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HUMAN PERFORMANCE AND LIMITATIONS

CHAPTER 4 – THE HEART

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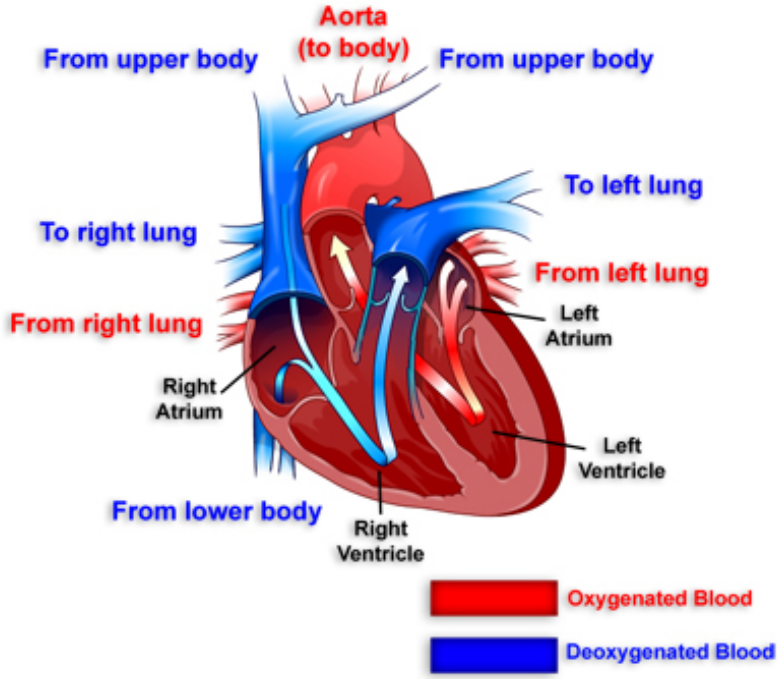
THE HEART

4.1 Introduction

The heart is a double-action muscular pump – its job is to pump blood to the lungs and around the body. The heart is about the size of our closed fist and is divided into two sides, (naturally enough the left and right), each with two chambers (atrium and ventricle.)



While the circulation is continuous, and there is no real start and finish to the circulation process, for simplicity we can consider the start of the circulation process as beginning when rich, oxygenated blood is pumped out of the left ventricle, upwards through the aorta and then on to all parts of the body via a system of arteries. As the blood traverses all areas of the body, it delivers oxygen to, and collects carbon dioxide from body cells. The de-oxygenated blood then returns via a system of veins to the right atrium of the heart. In a part of the heart's contraction, the returned blood is transferred to the right ventricle and on to the lung.

In the lung, carbon dioxide is exchanged for oxygen and the now oxygenated blood returns to the left atrium of the heart. During the next contraction, the oxygenated blood is transferred to the left ventricle and the process starts over again.

This circulatory system is called the *cardiovascular* system.

The heart is a hard-working organ. It needs its own supply of oxygenated blood which is delivered via a system of cardiac arteries leading off the aorta. Any shortage of blood to the heart will cause problems.

When dealing with the health of the heart, we will be looking at four aspects:

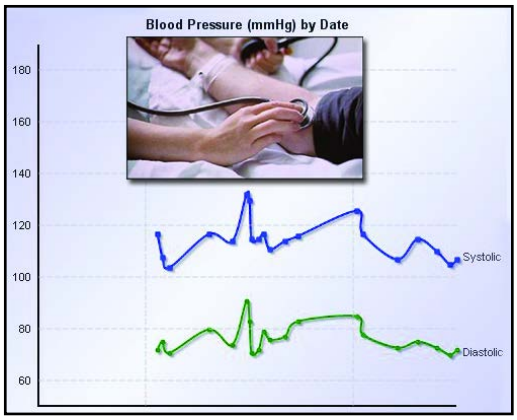
- Hypotension
- Hypertension
- Coronary artery disease
- Coronary thrombosis.

4.2 Electrocardiograph

The electrocardiograph measures electrical activity of the heart and graphs this electrical activity on paper. Electrodes are placed on various locations on the chest and back to measure this activity. While the test has some limitations, it gives the doctor an indication of any abnormal activity of the heart. Of particular benefit is the 'stress' or 'exercise' ECG, where the subject is required to undertake some strenuous activity during the test. This measures the heart activity under load and gives a better indication of any artery blockage.

4.3 Hypotension

In an otherwise healthy individual, low **blood pressure** is not really a recognised disease entity as with high blood pressure. People with blood pressure lower than the "normal" mean value of 120/80 mmHg can usually function completely normally provided their blood pressure is at or above 100/60 mmHg. There are also no long-term adverse effects of low blood pressure as are associated with high blood pressure.



Blood Pressure

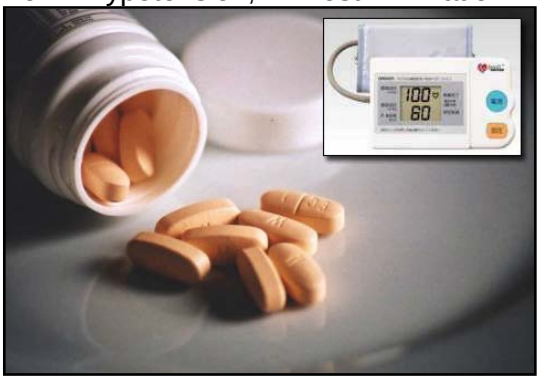
Blood pressure is the force the blood exerts against the inside walls of the blood vessels.

High blood pressure (or hypertension) can lead to a number of health problems, including coronary artery disease, strokes and diabetes. Consequently, monitoring of blood pressure may provide a warning of potential danger. The heart is a muscular pump, but it does not pump at a constant pressure. Higher pressure occurs during the period when the heart muscles are contracting (known as the ***systolic*** pressure) and after each contraction, the pressure drops when the heart chambers relax and refill with blood (the ***diastolic*** pressure). Even though the heart has relaxed, there is a residual level of pressure remaining in the blood vessels of the body.

Pressures are measured in millimetres of mercury, being the height of a column of mercury that the pressure of blood can support. The normal range of pressures varies with age, time of day and other factors, but the typical pressures for a healthy young person would be a systolic pressure of 120 mm Hg and a diastolic pressure of 70 mm Hg. This is recorded simply as 120/70.

The importance of low blood pressure in flying is that the person's g-tolerance is dramatically reduced. For instance, a person with normal blood pressure might have a g-tolerance of +5, while a person with a blood pressure of 100/60 mmHg (i.e. lower than normal) may have a g-tolerance of only +2.

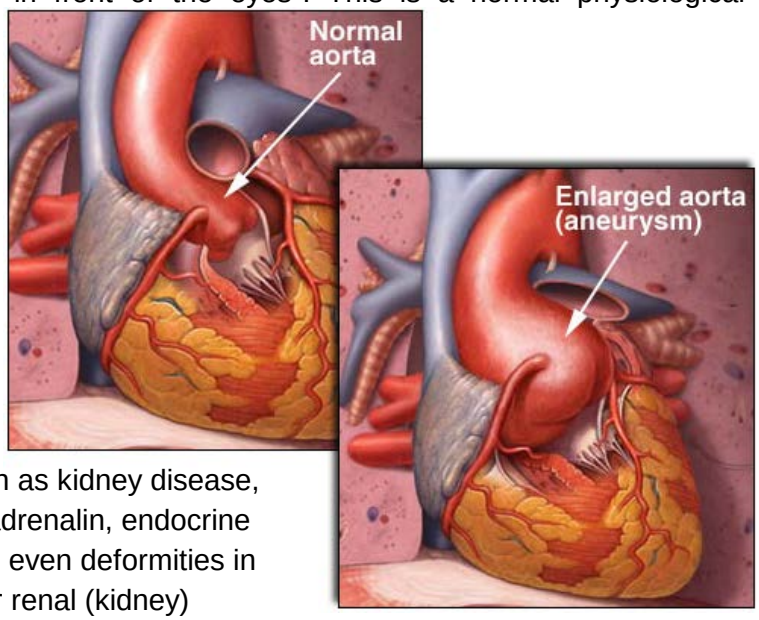
While there are no specific standards for hypotension, most Aviation Medical Examiners would be reluctant to medically certify a pilot with a blood pressure below 100/60 mmHg, especially if the flying involves activities where significant +g's are likely to be encountered (e.g. military flying, crop spraying, aerobatics).



Most people with low blood pressure are not treated unless they have symptoms (fainting spells, light headedness, dizziness and "spots in front of the eyes"). The medication given for low blood pressure raises the blood pressure only while the medication is being used, and the blood pressure drops to its initial value as soon as the medication is discontinued. The medication is not cleared for use by aircrew, so the person who needs medication, or is on medication for low blood pressure, will not be medically certified.

Postural hypotension is a related condition where the blood pressure drops for a short time following a change of posture from lying or sitting, to standing. It usually occurs as result of disease (e.g. diabetes) or due to certain medication, but can occur in a small percentage of otherwise healthy people. Medical certification of applicants with postural hypotension is done on an individualised basis.

Physiological postural hypotension occurs in normal people when they are lying down in a very hot environment (e.g. a hot bath), which causes the blood vessels in the skin and soft tissues to dilate and some blood to be distributed out of the main arteries into the skin and soft tissues. When the person suddenly comes upright, the blood pressure to the brain drops momentarily while the body takes some time to contract all the peripheral blood vessels to "get the blood back" from the skin and soft tissues into the main circulation, causing dizziness, light-headedness and "spots in front of the eyes". This is a normal physiological phenomenon, and in an otherwise healthy individual, will have no effect on medical certification.



4.4 Hypertension

Hypertension is a medical condition, which may be caused by several diseases, such as kidney disease, tumours, which secrete adrenalin, endocrine (glandular) disorders and even deformities in the Aorta (main artery) or renal (kidney) arteries.

When hypertension is suspected, the patient must be examined to exclude an underlying cause. In about 90% of patients, however, no underlying cause will be found, in which case it is called **essential hypertension**.

Because the blood pressure varies throughout the day and because a stressful situation can cause the blood pressure to rise, the diagnosis of hypertension is not made unless at least 3 readings (preferably on different days) are above 150/95 mmHg. A very useful alternative is ambulatory blood pressure monitoring, where the person wears a portable device, which logs the blood pressure every 15 minutes for 24 hours, while going about a normal daily routine.

The cut-off figure for the diagnosis of Hypertension varies somewhat from place to place, some starting at 140/90 mmHg, and some as high as 160/100 mmHg. In a pilot, it is often prudent to start treatment slightly below 150/95 mmHg, as according to Aviation Legislation, the pilot must be grounded if blood pressure exceeds 150/95 mmHg.

There are so called stressors that can affect an individual and form part of the **Social Readjustment Rating Scale of Holmes & Holmes**. If an individual has for example a pregnancy at home and trouble with the in-laws, one would add both these values on the scale and be left with a value of 69. It has been shown that the risk of disease for a score of above 300, is almost 80%, this includes hypertension.

SOCIAL READJUSTMENT RATING SCALE*

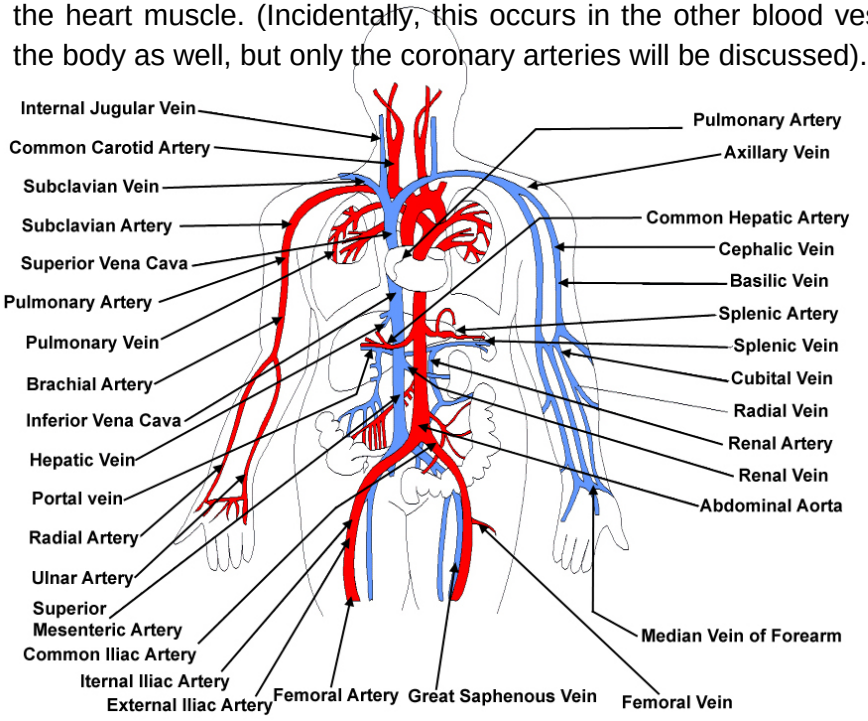
LIFE EVENT	LIFE-CHANGE UNIT
Death of one's spouse	100
Divorce	73
Marital Separation	65
Jail Term	63
Death of a Close Family Member	63
Personal Injury or Illness	53
Marriage	50
Being Fired	47
Retirement	45
Pregnancy	40
Change in One's Financial State	38
More Arguments with One's Spouse	35
Change in Responsibilities at Work	29
Son or Daughter Leaving Home	29
Trouble with In-Laws	29
Beginning or Ending School	26
Change in Living Conditions	25
Trouble with One's Boss	23
Change in Work Hours or Conditions	20
Change in Eating Habits	15
Vacation	13
Christmas	12

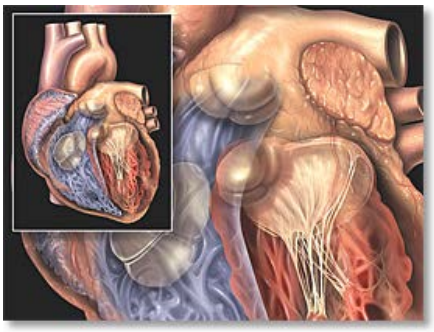
In pilots with an underlying disease, this disease will largely determine whether they will be medically certified. Once it has been established that the person has essential hypertension, and the blood pressure is controlled and stabilised with medication (most of the modern anti-hypertension medications are cleared for air crew) the pilot can be re-certified, usually only with the restriction that he/she must undergo an annual stress ECG.

Hypertension is dangerous because it generally gives no symptoms, but can lead to an incapacitating event like a stroke. In the long term, uncontrolled hypertension causes kidney damage, eye damage and enlargement of the heart - to name but a few. It is also one of the most important treatable risk factors for a heart attack. Early detection and treatment of hypertension during flight medicals play a very significant role in reducing cardiovascular diseases and deaths amongst aircrew.

4.5 Coronary Artery Disease

Coronary artery disease is the broad term used to describe unwanted changes in the coronary arteries (the arteries which supply the heart muscle with blood). These changes are usually in the form of narrowing due to deposition of plaques on the inner surfaces of the coronary arteries, causing a reduction in blood flow to the heart muscle. (Incidentally, this occurs in the other blood vessels throughout the body as well, but only the coronary arteries will be discussed).





Decreased blood flow to the heart muscle, especially when the heart is working harder (e.g. during exercise) causes chest pain (called angina), and the person is said to have ischeamic heart disease (ischeamic = "not enough blood").

Angina Pectoris

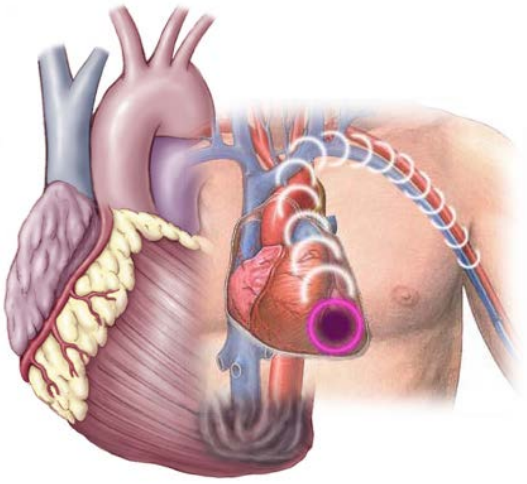
Angina Pectoris (or simply, **Angina**) occurs when there is a partial blockage of the heart's arteries caused by fatty deposits forming inside those arteries (atherosclerosis). The heart is a hard working pump and requires its own blood supply. Any partial blockage of these arteries results in a reduced blood flow to regions of the heart, so depriving that part of the heart of required blood and oxygen.

When demand is increased (often through exertion or exercise) the area of the heart deprived of blood goes into stress and pain is felt in the chest, neck, shoulders and arm (especially on the left side of the body). This pain will usually subside when exertion stops and the body is rested. Angina should be regarded as a critical warning sign of a major problem and should not be ignored. For any chest pain or discomfort, medical advice should be sought immediately. Prompt medical attention often results in successful treatment and the retention of a full aviation fitness capability. Nothing is gained from ignoring chest pain. To do so could be fatal.

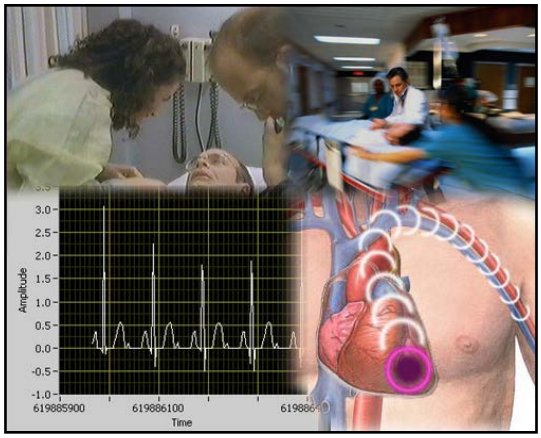
Angina, to fit its definition, must be less than 20 minutes in duration.

If, however the blood supply to a portion of the heart is cut off completely by:

- A blood clot forming on the plaque (coronary thrombosis)
- A piece of plaque breaking off and lodging in a narrowed section (coronary embolism)
- Spasm of a narrowed coronary artery (coronary artery spasm).



The portion of the heart which receives its blood supply from that particular coronary artery (or branch) will begin to die. If the blood flow is not restored very quickly, that portion of the heart will die permanently, and the patient has had a myocardial infarction or "heart attack".



4.5.1 Symptoms

The principal symptom of a myocardial infraction is severe angina-like chest pain, lasting longer than 20 minutes.

Additionally:

- The patient may be short of breath.
- The patient may be cold, clammy and pale.
- The patient may lose consciousness or die suddenly.

4.5.2 First Aid Treatment

- Give ½ an aspirin tablet immediately. (The dosage and immediacy are important, as this can often prevent the heart attack from completing its course. Giving too much aspirin will actually reduce the effectiveness of this measure!)
- If the patient is on angina medication, administer the angina medication until the chest pain is relieved or the maximum dosage according to the package insert is reached.

- Lay the patient on his/her back.
- Administer oxygen.
- Administer CPR (cardio pulmonary resuscitation), which may be required if the heart stops beating or the patient stops breathing.
- Get the patient to a suitably equipped emergency medical facility as soon as possible.
- Put up a drip and administer intravenous B-Blockers (e.g. Tenormin) and/or Nitrates and Morphine (only if a doctor is available).

4.5.3 Risk Factors

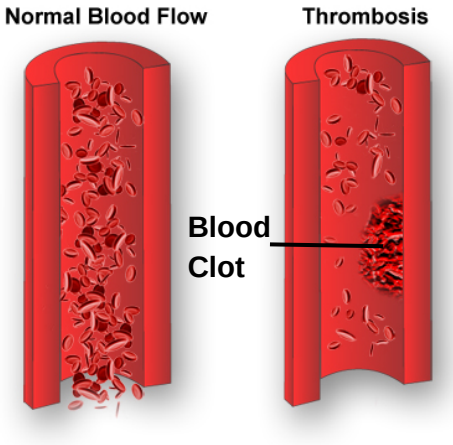
Some risk factors for the development of a heart attack are **not reversible** (e.g. positive family history or male gender), but many risk factors are reversible, risks include:

- **Family history of heart disease**
- Hypertension
- Obesity
- Lack of exercise

- **Male gender**
- High low-density Lipoprotein
- High total cholesterol
- Low high-density Lipoprotein
- **Cigarette smoking**
- Excess alcohol consumption
- Dietary deficiencies
- Diabetes
- High blood pressure (hypertension)
- Severe obesity (>30% overweight)
- Presence of arteriosclerosis.

Note: A pilot will not be re-certified if any of these reversible risk factors are still present.

4.6 Coronary Thrombosis



A 'thrombus' is a blood clot formed in an unbroken blood vessel. Typically they originate in the deep veins of the legs. If the clot moves through the blood vessels it may become trapped by narrowing vessels and cause a blockage, or 'occlusion'. The blockage could occur in critical areas such as the blood vessels of the lungs, in the coronary blood vessels, or in the brain. The extent of trauma depends on the size of the region denied blood supply by the blockage. A thrombus may be fatal.

They may result from a number of causes, including hereditary deficiencies and sitting still for extended periods.