Blood Pressure, Pulse and Circulation of Blood – Revision notes

**Blood Pressure**

- Force or pressure that the blood exerts on the walls of the blood vessels
- Blood pressure needs to be kept within normal limits
- If blood pressure becomes too high blood vessels can be damaged causing clots or bleeding from sites of blood vessel rupture
- If blood pressure is too low blood flow through tissue beds may be inadequate – particularly dangerous for essential organs:
  - Heart
  - Brain
  - Kidneys
- Systemic arterial blood pressure is result of the discharge of blood from the left ventricle into the already full aorta
- When left ventricle contracts and pushes blood into the aorta – pressure produced within the arterial system is the systolic blood pressure
  - In adults about 120mmHg
- When complete cardiac diastole occurs and the heart is resting following the ejection of blood – pressure within arteries is much lower and is the diastolic blood pressure
  - In adults about 80mmHg
- Difference between systolic and diastolic blood pressures is the pulse pressure
- Blood pressure varies according to
  - Time of day
  - Posture
  - Gender
  - Age
- During bed rest at night blood pressure is usually lower
- It increases with age – usually higher in women than in men
Arterial blood pressure is measured with a sphygmomanometer – usually expressed with the systolic pressure written above the diastolic pressure

- BP = 120 mmHg
  - 80

**Elasticity of the Artery Walls**

- Lots of elastic tissue in the arterial walls – especially in large arteries

- When left ventricle ejects blood into the already full aorta – aorta expands to accommodate it and the recoils due to the elastic tissue in the wall
  - Pushes blood forwards into the systemic circulation

- Distension and recoil occurs throughout arterial system

- During cardiac diastole the elastic recoil of the arteries maintains diastolic pressure

- Systemic arterial blood pressure maintains flow of blood into and out of organs

- Blood pressure is determined by
  - Cardiac output
  - Peripheral resistance
  - Change in either of the above parameters may alter the systemic blood pressure
    - Body’s compensatory mechanisms can usually adjust for any changes

- Blood pressure = cardiac output X peripheral resistance

**Cardiac Output**

- Determined by stroke volume and heart rate

- Any factors that affect heart rate and stroke volume may increase or decrease cardiac output and therefore blood pressure

- Increase in cardiac output raises both systolic and diastolic pressure

- Increase in stroke volume increases the systolic pressure than it does the diastolic pressure
Peripheral or Arteriolar Resistance

- Arterioles are smallest arteries
  - Have a tunica media
    - Composed of almost entirely smooth muscle
    - Responds to nerve and chemical stimulation
- Constriction and dilatation of the arterioles are main determinants of peripheral resistance
- Vasoconstriction causes blood pressure to increase
- Vasodilatation causes blood pressure to decrease
- When elastic tissue is replaced in the tunica media – replaced by inelastic fibrous tissue as part of ageing process – this causes increase in blood pressure
- Dilatation and constriction of arterioles occurs selectively around body – results in changes in blood flow through organs according to needs
- Highest priorities are blood supply to
  - Brain
  - Heart muscle
- In emergency situations blood supply to other parts of body are reduced
  - This insures adequate supply to major organs
- Generally changes in the amount of blood flowing to any organ depend on how active it is
  - A very active organ needs more oxygen and nutrients than a resting organ
  - Produces more waste materials for excretion

Control of Blood Pressure

- Controlled in two ways
  - Short term control
    - Moment-to-moment basis
    - Mainly involves
      - Baroreceptor reflex
      - Chemoreceptors
      - Circulating hormones
  - Long term control
    - Involves regulation of blood volume by
- Kidneys
- Renin-angiotensin aldosterone system

**Short Term Blood Pressure Regulation**

- Cardiovascular system (CVC) is a collection of
  - Interconnected neurones in medulla and pons of brain system

- CVC receives, integrates and coordinates inputs from
  - Baroreceptors (pressure receptors)
  - Chemoreceptors
  - Higher centres in brain

- CVC sends autonomic nerves (both sympathetic and parasympathetic) to
  - Heart
  - Blood vessels

- Controls blood pressure by
  - Slowing down or speeding up heart rate
  - Dilating or constricting blood vessels

- Activity in these fibres – essential for control of blood pressure

**Baroreceptors**

- Nerve endings sensitive to pressure changes within the vessel

- Situated in
  - Arch of aorta
  - Carotid sinuses

- Body’s principle moment-to-moment regulatory mechanism for controlling blood pressure

- Rise in blood pressure in these arteries stimulates baroreceptors - increasing input to CVC
  - CVC responds by increasing parasympathetic nerve activity to heart – slows down heart rate
  - Sympathetic stimulation to blood vessels is inhibited causing vasodilatation
  - Net result = decrease in systemic blood pressure
If pressure within aortic arch and carotid sinuses decrease – rate of baroreceptor discharge also decreases
  o CVC responds by increasing sympathetic stimulation to heart to speed the rate up
  o Sympathetic activity in blood vessels is also increased causing vasoconstriction
  o Both measures counteract decreasing blood pressure

**Chemoreceptors**

- Nerve ending situated in
  o Carotid bodies
  o Aortic bodies

- Primarily involved in control of respiration

- Sensitive to changes in levels of
  o Carbon dioxide
  o Oxygen
  o Acidity of blood (pH)

- Rising blood CO$_2$, falling blood O$_2$ levels and/or falling pH all indicate failing tissue perfusion

- When these changes are detected by chemoreceptors – they send signals to CVC – then increase sympathetic stimulation to the heart and blood vessels
  o Increases blood pressure to improve tissue blood supply

- Due to respiratory effort also being stimulated – blood oxygen levels increase

- Chemoreceptor input to CVC influences output only when severe disruption of respiratory function occurs or when arterial blood pressure falls to less than 80mmHg

- Similar chemoreceptors are found on brain surface in medulla oblongata
  o Measure
    ▪ Carbon dioxide levels
    ▪ Oxygen levels of cerebrospinal fluid
    ▪ pH
  o Changes from normal – activate responses similar to those for aortic/carotid receptors
**Higher Centres in the Brain**

- Input to CVC from higher centres is influenced by emotional states
  - Fear
  - Anxiety may stimulate change in blood pressure
  - Pain
  - Anger

- Hypothalamus in brain controls body temperature and influences CVC
  - Responds by adjusting diameter of blood vessels in skin – important mechanism in determining heat loss and retention

**Long Term Blood Pressure Regulation**

- Mainly exerted by renin-angiotensin aldosterone system (RAAS) and action of antidiuretic hormone (ADH)
  - Both systems regulate blood volume
    - Influences blood pressure

- Atrial natriuretic peptide (ANP) – hormone released by heart
  - Causes sodium and water loss from kidneys
  - Reduces blood pressure
  - Opposing activities of ADH and RAAS

**Pulse**

- Wave of distension and elongation felt in an artery wall due to contraction of left ventricle

- Each contraction of the ventricle forces about 60-80 ml of blood through the already full aorta and into the arterial system

- When aorta is distended a wave passes along walls of arteries and can be felt at any point where a superficial artery can be pressed gently against a bone

- Number of pulse beats per minute normally represents the heart rate and varies from person to person, and also in the same person at different times
Average of 60-80 bpm is common at rest

Information obtained from measuring a pulse
  - Rate at which heart is beating
  - Regularity of the heart beat – intervals between each heartbeat should be equal
  - Volume or strength of beat – should be possible to compress the artery with moderate pressure, stopping blood flow; compressibility of blood vessel = some indication of the blood pressure and state of blood vessel wall
  - Tension – the artery wall should feel soft and pliant under the fingers

Factors affecting the Pulse

- In health pulse rate and heart rate are identical
- In some circumstances the pulse rate may be less than the heart rate:
  - The arteries supplying the peripheral tissues are narrowed or blocked – blood is not pumped through with each heartbeat
  - Heart may be diseased or failing – unable to generate enough force with each contraction to circulate blood to peripheral arteries

Circulation of the Blood

- Although circulation of blood around body is continuous is helps to describe in two parts
  - Pulmonary circulation
  - Systemic (general) circulation

Pulmonary Circulation

- Circulation of blood from right ventricle of heart to lungs and back to left atrium
- In lungs
  - Carbon dioxide is excreted
  - Oxygen is absorbed
Pulmonary artery carrying deoxygenated blood leaves the upper part of the right ventricle of heart
  - Passes upwards and divides into left and right pulmonary arteries at level of 5<sup>th</sup> thoracic vertebra

Left pulmonary artery runs to root of left lung
  - Divides into two branches – one passing into each lobe

Right pulmonary artery passes to root of right lung
  - Divides into two branches
    - Larger branch carries blood to middle and lower lobes
    - Smaller branch carries blood to upper lobe

Within lung these arteries divide and subdivide into smaller arteries – arterioles – capillaries

Exchange of gases occurs between capillary blood and air in alveoli of lungs

In each lung capillaries containing oxygenated blood join up and form two pulmonary veins

Two pulmonary veins leave each lung – returning oxygenated blood to left atrium of heart

During atrial systole this blood is pumped into left ventricle and during ventricular systole it is forced out into the aorta – first artery of general circulation

**Systemic Circulation**

Blood pumped out from left ventricle is carried by branches of the aorta around the body and returns to the right atrium of heart by superior and inferior venae cavae