Causes and Treatment of Shock

I. Components of Blood
   1. Plasma
      a. “Watery” part of the blood (Plasma is 90% water).
      b. Contains plasma proteins that exert osmotic pressure (or oncotic force) to help retain water in the capillaries.
      c. Also contains electrolytes, dissolved gases, glucose, and hormones.
      d. Transports the formed elements (red blood cells, white blood cell, platelets).
   2. Formed Elements
      a. Red Blood Cells (Erythrocytes)
         (1) Primary function is oxygen transport.
         (2) Oxygen attaches to hemoglobin molecules in the red blood cell.
         (3) Each hemoglobin molecule can carry 4 oxygen molecules.
      b. White Blood Cells (Leukocytes)
         (1) Primary function is to provide protection from foreign invasion.
         (2) Examples of Different Types of Leukocytes:
            (a) Neutrophils
               i) The most common type of leukocyte.
               ii) These are the first leukocytes to respond to an invasion.
               iii) They engulf the foreign microorganisms.
            (b) Basophils
               i) Contain histamine.
               ii) Basophils that leave the blood stream and live in the tissues are called mast cells.
            (c) Macrophages
               i) “Garbage collectors” of the immune system.
               ii) Engulf cellular debris, dead blood cells, and help the neutrophils attack foreign microorganisms.
            (d) Lymphocytes
               i) T cells are responsible for cellular immunity.
               ii) B cells are responsible for humoral immunity.
      c. Platelets (Thrombocytes)
         (1) Primary function is to form a platelet plug at the site of a break in a blood vessel.
         (2) Also release chemicals that activate the blood clotting process.

A. Hemostasis
   1. The physiologic process used by the body to prevent or control blood loss.
   2. Consists of Three Mechanisms:
      a. Vasoconstriction (sometimes called vascular spasm).
      b. Platelet plug formation.
      c. Coagulation (the formation of blood clots).

B. Blood Typing
   1. ABO Blood Groups
   2. Rh Blood Groups
II. The Physiology of Perfusion

1. Perfusion and Hypoperfusion
   a. Perfusion
      (1) The constant supplying of oxygen and nutrients to the body’s cells, along with the constant removal of waste products from the cells.
      (2) Accomplished by the constant passage of blood through the capillaries.
   b. Hypoperfusion
      (1) The inadequate perfusion of body tissues.
      (2) Commonly called shock.
      (3) Occurs first at the cellular level and will progress to the tissues, organs, organ systems, and the entire organism. If not corrected, shock will lead to death.

2. Components of the Circulatory System
   a. The Pump (Heart)
      (1) Stroke Volume – the amount of blood ejected by the heart in one contraction. Factors affecting stroke volume:
         i) Preload – the amount of blood delivered to the heart during diastole.
         ii) The greater the preload, the greater the stroke volume.
      (2) Cardiac Output
         a) The amount of blood pumped by the heart in one minute.
         b) Expressed in liters/minute
         c) Cardiac Output = Stroke Volume x Heart Rate
      (3) Blood Pressure
         a) The pressure that the blood exerts against the walls of the blood vessels.
         b) BP = Cardiac Output x Peripheral Vascular Resistance
   b. The Fluid (Blood)
   c. The Container (Blood Vessels)
      (1) Consists of the arteries, arterioles, capillaries, venules, and veins.
      (2) Microcirculation = arterioles, capillaries, and venules.
      (3) Capillary Sphincters
         i) Pre-capillary sphincter (located between the arteriole and capillary)
         ii) Post-capillary sphincter (located between the capillary and venule)
3. Oxygen Transport
   a. Respiration
   b. Fick Principle—movement and utilization of oxygen by the body depends upon:
      (1) Adequate concentration of inspired oxygen
      (2) Appropriate movement of oxygen across the alveolar/capillary membrane into the arterial bloodstream
      (3) Adequate number of red blood cells to carry the oxygen
      (4) Proper tissue perfusion
      (5) Efficient off-loading of oxygen at the tissue level

4. Waste Removal
   a. Carbon dioxide eliminated by exhalation from the lungs.
   b. Other wastes are cleansed from the blood by the kidneys and excreted as urine
   c. Some waste is emptied into the gastrointestinal system and expelled as feces.

III. The Pathophysiology of Hypoperfusion
   1. Causes of Hypoperfusion
      a. Inadequate pump
      b. Inadequate fluid
      c. Inadequate container

2. Shock at the Cellular Level
   a. Shock is inadequate tissue perfusion and the ultimate outcome of inadequate tissue perfusion is impaired cellular metabolism.
   b. Two Characteristics of Impaired Cellular Metabolism:
      (1) Impaired Use of Oxygen
         (a) Glucose is the primary source of energy for the cells, but does not provide energy until it is broken down inside the cell.
         (b) Glucose is broken down in two stages:
            i) Stage 1: (Glycolysis) Forms pyruvic acid and a small amount of ATP. This process is anaerobic (does not require O₂).
            ii) Stage 2: (Krebs or Citric Acid Cycle) Pyruvic acid is broken down into CO₂, H₂O, and a lot of ATP. This process is aerobic (requires O₂).
      (c) When O₂ is not available due to hypoperfusion, the breakdown of glucose never gets past Stage 1. The pyruvic acid is quickly changed into lactic acid, and only a small amount of ATP is made.
      (d) The lactic acid diffuses into the blood where it reduces the ability of the hemoglobin to bind with and carry O₂.
      (e) The small amount of ATP in the cells is quickly used up, so that the cells have no energy to function.
      (f) Waste products build up in the cell, causing the lysosomes to rupture, releasing digestive enzymes that begin to destroy the other organelles.
      (g) At the same time, because of the lack of ATP, the sodium-potassium pump begins to fail.
      (h) Sodium builds up inside the cell, causing water to be pulled into the cell, causing it to swell and rupture.
      (i) Cellular death immediately follows.
2. Impaired Use of Glucose
   (a) The same factors that reduce the delivery of O\textsubscript{2} to the cells also reduces the delivery of glucose to the cells.
   (b) When cells can’t get glucose to make energy, they will try to convert other substances to glucose.
      i) Glycogen – a form of glucose that certain cells store and hold in reserve. Glycogen is converted to glucose in a process called glycogenolysis.
      ii) Fats or Amino Acids from Proteins. These non-carbohydrate substances are converted to glucose in a process called gluconeogenesis.
   (c) These processes impair cellular metabolism by creating very little ATP (which is quickly exhausted), and producing ammonia and acids which are toxic to the cells. As the waste products build up in the cells, cell function is impaired and the cell membrane eventually ruptures.

3. Compensation
   a. When the baroreceptors detect a decrease in arterial blood pressure, several body systems are activated to attempt to reestablish a normal blood pressure.
      (1) Sympathetic nervous system (the “fight or flight” system) - stimulates the adrenal gland of the endocrine system to secrete epinephrine and norepinephrine.
         (a) Increased heart rate
         (b) Increased force of contractions
         (c) Blood vessel constriction (increased peripheral vascular resistance)
      (2) Renin-angiotensin system – the enzyme renin is released from the kidneys and acts on a plasma protein called angiotensin to produce angiotensin I. This is converted to angiotensin II by an enzyme in the lungs called angiotensin converting enzyme (ACE). Angiotensin II does the following:
         (a) Blood vessel constriction
         (b) Stimulates the adrenal gland to produce aldosterone which stimulates the kidneys to reabsorb sodium which pulls water back into the intravascular space.
      (3) The pituitary gland releases anti-diuretic hormone (ADH)
         (a) Blood vessel constriction
         (b) Causes kidneys to reabsorb water
      (4) The sympathetic nervous system can stimulate constriction of a certain area of the spleen that can expel up to 200ml of blood into the venous circulation.
      (5) Reabsorption of interstitial fluid increases as hydrostatic pressure is reduced due to hypovolemia.
   b. Compensated shock = the early stage of shock during which the body’s mechanisms are able to maintain normal perfusion (blood pressure will appear normal).

4. Decomposition
   a. Decompensated (Progressive) Shock
      (1) A more advanced stage of shock when the body’s mechanisms are no longer able to maintain normal perfusion (blood pressure will begin to drop).
      (2) Medical intervention may still be able to correct the problem.
   b. Irreversible Shock
      (1) Shock that has progressed so far that no medical intervention can reverse the condition and death is inevitable.
      (2) This is due to massive cellular damage which has progressed to tissue and then organ failure.
      (3) Even if blood pressure is restored, once the patient has reached this stage, death will usually occur within 1 day to 3 weeks due to organ failure.
A. Types of Shock

1. Cardiogenic Shock
   a. Caused by insufficient cardiac output.
   b. Inability of the heart to pump enough blood to perfuse all parts of the body.
   c. Usually the result of left ventricular failure due to acute myocardial infarction.

2. Hypovolemic Shock
   a. Caused by a loss of intravascular fluid volume.
   b. Most often the result of:
      (1) Internal or external hemorrhage (hemorrhagic shock)
      (2) Severe dehydration (especially in children)
      (3) Plasma loss from burns

3. Neurogenic Shock
   a. Caused by brain or spinal injury that causes an interruption of nerve impulses to the arteries.
   b. The arteries then lose their tone and dilate.
   c. No fluid has been lost, but the blood vessels have become enlarged.

4. Anaphylactic Shock
   a. Caused by a life-threatening allergic reaction.
   b. Histamine causes arterioles and capillaries to dilate and increases capillary permeability causing intravascular fluid to leak into the interstitial space. This can lead to hypotension as well as the development of laryngeal edema.
   c. Other mediators can cause constriction of both the upper and lower airways.

5. Septic Shock
   a. Caused by an infection that enters the bloodstream and is carried throughout the body.
   b. Hypotension results from intravascular fluid leaking into the interstitial space due to increased permeability of the blood vessels.
   c. Unless treated, septic shock will cause the dysfunction of more than one organ system, resulting in multiple organ dysfunction syndrome (MODS).

IV. Hemorrhage

A. Hemorrhage Classification

1. Capillary
   a. Oozes from the wound (usually an abrasion).
   b. Usually bright red (because it is well oxygenated).
   c. Often clots quickly on its own.

2. Venous
   a. Steady flow of blood.
   b. Darker red in color (because it is oxygen poor).
   c. Generally stops in a few minutes or is easily controlled with pressure.

3. Arterial
   a. Spurting or pulsating flow.
   b. Bright red in color.
   c. Requires direct pressure to be controlled (often with elevation and possibly the use of pressure points as well).
B. Stages of Hemorrhage (either internal or external)
   1. Stage 1
      a. Blood loss up to 15% (500-750 mL in an average adult male).
      b. Nervousness, marginally cool skin, slight pallor, slight tachycardia.
   2. Stage 2
      a. Blood loss between 15-25% (750-1250 mL).
      b. Tachycardia, cool, clammy skin, increased anxiety and restlessness, thirst.
   3. Stage 3
      a. Blood loss between 25-35% (1250-1750 mL).
      b. Decreased LOC, falling blood pressure, tachycardia/tachypnea, weak pulse.
      c. Without rapid intervention survival is unlikely.
   4. Stage 4
      a. Blood loss greater than 35% (greater than 1750 mL).
      b. Pulse barely palpable (if at all), respirations are rapid and shallow, lethargic or unconscious.
      c. Survival unlikely, even with treatment.

C. Internal Hemorrhage Assessment
   1. Injuries That Can Cause Significant Blood Loss:
      a. Fractured pelvis (2,000 mL)
      b. Fractured femur (1,500 mL)
      c. Fractured tibia (750 mL)
      d. Fractured humerus (750 mL)
      e. Large contusion (500 mL)
   2. Signs and Symptoms of Internal Hemorrhage:
      a. Pain, tenderness, swelling, discoloration, or deformity of injury site (indicating any of the injuries listed above).
      b. Bleeding from mouth, rectum, vagina, or other orifice.
      c. Vomiting of bright red blood or “coffee ground” type emesis.
      d. Tender, rigid, and/or distended abdomen.
      e. Signs and symptoms of hypovolemic shock (listed later in the notes).

D. Assessment of Hypovolemic Shock
   1. Signs/symptoms of Early (Compensated) Shock:
      a. Nervousness or anxiety (or level of consciousness may be normal).
      b. Tachycardia.
      c. Pale, cool, and/or clammy skin.
      d. Systolic blood pressure maintained.
      e. Narrowing pulse pressure:
         (1) Pulse pressure is the difference between the systolic and diastolic pressures.
         (2) Pulse pressure reflects the tone of the arterial system and is more sensitive to changes in perfusion than the systolic or diastolic alone.
      f. Complaints of thirst.
      g. Weakness.
      h. Capillary refill greater than 2 seconds (in children under 6 years of age).
      i. Dry mucous membranes.
      j. Positive orthostatic tilt test.
2. Signs/symptoms of Late ( Decompensated or Progressive) Shock:
   a. Significantly decreased or altered level of consciousness.
   b. Extreme tachycardia (eventually leading to bradycardia).
   c. Extremely pale (or cyanotic), cool, diaphoretic skin.
   d. Hypotension.
   e. Nausea.
   f. Dilated and sluggish pupils.

E. Shock Management
1. Airway and Breathing Management
   a. High-flow oxygen via nonrebreather.
   b. Assist ventilations as needed.
2. Control External Hemorrhage
   a. Direct pressure.
   b. Elevation.
   c. Pressure points.
   d. A tourniquet is used only as a last resort and is almost never required.
3. Trendelenburg Positioning
   a. Elevate the distal end of the spine board after the patient is immobilized.
   b. Contraindications include head trauma and pulmonary edema.
4. Temperature Control
   a. Maintain body warmth by covering with a blanket.
   b. If a trauma patient complains of feeling cold in the back of your ambulance, turn off the A/C or turn up the heat.
5. Fluid Resuscitation
   a. Lactated Ringer’s (LR) is considered the fluid of choice (normal saline is also acceptable).
   b. Fluid flow is directly related to the diameter of the I.V. catheter, and indirectly related to the length of the I.V. catheter.
   c. Fluid boluses are administered at 20 mL/kg. Blood pressure and breath sounds should be evaluated frequently during administration.
      (1) Reduce to TKO if pulmonary edema develops.
      (2) Reduce to TKO when systolic blood pressure reaches 90 mmHg.
6. Pneumatic (or Medical) Anti-Shock Garment (PASG or MAST)
   a. Use of this device to raise blood pressure is extremely controversial. Follow local protocols or the advice of on-line medical direction.
   b. Indications:
      (1) Shock patients with controlled external bleeding.
      (2) Patients with unstable pelvic or lower extremity fractures.
      (3) Patients with possible neurogenic shock.
   c. Contraindications:
      (1) Shock patients with internal bleeding.
      (2) Pulmonary edema.
      (3) Penetrating chest trauma.
      (4) Cardiogenic shock.