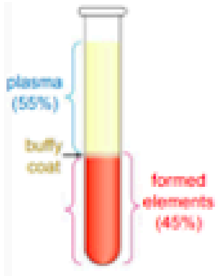
Cardiovascular System

A transport system for blood and its constituents around the body

- Deoxygenated blood in the veins is darker, oxygenated blood in the arteries is lighter
- Through blood transport, our body
  - Delivers oxygen, nutrients and hormones to cells
  - Removes carbon dioxide and other waste (e.g. urea) from cells
  - Maintains water and electrolyte balance
  - Thermoregulates – alters blood flow to the skin based on temperature



Blood

- Makes up around 7% of our body weight
- Comprised of
  - 55% plasma (liquid)– dissolved gases, nutrients, electrolytes, waste
  - 45% "formed elements" (cells) – erythrocytes, leucocytes, platelets (buffy coat)
- Blood/Oxygen Supply
  - INTO the heart
    - Deoxygenated blood carried by the vena cava enters the right atrium and right ventricle of the heart, it is pumped to the pulmonary trunk and then pulmonary arteries ("pulmonary circulation") which carry the blood to the lungs to be oxygenated
    - Supplying the airways involved in respiration and gaseous exchange (bronchioles and alveoli)
  - OUT of the heart
    - Oxygenated blood returns from the lungs via the pulmonary vein to the left atrium, the blood flows to the left ventricle which pumps the blood to the thoracic aorta and bronchial arteries ("systemic circulation") for distribution around the body
    - Supplying the airways involved in conducting the air (trachea, bronchi and bronchioles)

Heart

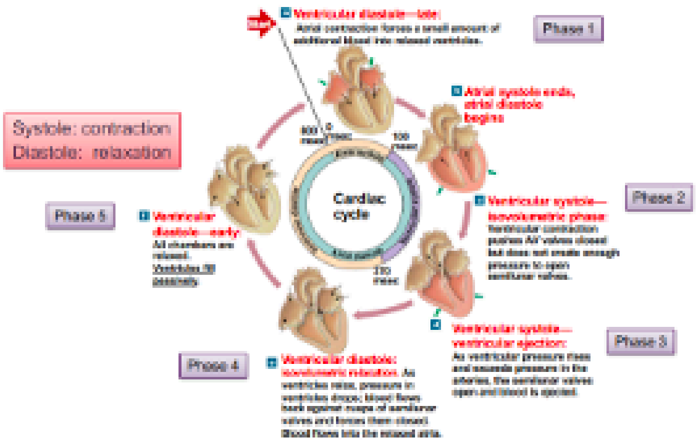
- When the heart contracts, it is systolic… when the heart relaxes, it is diastolic
- You need less force to push blood through pulmonary circulation then systemic circulation, hence
  - The left ventricle is thicker than the right ventricle
  - The left atrium is thicker than the right atria
  - Ventricles are stronger/thicker than atria

Cardiac Valves

- Right atrioventricular valve (tricuspid), separates the right atrium from the right ventricle
- Pulmonary valve (semilunar valve), separates the pulmonary trunk from the right ventricle
- Left atrioventricular valve (bicuspid), separates the left atrium from the left ventricle
- Aortic valve (semilunar valve), separates the aorta from the left ventricle
- Atrioventricular valves close together, as do the semilunar valves… when the atrioventricular valves are closed the semilunar valves are opened etc.
- Chordae tendineae and papillary muscles open and close the valves
- Opening and Closing
    - During ventricular systole
        - The left atrioventricular valve is closed
        - The aortic and pulmonary valves are opened
        - The chordae tendineae is taut
        - The papillary muscles are contracted
        - Blood is released from the left ventricle into the aorta
    - During ventricular diastole
        - The left atrioventricular valve is opened
        - The aortic and pulmonary valves are closed
        - The chordae tendineae is slack
        - The papillary muscles are relaxed
        - Blood is taken into the left ventricle via the pulmonary veins

The Cardiac Cycle

- The sequence of electrical and mechanical events which occur between heartbeats, including the generation of electrical impulses, contraction and relaxation of the heart muscle, the filling and emptying of the chambers, and the flow of blood through the circulatory system.
- At the end of ventricular diastole, atrial systole occurs and forces a small amount of blood (20%) into relaxed ventricles, then, atrial diastole and ventricular systole begins (for a short time, all valves are closed, and pressure rises), the pressure rises to a point and the aortic and pulmonary valves open and blood is ejected, (then all valves are closed, and pressure falls), the pressure falls to a point and ventricles are filled passively (80%).

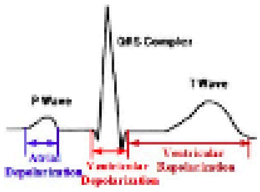


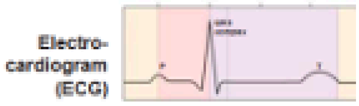
Sounds of the Cardiac Cycle "lub-dub"

- Sound I "lub"
  - Closing of the left and right atrioventricular valves at the start of ventricular contraction (systole) – just after the QRS complex
- Sound II "dub"
  - Closing of the semilunar (aortic and pulmonary) valves at the start of ventricular relaxation (diastole) – just after the T wave

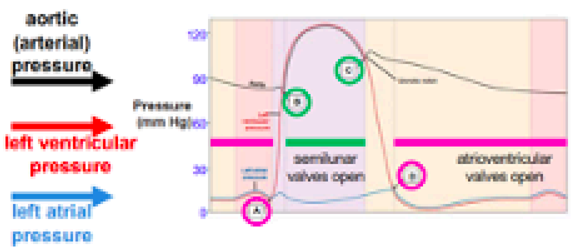
Wiggers Diagram

- A graphical representation of the cardiac cycle and their relation to one another
- The Wiggers diagram (ECG, pressure and volume) shows us that:
  - Mechanical events follow electrical events (ECG)
  - Cardiac valves open and close according to the pressure gradient across them
  - Blood flows according to the pressure gradient (when valves are opened)
- An electrocardiogram or ECG is a recording of the electrical activity of the heart during a cardiac cycle, its three main components are:
  - P Wave (systole)
    - Depolarisation/activation of the atria (electrical)
    - Contraction of the atria (mechanical)
    - This, increases atrial pressure
  - QRS Complex (systole)
    - Depolarisation/activation of the ventricles (electrical)
    - Contraction of the ventricles (mechanical)
    - This, increases ventricular pressure
  - T Wave (diastole)
    - Repolarisation/recovery of the ventricles (electrical)
    - Relaxation of the ventricles (mechanical)
    - This, decreases ventricular pressure





- During the QRS complex, ventricular pressure will eventually become greater than atrial pressure (point A), at this point the atrioventricular valve closes and the "lub" (sound 1) is heard… the ventricular pressure continues to rise and eventually becomes greater than aortic pressure (point B), at this point the aortic/semilunar valve opens and blood flows into the aorta via ventricular ejection/emptying
- Following the QRS complex, the T wave begins and ventricular pressure falls, eventually becoming lower than aortic pressure (point C), at this point the aortic/semilunar valve closes and the "dub" (sound 2) is heard
- When ventricular pressure falls below atrial pressure (point D), the atrioventricular valve opens, and ventricular filling occurs



- Potassium
    - Should be 3.5-5.2 mmol/L
    - Regulates heart contraction etc. an intracellular cation
    - Controlled by the kidneys
    - Measured by ISE to assess patients on diuretics, IV therapy, renal disease, acid-base disturbances, GIT fluid loss… investigation of mineralocorticoid status
    - Hyperkalaemia
        - Elevated levels of potassium
        - Due to renal disease, heart failure, dehydration, acidosis, Addison's disease, tissue damage, infection, drugs – NSAIDs, beta blockers, ACE inhibitors
        - Is a medical emergency because it can interfere with the heart
    - Hypokalaemia
        - Decreased levels of potassium
        - Due to loop or thiazide diuretics, GIT fluid loss, alkalosis etc.
- Chloride
    - Should be 95-110 mmol/L
    - Controlled by the kidneys
    - An extracellular anion – changes in chloride mirror that of sodium
    - Measured by ISE to assess the possible cause of acid-base disturbances and to calculate the anion gap
    - Dependent on hydration state
    - Hyperchloremia
        - Elevated levels of chlorine
        - Due to hypernatremia, dehydration, metabolic acidosis
    - Hypochloraemia
        - Decreased levels of chlorine
        - Due to hyponatremia, metabolic acidosis, prolonged vomiting
- Bicarbonate
    - Should be 22-32 mmol/L
    - Controlled by the kidneys
    - Regulates pH balance in the body, helps maintain electric neutrality in cells
    - Measured by spectrophotometry to assess acid-base disorders, particularly metabolic abnormalities and renal tubular acidosis
    - Hyperbicarbonatemia
        - Elevated levels of bicarbonate
        - Due to metabolic alkalosis and in compensated respiratory acidosis
    - Hypobicarbonatemia
        - Decreased levels of bicarbonate
        - Due to metabolic acidosis
- Anion Gap
    - Should be 8-16 mmol/L OR 4-13 mmol/L if potassium is not included
    - Controlled by the kidneys
    - Anion Gap = (sodium + potassium) – (chlorine + bicarbonate)
    - Measured to assess/diagnose metabolic acidosis
    - Increased Anion Gap
        - Indicates metabolic acidosis in renal failure, ketoacidosis etc.
    - Metabolic acidosis in a normal anion gap is due to renal tubular acidosis or due to bicarbonate loss e.g. diarrhoea

Ions/ Minerals

- Found in all body fluid, inside and outside the cells
- They maintain osmotic pressure, fluid balance and acid-base balance
- Play an important role in many metabolic processes
- Measured by a potentiometer
    - Measures the electric potential between two electrodes – a stable reference electrode and the Ion Selective Electrode (ISE) and is altered based on concentration of ion changes
- Calcium
    - Should be 2.1-2/6 mmol/L
    - Controlled by the kidneys
    - Regulates the functioning of muscles, nerves, heart, blood clotting, bone formation
    - Measured by spectrophotometry or ISE to assess general health and in renal disease
    - Hypercalcaemia
        - Elevated levels of calcium due to hyperparathyroidism, cancers, excessive vitamin D intake
    - Hypocalcaemia
        - Decreased levels of calcium due to hypoparathyroidism, **renal failure**, vitamin D deficiency
- Phosphate
    - Should be 0.75-1.5 mmol/L
    - Controlled by the kidneys
    - Regulates energy production, muscle and nerve function, bone growth
    - Measured by spectrophotometry or ISE to assess renal failure, metabolic bone disease hypo or hyperparathyroidism
    - Hyperphosphatemia
        - Elevated levels of phosphate due to renal failure, hypoparathyroidism, vitamin D overdose
    - Hypophosphatemia
        - Decreased levels of phosphate due to renal tubular disorders, hyperparathyroidism, overuse of diuretics or antacids with magnesium/aluminium
- Magnesium
    - Should be 0.7-1.10 mmol/L
    - Controlled by the kidneys
    - Regulates energy production, muscle and nerve function, cardiac rhythm
    - Measured by spectrophotometry or ISE to assess renal disease, diabetes, GI disorders, unexplained cardiac arrythmias
    - Hypermagnesemia
        - Elevated levels of magnesium due to renal failure, hyperparathyroidism, magnesium antacids in renal impairment
    - Hypomagnesaemia
        - Decreased levels of magnesium due to renal loss, GI loss (vomiting/diarrhoea), diabetes