Bio Factsheet

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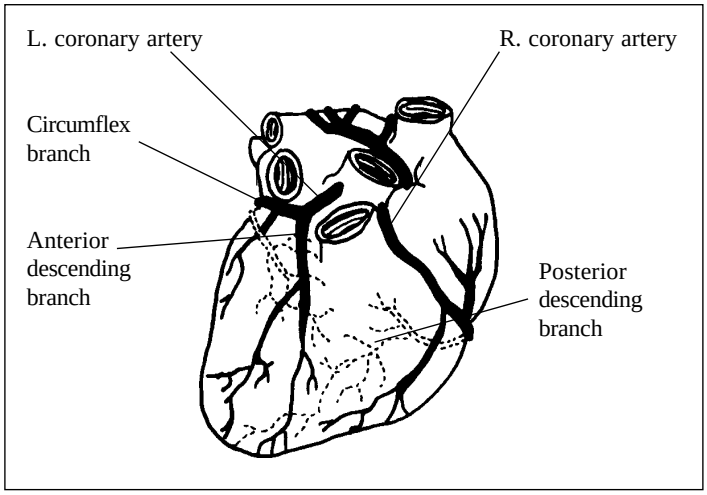
Ischaemic (Coronary) Heart Disease

Ischaemia is the term used to describe the condition when there is a mismatch between the amount of oxygen which a cell needs and the amount which it receives. Insufficient oxygen supply results in anaerobic glycolysis and this produces lactic acid and a decrease in pH. When this occurs in cardiac (heart) muscle, it impairs the ability of the heart muscle to contract and the associated pain is known as angina. The most common cause of ischaemic heart disease (IHD) - also called coronary heart disease (CHD) - is atherosclerosis - the development of a lipid plaque known as an atheroma in a coronary artery i.e. in one of the arteries which supplies the heart itself with blood, nutrients and oxygen (Fig 1).

Fig 1. The coronary arteries



Atherosclerosis is just one of the causes of arteriosclerosis which is defined as the hardening and thickening of the arteries.

Table 1 contains definitions of words commonly used when describing heart disease.

IHD can be described as chronic or acute. Chronic IHD involves what is known as **stable angina** and is caused by decreased blood flow in the coronary arteries which become blocked by plaques. The build up of plaque decreases blood flow and hence decreases oxygen supply to the cardiac muscle. Acute IHD involves **unstable** (or crescendo) angina, which occurs when a plaque ruptures.

The pain of angina is usually experienced in the centre of the chest and often radiates to the neck and left arm. Angina can be brought on, or "precipitated", by a number of events (Table 2), all of which increase the amount of oxygen which the heart needs beyond that which can be supplied.

Table 2. Precipitants of angina

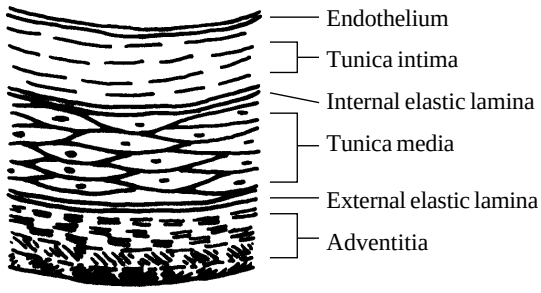
Event	Effect
Exercise	Causes tachycardia → ↑ the force and frequency of contraction, which ↑ oxygen consumption.
Emotional stress	↑ stimulation of heart muscle by the sympathetic nervous system → ↑ heart rate ↑ force and frequency of contraction → ↑ oxygen consumption.
Cold weather	Vasoconstriction of the peripheral arterioles → ↑ volume of blood in the ventricles. This makes the heart muscle work harder and → ↑ its oxygen consumption.

Table 1. Heart Disease Definitions

Term	Definition
Ischaemia	Mismatch between demand for and supply of O_2 to a cell, tissue or organ.
Ischaemic heart disease (IHD)	- Coronary heart disease (CHD) results when blood supply to heart muscle is insufficient for its needs.
Coronary arteries	The arteries which supply the heart itself with blood.
Plaque (Atheroma)	A lipid-rich deposit which blocks arteries.
Atherosclerosis	The development of a lipid plaque in the arteries. One cause of arteriosclerosis.
Arteriosclerosis	Thickening and hardening of the arteries.
Myocardial infarction	A heart attack, caused by death of part of the heart muscle. This may or may not be caused by CHD.
Heart failure	When the heart cannot maintain circulation to the tissues. This may be because the heart is damaged, e.g. via CHD or because the heart is having to overwork, for example as a result of hypertension.
Tachycardia	A rapid heartbeat or pulse rate
Electrocardiogram (ECG)	A recording of the electrical changes in the heart during the cardiac cycle. The ECG can be recorded from the surface of the body during the cardiac cycle.

The development of atherosclerosis
Atherosclerosis can develop anywhere in the arterial system but if it occurs within the coronary arteries it results in heart disease. Atherosclerosis results from the development of plaques (atheromas) in the walls of arteries. The plaque may involve the tunica intima and the tunica media, thus disrupting the distribution pattern of elastic tissue in the artery (so the artery is less elastic - hardening of the arteries). The plaque may also intrude into the lumen of the artery thus restricting the blood flow to the supplied organs and thus limiting oxygen supply. If this is heart muscle it may cause the pain of angina, or if the blood flow is seriously reduced, it may cause the death of some cardiac muscle fibres. This is called myocardial infarction. The basic structure of an artery is shown in Fig 2.

Fig 2. TS of an artery



The main lipid content within plaques is cholesterol. This is made in the body by the liver using breakdown products from the metabolism of saturated fats. If the body ingests too much saturated fat (e.g. from butter, cheese, eggs, fatty meats) the liver, as a result, can produce too much cholesterol. The problem can also be increased by ingesting too much cholesterol, by over indulgence in dairy products. Cholesterol and saturated triglycerides cannot dissolve in water and thus cannot be transported in their unaltered forms in blood. They are thus combined with proteins produced by the liver and intestines, forming lipoproteins. These vary in size, molecular weight and density. **Low density lipoproteins (LDLs)** pick up cholesterol and deposit it into body cells which have LDL receptors, including smooth muscle cells in damaged arteries. LDLs thus increase the risk of heart disease. **High density lipoproteins (HDLs)** gather cholesterol from body cells and transport it to the liver for excretion. HDLs thus reduce the risk of heart disease.

Unsaturated fatty acids known as omega-3 fatty acids are known to decrease the risk of heart disease by reducing the blood content of LDLs and increasing the content of HDLs although the mechanisms involved are unknown. They also tend to reduce the risk of blood clot formation. They are found in high concentrations in red fish, such as salmon, trout, mackerel, herring and sardines. These should form a regular dietary component of potential heart disease sufferers. The probable sequence of events in plaque formation is as follows;

l. The endothelial cells lining the inside of the artery in some way become damaged. This could be mechanical damage caused by high blood pressure disrupting the endothelium, or biochemical damage to the cell membranes and receptors caused, for instance, by high blood carbon monoxide levels due to cigarette smoking, or to high blood glucose and ketone levels found in sugar diabetes, or even to high blood cholesterol levels in the form of LDLs.

2. Following endothelial cell damage, monocytes (white blood cells) stick to the endothelial cells and squeeze through into the underlying tissues. These monocytes are active macrophages and do two main things:

   (a) They take up large amounts of cholesterol from LDLs. (Remember that much of this can come from the capillary network that is within the arterial wall itself).

   (b) They secrete growth factors which stimulate adjacent smooth muscle cells in the tunica media to multiply by mitosis and also take up large amounts of cholesterol from LDLs. The more cholesterol there is in the blood, the faster the plaque develops.

3. The cells containing accumulated cholesterol are called **foam cells** and give the plaque the appearance of pearly gray or yellow mounds in the arterial walls. The plaque is made larger by the migration of newly formed smooth muscle cells into it.

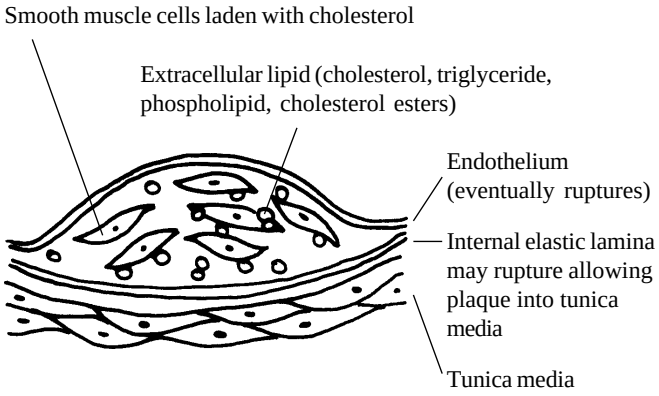
4. The protruding surface of the plaque has a roughened surface often containing collagen fibres. Platelets will stick to this and rupture causing two effects:

   (a) The platelets release a hormone called platelet derived growth factor (PDGF) which together with similar growth factors released from the macrophages and damaged endothelial cells cause the plaque to grow larger due to more proliferation of smooth muscle cells and cholesterol uptake. Eventually the arterial lumen may become completely blocked.

   (b) The ruptured platelets release clotting factors, which may, if in high enough concentration, initiate the clotting cascade forming a clot (thrombus) over the plaque surface. If this breaks off (an embolus) it may block a narrower artery further along the system, again contributing to myocardial infarction.

The structure of an atheromatous plaque is shown in Fig 3. The heart can continue working providing only small areas suffer myocardial infarction. Death of large amounts of cardiac muscle will result in the death of the individual due to heart failure.

Fig 3. Structure of an atheromatous plaque



Causes of CHD
The precise causes of coronary heart disease are unknown. However, several predisposing factors have been identified (Fig 4).

Fig 4. Predisposing factors