may have serious affects. Paramedics should take all measures to prevent air from entering the vascular system. To ensure an air embolus does not occur, always ensure the presence of fluid in the IV bag, that the drip chamber is ½ full and that all connections are tight.

Catheter Embolus – occurs when a portion of the teflon cannula breaks off and flows into the vascular system. Paramedics should check a removed catheter to ensure the bevelled end remains when an IV is discontinued. Treatment includes immediate identification of this condition and application of a tourniquet proximal to the IV site to trap the broken piece.

Troubleshooting

Dislodged IV/Interstitial IV

- Shut off flow
- Remove/discontinue IV
- Apply pressure to site with a gauze pad
- Document appearance of site, amount of fluid left in bag
- Reattempt the IV proximal to the affected site

Loose IV tubing connection

- ↓ IV flow rate
- Loosen securing tape
  If completely detached, clean both ends with alcohol wipe and reattach
- Clean site/replace tape/occlusive dressing
- Regulate IV rate

Flow Rate Problem

- Check height of tubing drip chamber
- Check level of fluid in bag. Replace the bag at 150 ml remaining
- Check for signs of infiltration
- Ensure the roller clamp is open
- Check the tube for kinking
- Is the cannula near a joint? Does straightening the joint help?
- Adjust tape, apply on arm board
- Is the catheter too small?
- Venous spasm – is the flow rate problem intermittent? (Cold IV fluids?).

Calculating IV rates

The example below illustrates how a paramedic would calculate the flow rate if he or she were ordered to administer 250 ml of normal saline to patient over a period of 1 hour using a 15 drop/ mL administration set.

Calculating the flow rate:

$$\underline{mL/hr}$$

$$\frac{total\ mL\ to\ be\ given}{total\ time\ (hours)} = \frac{250ml}{1\ hr\ (all\ boluses\ to\ be\ given\ over\ 1\ hr)} = 250ml/hr$$

To more precisely regulate the amount of solution, it is advised that the paramedic calculate the number of drops/min.

$$\underline{Drops/\min}$$

$$\frac{drops/mL\ (see\ the\ infusion\ set\ packaging) \times amount\ of\ fluid\ to\ be\ infused}{total\ time\ of\ infusion (in\ min)}$$

$$= \frac{15\ drops/mL \times 250mL}{60\ \min}$$

$$= 63\ drops/\min$$

That number may be further divided into 20 or 15 seconds to save time

$$\frac{60\sec}{15\sec} = \frac{63\ drops/\min}{x}$$

$$60\ x = 15 \times 63$$

$$x \cong 15\ drops\ in\ 15\ seconds$$

Documentation

In the procedures section of an ACR, the paramedic should document

- Unsuccessful IV attempt: record time, the details of the procedure including location attempted the code and what the result was.

Time	Procedure	Code	Remarks	Initial	No.
1405	IV catheter 20g x 32mm Rt hand	350	Interstitial – catheter removed intact.	MH	2
1406	Dressing applied	100	Bleeding controlled	AB	1

- Successful IV: record time, the details of the procedure including the location used, the code, the fluid set hung, and the rate.
- Additionally, the amount infused on-scene and en-route are to be recorded.
- Any adverse reactions/complications

Time	Procedure	Code	Remarks	Initial	No.
1410	IV catheter 18g x 32mm Rt forearm. 1000ml NS.	345	Successful, infusing TKVO.	MH	2
1412	Fluid bolus	351	1600ml bolus initiated	MH	2
1439	Fluid bolus completed	345	1600 mlinfused, return to TKVO rate.	MH	2

Pre-Test

1. Indicate a catheter size for the following scenarios

    Unconscious diabetic with a blood sugar of 2.6 mmol/L _______

    Stable chest pain __________

    Unstable patient involved in an MVC (requiring fluid resuscitation) __________

    Fractured tibia/fibula (stable v/s) age 7 __________

2. List 3 reasons for starting an IV.

3. Describe the structure of a vein.

4. Describe characteristics of an interstitial IV.

5. An IV is running at 120 ml/hr. In a macrodrip (15 drops/mL), how many drops/min should you observe?

6. A patient, unstable due to abdominal trauma, requires fluid resuscitation. He weighs 85 kg. His blood pressure is 80/40. His chest is clear.

    a) Describe the relevant Medical Directive(s).

    b) Assuming a full fluid bolus is required; calculate the amount of fluid this patient will initially receive?

    c) Knowing the amount of fluid to be given, at what rate should this bolus be given?

Glossary

Afferent
Anion
Buretrol
Cation
Crystalloid
Colloid
Diastole
DVT
Efferent
Extracellular
Hypertonic
Hypotonic
Intracellular
Ion
Ischial Tuberosity
Isotonic
Positional (IV)
Thenar Prominance
Vasovagal response

Bibliography

Grey Bruce Regional Health Centre (June 1990). **Venipuncture – To Start an IV**. Owen Sound, Ont: GBRHC

Markham Stouffville Hospital (September 1996). **IV Cannulation.** Markham, Ont: MSH

Bohony, J. (October 1993) **Common IV Complications and What to do about them**. American Journal of Nursing

Angeles, Tess. **Catheter Selection: Choosing the Right Size**. Nursing 97, February 1997.

Editor. August 2000. **Innocent Contamination.** JEMS

Hafen & Karren. **Pre Hospital Emergency Care and Crisis Intervention.** Third Edition. Morton Publishing 1989. Colorado.

Emergency Health Service Branch **Intravenous Monitoring Program Provider Guide** *Ontario* Government, October 1993.

Ministry of Health. **Intravenous Initiation Learning Package** Revised October 1998.

Tortora, G & Anagnastakos, N. **Principles of Anatomy and Physiology** Sixth Edition. Harper and Row. New York 1995.

Seeley & Stephens, T. Take, P. **Anatomy and Physiology** Mosley College Publishing. St. Louis 1989.xxxx