Cardiovascular drugs

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Learning objectives

After studying this chapter you should be able to:

- Briefly explain the epidemiology and aetiology of cardiovascular disease in the UK.
- Describe what is meant by atherosclerosis.
- Demonstrate an understanding of the role of cholesterol in the body.
- List the principal drug categories used in lowering cholesterol levels.
- Describe what is meant by the term ‘angina’.
- Outline how nitrate drugs affect the body.
- Explain electrical conduction through the heart.
- Review the physiology of cardiac muscle contraction.
- Describe the terms ‘paroxysmal’, ‘supraventricular’, ‘tachycardia’ and ‘atrial fibrillation’.
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- Compare and contrast the modes of action between different drug classifications used in the treatment of arrhythmias.
- Outline the drugs used in cardiopulmonary resuscitation.
- Demonstrate what you understand about the condition Wolff-Parkinson-White syndrome.
- Use basic maths to calculate simple drug dosages.

Introduction

Cardiovascular disease (CVD) causes more deaths in the UK each year than any other single disease or condition. According to the British Heart Foundation (2011) CVD costs the National Health Service (NHS) nearly £15 billion annually. Coronary heart disease (CHD) is preventable and yet was the cause of 18 per cent of male and 12 per cent of female deaths in 2009. Between 110,000 and 300,000 people have a heart attack each year.

The problem of CHD does not stop with the death rate but includes the symptoms of angina. Angina is chest pain or discomfort that occurs when an area of the heart muscle does not receive enough oxygen-rich blood. It may feel like pressure or squeezing in the chest and/or like indigestion. The pain may also occur in the shoulders, arms, neck, jaw or back. Angina affects about 1 in 50 people, and in the UK there are between 1.2 and 2 million sufferers (British Heart Foundation 2011). It affects men more than women, and your chances of suffering from angina increase as you get older. The pain resulting from angina and the consequent restriction on lifestyle causes a great reduction in quality of life.

Senior (2010) suggests that the stereotypical view that we tend to have of heart disease is that it affects middle-aged men. Women are thought to be much less likely to have a heart attack and it is therefore a sobering fact that three times as many women die of heart disease than of breast cancer each year in the UK. Although the female hormones do provide some protection against heart disease before the menopause, the growing impact of risk factors such as an unhealthy diet, smoking and taking too little exercise means that a higher proportion of younger women are now succumbing to heart disease. Following the menopause, the lack of oestrogen – and therefore the loss of its protective benefits – increases a woman’s risk of CVD to the same level as a man’s.

Senior goes on to highlight that although younger people are now developing chronic heart disease earlier in life, the UK figures for congenital heart disease show that fewer than 5000 babies born in any one year suffer a problem with their heart, such as a hole in the heart. Surgical treatments for congenital heart problems are very advanced in the UK and survival rates are high.

The underlying cause of heart disease in the UK is lifestyle. We just do not live healthy lives. Many people in the UK are overweight – around 43 per cent of adult men and 32 per cent of adult women. Worse still, 30 per cent of children are overweight and experts predict that heart disease in the future will continue to rise. Younger people now have the same sorts of problems with their cardiovascular system as middle-aged people did a few years ago.

The number of people who have other risk factors for heart disease is also high: 6 out of 10 people over 18 in the UK have high cholesterol, approximately 30 per cent of all adults have high blood pressure and far less than half of all adults take enough exercise. Smoking continues to be a habit which kills 25,000 people every year because of the impact it has on the cardiovascular system. Most of these deaths could have been prevented.

Most nurses will care for a person suffering from heart disease of some form, and therefore it is of great importance that we understand the medicines they take in order to afford them the best quality care.
Atherosclerosis

Atheroma is the root cause of cardiovascular diseases such as angina and heart attack. However, before we delve into the pathophysiology of this type of disease we need to revisit the anatomy and physiology of the blood vessels.

The walls of all blood vessels, apart from capillaries, have the same basic layers or ‘tunics’. The outermost layer is called the tunica adventitia and is composed of fibrous connective tissue. The middle layer is known as the tunica media and is made up predominantly of smooth muscle. Finally the inner layer is referred to as the tunica intima and comprises flattened epithelial cells. This inner layer of the vessel is also referred to as the endothelium. The endothelium works to keep the inside of arteries toned and smooth, which keeps blood flowing.

Atherosclerosis is a degenerative disease that results in narrowing of the arteries. It is caused by fatty deposits, most notably cholesterol, on the interior walls of the coronary arteries. When the walls become narrowed or occluded, the blood flow through the artery is reduced (see Figure 1.1). When this occurs in the coronary arteries the blood flow to the heart muscle is reduced. If the artery remains open to some degree, the reduced blood flow is noticed during periods of rapid heartbeat. The resulting pain is called angina. When the artery is completely closed or occluded, a section of the heart muscle can no longer get oxygenated blood, and begins to die. This is called a heart attack or myocardial infarction. Only quickly restoring the blood flow can reduce the amount of heart muscle that will die.

Cholesterol

Cholesterol is a waxy, fat-like (lipid) substance that is found in all cells of the body. In addition to being a structural component of cell membranes, cholesterol also plays an important role in making hormones, vitamin D and bile acids that aid in the digestion of foods. Cholesterol itself is not harmful, but too much cholesterol in the blood, or high blood cholesterol, can be dangerous. Blood is watery, and cholesterol is fatty. Just like oil and water, the two do not mix. To travel in the bloodstream, cholesterol is carried in small packages called lipoproteins. There are two kinds of lipoprotein that carry cholesterol throughout the body: low-density lipoprotein (LDL) and high-density lipoprotein (HDL).

- LDL is the main cholesterol transporter and carries cholesterol from your liver to the cells that need it. If there is too much cholesterol for the cells to use, this can cause a harmful build-up in your blood. Too much LDL cholesterol in the blood can cause cholesterol to build up in the artery walls, leading to disease of the arteries. For this reason, LDL cholesterol is known as ‘bad cholesterol’, and lower levels are preferable.
- HDL carries cholesterol away from the cells and back to the liver, where it is either broken down or passed from the body as a waste product. For this reason, it is referred to as ‘good cholesterol’, and higher levels are preferable.

The amount of cholesterol in the blood (including both LDL and HDL) can be measured with a blood test.

Normal cholesterol level

Blood cholesterol is measured in units called millimoles per litre of blood, often shortened to mmol/L. The Department of Health (DH) recommends that cholesterol levels should be less than 5mmol/L. In the UK, two out of three adults have a total cholesterol level of 5mmol/L or above. On
average, men in England have a cholesterol level of 5.5mmol/L and women have a level of 5.6mmol/L. The UK population has one of the highest average cholesterol concentrations in the world.

Diets that are high in saturated fats and cholesterol raise the levels of LDL cholesterol in the blood. Fats are classified as ‘saturated’ or ‘unsaturated’ according to their chemical structure. Saturated fats are derived primarily from meat and dairy products and can raise blood cholesterol levels. Some vegetable oils made from coconut, palm and cocoa are also high in saturated fats.

Lowering LDL cholesterol is currently the primary focus in preventing atherosclerosis and heart attacks. Lowering LDL involves losing excess weight, exercising regularly and following a diet that is low in saturated fat and cholesterol. Medications are prescribed when lifestyle changes cannot reduce the LDL cholesterol to desired levels. The most effective and widely used medications to lower LDL cholesterol are called statins.

Lipid regulating drugs

Lowering the amount of LDLS and raising the levels of HDLs slows the progression of atherosclerosis and may even cause a reduction in its formation. However, before medication is considered in people who are deemed to be at high risk of cardiovascular disease, changes in lifestyle should be advised. These lifestyle changes include changes to the diet, particularly in terms of fat and salt content. An increase in exercise is an important step and many GPs work with local councils in offering exercise regimes for free, or at a reduced fee, to encourage participation. Smoking and alcohol consumption are further areas of lifestyle that require modification in order for the individual to lower their chances of developing cardiovascular disease.

Statins

Statins lower the level of cholesterol in the blood by reducing the production of cholesterol by the liver. Statins block the enzyme in the liver that is responsible for making cholesterol. This enzyme is called hydroxy-methylglutaryl-coenzyme A reductase (HMG-CoA reductase). Scientifically, statins are referred to as ‘HMG-CoA reductase inhibitors’ and you should be aware that some pharmacology texts index this class of drug under this name rather than an index heading of ‘statins’.

This class of drug reduces the risk of cardiovascular disease, irrespective of the cholesterol content of the blood. This makes statins the drug of first choice for primary and secondary prevention of cardiovascular disease. By ‘primary prevention’ we mean they help prevent significant build-up of atheroma so that cardiovascular disease can be avoided. Secondary prevention relates to a reduction in cardiovascular disease once the person has already been diagnosed or had an ‘event’, such as angina or myocardial infarction.

Most individuals are placed on statins because of high levels of cholesterol. Though reduction of cholesterol is important, heart disease is complex. Thirty-five per cent of individuals who develop heart attacks do not have high blood cholesterol levels, yet most of them have atherosclerosis. This means that high levels of cholesterol are not always necessary for atherosclerotic deposits or plaques to form.

Because it is not clear which effect of statins is responsible for their benefits, the goal of treatment with this drug should not only be the reduction of cholesterol to normal levels, but also the prevention of the complications of atherosclerosis (angina, heart attacks, stroke, intermittent claudication and death). This is important because it allows for individuals who have, or are at risk of, atherosclerosis but who do not have high levels of cholesterol, to be considered for treatment with statins.

Statins are usually well absorbed, given orally and prescribed last thing before going to bed. One of the most obvious differences between different statins is the ability to reduce cholesterol. Currently, atorvastatin (Lipitor) and rosuvastatin (Crestor) are the most potent, and fluvastatin (Lescol) is the least potent.
The statins also differ in how strongly they interact with other drugs. Specifically, pravastatin (Pravachol) and rosuvastatin (Crestor) levels in the body are less likely to be elevated by other drugs that may be taken at the same time as statins. This is so because the enzymes in the liver that eliminate pravastatin and rosuvastatin are not blocked by many of the drugs that block the enzymes that eliminate other statins. This is referred to in technical terms as ‘enzyme inhibition’ and is discussed in Chapter 2 of Essentials of Pharmacology for Nurses (Barber and Robertson 2012). This in turn prevents the levels of pravastatin and rosuvastatin from rising and leading to increased toxicity which results in myopathy (inflammation of the muscles).

The most serious (but fortunately rare) side-effects of statins are liver failure and rhabdomyolysis. Rhabdomyolysis is a serious side-effect in which there is damage to the muscles and involves the breakdown of muscle fibres, resulting in the release of myoglobins into the bloodstream, some of which are harmful to the kidneys and frequently result in damage to those organs. Rhabdomyolysis often begins as muscle pain and can progress to loss of muscle cells, kidney failure and death. It occurs more often when statins are used in combination with other drugs that themselves cause rhabdomyolysis such as selective serotonin re-uptake inhibitors (SSRIs), or with drugs that prevent the elimination of statins and raise the levels of statins in the blood.

Clinical tip
Since rhabdomyolysis may be fatal, unexplained joint or muscle pain that occurs while taking statins should be taken seriously by the nurse, documented and passed on to the doctor for evaluation. Statins must not be used during pregnancy because of the risk of serious adverse effects to the developing foetus.

Since the primary effects of statins are on the liver it is clear that any problems with the liver would cause concern when prescribing such medicines. Indeed, statins should be used with caution in those with liver disease or with a high alcohol intake. The National Institute for Health and Clinical Excellence (NICE) guideline 67 suggests that liver enzymes should be measured before treatment and that measurement should be repeated within 3 months and at the end of 12 months after starting treatment.

Fibrates
Fibrates are a class of medication that lowers blood triglyceride levels by reducing the production in the liver of very low density lipoproteins (VLDLs) (the triglyceride-carrying particles that circulate in the blood) and by speeding up the removal of triglycerides from the blood. Raised levels of triglycerides are often part of what is known as ‘metabolic syndrome’, a condition that increases the risk of cardiovascular disease. A person with metabolic syndrome will have excess weight around the waist and at least two of the following:

- high blood pressure;
- raised levels of triglycerides;
- low levels of HDL cholesterol;
- abnormal fasting blood glucose.

However, researchers are increasingly recognizing that raised triglycerides can by themselves increase the risk of cardiovascular disease, even if cholesterol levels are normal.

Fibrates are also modestly effective in increasing blood HDL cholesterol levels; however, they are not effective in lowering LDL cholesterol. Examples of fibrates available in the UK include gemfibrozil (Lopid) and fenofibrate (Liptil).

Even though fibrates are not effective in lowering LDL cholesterol, when a high-risk patient also has high blood triglyceride or low HDL cholesterol levels doctors may consider combining a fibrate, such as fenofibrate (Liptil) with a statin. Such a combination will not only lower LDL cholesterol
but will also lower blood triglycerides and increase HDL cholesterol levels.

**Bile-acid binding resins**

Bile-acid binding resins, and similar agents including powders such as cholestyramine (Questran and Questran Light) and tablet preparations like colesevelam hydrochloride (Cholestagel) are able to lower LDL. As their name suggests, they work by binding to bile in the digestive tract. As part of normal digestion, the liver turns cholesterol into bile acids and these move into the intestines, where most of them are reabsorbed and returned to the liver. Bile-acid drugs bind to the bile acids as they move through the intestine so that the acids exit the body with the faeces, rather than re-entering the bloodstream. In response, the liver converts more cholesterol into bile acids and these, too, are cleared from the body in the faeces. The result is that LDL cholesterol is effectively removed from the liver and the blood.

When used with dietary control, bile-acid resins can reduce LDL levels by 15–20 per cent. When they are combined with nicotinic acid, LDL levels can drop by as much as 40–60 per cent. Colesevelam, a newer resin, appears to produce minimal gastrointestinal (GI) side-effects.

**Clinical tip**

Patients often experience constipation, heartburn, gas and other GI problems while taking a drug in this class and so it is important that you explain these potential side-effects to the patient prior to their commencing therapy. These symptoms can become so bothersome that the person may seek to change, or cease to take, their medication.

Over time, deficiencies of vitamins A, D, E, K and B9 (folic acid) may occur, and vitamin supplements may be necessary. If long-term use of bile-acid binding resins leads to depletion of vitamin K in the body, problems of bleeding may occur.

Rarely, toxic effects on the liver have been reported and therefore patients with liver disorders should always be monitored. Bile-acid binding resins may interfere with other medications, including digoxin, warfarin, beta-blocker drugs for high blood pressure (such as atenolol, metoprolol and propranolol), diuretics and sulfonylureas (such as glimepiride), used to treat diabetes. In order to prevent these adverse interactions, such medications should be taken one hour before, or four to six hours after, taking the bile-acid binding resin.

**Angina**

Angina (*angina pectoris*, Latin for ‘squeezing of the chest’) is discomfort that occurs when there is a decreased blood oxygen supply to an area of the heart muscle. In most cases, the lack of blood supply is due to a narrowing of the coronary arteries as a result of atherosclerosis.

Angina usually occurs during exertion, severe emotional stress or after a heavy meal. During these periods the heart muscle demands more blood oxygen than the narrowed coronary arteries can deliver. Angina typically lasts from 1 to 15 minutes and is classified as either stable or unstable.

Stable angina is the most common type, and what most people mean when they refer to ‘angina’. People with stable angina suffer angina symptoms on a regular basis and the symptoms are somewhat predictable (e.g. walking up a flight of steps causes chest pain). For most patients, symptoms occur during exertion and commonly last less than five minutes. They are relieved by rest or medication such as glyceryl trinitrate under the tongue (sublingual).

Unstable angina is now referred to as ‘acute coronary syndrome’ and is less common and more serious. The symptoms are more severe and less predictable and the pains are more frequent, last longer, occur at rest and are not relieved by glyceryl trinitrate. Unstable angina is not the same as a heart attack, but warrants an immediate visit to a GP or hospital emergency department as further cardiac testing is urgently needed. Unstable angina often precedes myocardial infarction.
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Glyceryl trinitrate
The first drug to be considered in the relief of angina is glyceryl trinitrate, more commonly known as GTN, which belongs to a group of drugs called nitrates that contain the chemical nitric oxide. This chemical is made naturally by the body and has the effect of making the veins and arteries relax and widen (dilate). As a result more oxygen can be carried in the blood and the heart does not have to work so hard to keep up with both the demands of the tissues and the resistance caused by the atheroma in the vessels.

Widening the veins also decreases the volume of blood that returns to the heart with each heartbeat (preload). This makes it easier for the heart to pump that blood out again. As a result of both of these actions, the heart does not need as much energy to pump the blood around the body and therefore needs less oxygen. GTN also widens the arteries within the heart itself, which increases the blood and oxygen supply to the heart muscle.

This drug can be prescribed in a variety of forms, including tablets and an oral spray. The tablets are designed to be slow release and dissolve under the tongue. They usually come in a dose of 300mcg per tablet. The spray is also applied under the tongue, as this area is highly vascular, meaning that there is a plentiful supply of blood vessels that can absorb the medication. The spray gives a dose of 400mcg per dose. This drug is ingested sublingually because if it were swallowed it would be absorbed by blood vessels that go straight to the liver. This drug is broken down very rapidly by the liver (the ‘first pass’ effect) and as a result, following the first pass through the liver there would not be enough active drug remaining to be of any use in preventing the episode of angina.

The drug effect starts rapidly, usually within one minute of administration and lasts between 15 and 30 minutes. Patients often have a choice of which preparation they prefer and the drug can be taken on an ‘as required’ basis, which benefits the patient if they anticipate doing any exercise or activity that will put additional pressure and workload on the heart.

As GTN is absorbed well by the skin it is also available in transdermal patches — medicated adhesive pads that are placed on the skin to deliver a time-release dose of medication into the bloodstream. Therapeutic levels of the drug are achieved in approximately 1 hour and last for a period of 24 hours.

Clinical tip
One of the problems with using GTN tablets is that once a bottle has been opened the drug effects start to deteriorate (short shelf life). Therefore it is important that the patient does not hoard the drug over a period of time, as it will become ineffective. Spray preparations overcome this problem and are therefore gaining in popularity.

Clinical tip
Using transdermal patches safely and effectively

DO NOT

- Shave the area.
- Apply a new patch without first removing the previously applied patch.
- Get any medication on your hands or touch the adhesive surface of the patch.
- Apply a patch to damaged or irritated skin or to an area with skin folds or scars.
- Apply a patch below your patient’s elbows or knees.
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\textbf{DO}
- Take your patient's vital signs and check other assessment parameters, as indicated, such as pain scoring.
- Explain to your patient that the patch contains a medication. Tell them about the drug, its purpose and possible adverse effects.
- Check any expiry date to ensure the patch is within date.
- Wash your hands and put on gloves.
- Select a clean, dry area of skin such as the upper chest. Clip body hair, if necessary.
- Clean the selected area according to the manufacturer’s directions.
- Remove the patch from its protective covering. Without touching the adhesive, remove the clear plastic backing.
- Use your palm to apply the patch and press firmly for about 10 seconds. Check that the patch adheres well, especially around the edges. Write the date, the time and the site used in the patient's records.
- Remove the patch for a few hours in every 24 to avoid the patient building up a tolerance to glyceryl trinitrate.
- Remove the used patch and dispose of it safely—it contains residual medication that could harm others, particularly children or pets.
- Reapply the transdermal patch at the correct time to ensure the appropriate medication effect. To avoid irritating the patient's skin, rotate application sites, using the corresponding site on the opposite side of the patient’s body. Try not to use the same site more than once a week, if possible.

The intravenous (IV) form of GTN is more effective than the sublingual form in controlling arrhythmias arising during acute ischaemic episodes because of prompt delivery of the drug to the coronary circulation where vasodilation occurs. In addition, the ability to control the quantity and rate of drug delivery with an IV infusion offers distinct advantages in cases of coronary spasm occurring during situations such as coronary arteriography where it can be administered with careful electrocardiographic and haemodynamic monitoring.

\textbf{Clinical tip}
GTN is best administered from a glass container and given via a polyethylene giving set.

\textbf{Clinical tip}
It is important to remember that when giving this drug as an infusion you use a syringe pump.

GTN can interact with certain polyvinylchloride (PVC) containers and giving sets. It is not compatible with PVC and severe losses of GTN (up to 50 per cent) may occur if PVC is used, resulting in a reduction of delivered dose and efficacy. Contact of the solution with PVC bags should therefore be avoided.

\textbf{Isosorbide mononitrate and dinitrate}
These are both nitrate drugs and their mode of action is the same as that of GTN, but they have a longer period of action. They are taken in order to prevent, or at least reduce, the occurrence of angina. These drugs will not be effective in a person who is having an angina attack. Side-effects are similar to those of GTN. Isosorbide mononitrate can cause severe headaches, especially when the
Patient first starts taking the drug. However, these may gradually become less severe over time.

**Clinical tip**

In the case of headache, the patient should be informed not to stop taking isosorbide mononitrate and to ask a doctor before using any headache pain medication.

Isosorbide dinitrate should not be prescribed if the patient is taking sildenafil (Viagra) as serious, life-threatening side-effects can occur. This is because Viagra can potentiate the vasodilatory effect of isosorbide mononitrate with the potential result of serious syncope (transient loss of consciousness due to a sudden fall in blood pressure) or myocardial infarction.

This medication should not be used if the patient is allergic to isosorbide dinitrate, isosorbide mononitrate (Imdur, ISMO, Monoket) or nitroglycerin, or if there are early signs of a myocardial infarction such as chest pain or ‘heavy feeling’, pain spreading to the arm or shoulder, nausea, sweating or a general ill feeling.

Tolerance is an issue with nitrate-based drugs and means that following repeated ingestion of a drug the effect produced by the original dose no longer occurs. As a result the dose has to be continually increased to obtain the desired response. It is well documented that people build up a tolerance to this group of drugs and it is therefore important that patients receive a ‘nitrate-free period’ where the levels of nitrate in the bloodstream are allowed to fall. Such a period should occur every 24 hours.

Finally, you will not find isosorbide dinitrate being used in children as its safety and effectiveness have not been confirmed.

**Clinical tip**

If a patient has a transdermal patch, advise them to remove it for a six-hour period every day. If a patient is taking three doses of the drug daily it is important to tell them to take the evening tablet at teatime rather than before going to bed.
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The next group of drugs is those used when the heart has been damaged and, as a result, the rhythm of the organ has been altered. This group, not surprisingly, is called anti-arrhythmic medicines. First, however, it is important to remind ourselves about the processes involved in the contraction of the heart muscle and the electrical conduction through the heart, as a number of anti-arrhythmic medicines act on these.

Electrical conduction through the heart

The heart is a muscle with a special electrical conduction system. The system is made up of two nodes (special conduction cells) and a series of conduction fibres or bundles (pathways).

The normal heart begins with an electrical impulse from the sinoatrial (SA) node, located high in the right atrium (number 1 in Figure 1.2). The SA node is the pacemaker of the normal heart, responsible for setting the rate and rhythm. The impulse spreads through the walls of the atria, causing them to contract. Next, the impulse moves through the atrioventricular (AV) node, a relay station (number 2), into the ‘bundle of His’ (number 3), continuing into conduction bundles (numbers 4 and 5) which are located in the ventricles themselves. As the impulse travels down the bundles, the ventricles contract. The cycle then repeats itself.

This regular cycle of atrial and ventricular contractions pumps blood effectively out of the heart. Problems may occur anywhere in the conduction system and interfere with effective pumping of blood. The heart may beat too fast (tachycardia), too slow (bradycardia) or irregularly. These abnormal beats are known as arrhythmias. Special studies of the heart’s electrical system may be needed to accurately diagnose the type and cause of the arrhythmia. Therapy for arrhythmias is based on their type and the difficulties they cause.

Contraction of cardiac muscle

To look at, cardiac muscle is similar to skeletal (striated) muscle. However, cardiac muscle differs from skeletal muscle in the membranes that separate each muscle. Cardiac muscles are separated by what are known as intercalated discs. The discs have a very low electrical resistance which means that the action potential, or wave of contraction, can spread throughout the cardiac muscle very easily. This means that the heart muscle can act as a functional whole as soon as it is excited. Given that the heart acts as a pump, this is of prime importance.

If you have read Chapter 3 of Essentials of Pharmacology for Nurses (Barber and Robertson 2012) on local anaesthetics and analgesics, you will appreciate the importance of understanding the movement of ions across membranes. This appreciation comes into play once again when discussing cardiac contraction. In order for the myocardium to contract, sodium must enter the muscle cell. This is known as Phase 0 of the action potential or depolarization (contraction). Phase 1 occurs next, where the movement of sodium ions into the muscle ceases and potassium ions start to move out. The heart muscle is getting ready to fire again (repolarization). Phase 2 is very important in terms of muscular contraction of the heart and is known as the plateau. In this phase the potassium
ions continue to move out of the muscle cell but this is counterbalanced by a slow inward movement of calcium ions. This phase helps with heart contraction by slowing the rate of repolarization. Phase 3 continues the further movement of potassium ions out of the cardiac muscle. Phase 4 is said to have been reached by the swapping of potassium and sodium across the membrane so that it is ready to receive another action potential and the cycle starts all over again (see Figure 1.3).

Figure 1.3 The phases of the action potential

Drugs used in heart arrhythmias
Anti-arrhythmic drugs can be grouped under three headings:

- drugs that act on supraventricular arrhythmias (originating above the ventricles);
- drugs that act on both supraventricular and ventricular arrhythmias;
- drugs that act on ventricular arrhythmias (originating in the ventricles).

Before we go on to consider these drugs in more detail it is worth noting that all anti-arrhythmic drugs have potentially serious side-effects. They may worsen or indeed cause life-threatening arrhythmias themselves. Close medical and nursing monitoring is therefore essential.

Paroxysmal supraventricular tachycardia
Paroxysmal supraventricular tachycardia is a regular, fast (160 to 220 beats per minute) heart rate that begins and ends suddenly and originates in heart tissue other than that of the ventricles. It is most common among young people, is more unpleasant than dangerous and may occur during vigorous exercise.

The fast heart rate may last from a few minutes to many hours. It is almost always experienced as an uncomfortable palpitation. It is often associated with other symptoms such as weakness, light-headedness, shortness of breath and chest pain. Usually, the heart is otherwise normal. The doctor confirms the diagnosis by doing an electrocardiogram (ECG).

Episodes of paroxysmal supraventricular tachycardia can often be prevented by one of several manoeuvres that stimulate the vagus nerve and thus decrease the heart rate. The heart rate decreases because the vagus nerve initiates a parasympathetic effect. These manoeuvres are usually conducted or supervised by a doctor, but people who repeatedly experience the arrhythmia often learn to perform them themselves. In practice you may see the doctor rubbing the neck just below the angle of the jaw; this stimulates a sensitive area on the carotid artery called the carotid sinus. This is a dilated area located at the junction where the carotid arteries split (bifurcate) and contains numerous baroreceptors that function in the control of blood pressure by influencing changes in the heart rate. If this is not effective, if the arrhythmia produces severe symptoms, or if the episode lasts more than 20 minutes, doctors can usually stop an episode promptly by giving an IV injection, usually of adenosine.

Adenosine
Adenosine is a compound that occurs naturally in all cells of the body. One of its properties is to slow down the electrical impulses through a specialized area of tissue in the heart – the AV node – in order to attempt to restore a normal heart rate and rhythm (sinus rhythm) when a person is having an episode of paroxysmal supraventricular tachycardia.

The drug is administered by rapid IV bolus injection and is intended for hospital use only, with monitoring and cardiorespiratory resuscitation equipment available for immediate use.
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Clinical tip
To be certain the solution reaches the systemic circulation the adenosine should be administered either directly into a vein or into an IV line. If administered via an IV line it should be injected as near as possible to the patient and followed by a rapid saline flush. The drug should only be used when facilities for cardiac monitoring exist.

An adult may receive an initial dose of 3mg given as a rapid IV injection over a two-second period. If the patient's heart rhythm does not respond then a second dose of 6mg should be given. If this is not successful then a third dose of 12mg can be considered. The drug can be used in children but, as you would expect, the dose is smaller: between 0.0375 and 0.25mg/kg.

Atrial fibrillation
Atrial fibrillation is a condition where the heart’s two upper chambers (the atria) beat chaotically and irregularly – out of coordination with the two lower chambers (the ventricles). Atrial fibrillation is an irregular and often rapid heart rate that commonly causes poor blood flow to the body and symptoms of heart palpitations, shortness of breath and weakness. It can also cause fatigue and stroke. This condition is often caused by changes in the heart that occur as a result of heart disease. Episodes of atrial fibrillation can come and go, or a patient may have chronic atrial fibrillation. If the latter is the case, because the atria are beating rapidly and irregularly, blood does not flow through them as quickly. This makes the blood more likely to clot. If the clot is pumped out of the heart it can travel to the brain (cerebral embolism), resulting in a stroke. People with atrial fibrillation are five to seven times more likely to have a stroke than the general population. Clots can also travel to other parts of the body (kidneys, heart, intestines), causing damage.

Atrial fibrillation can decrease the heart’s pumping ability (cardiac output) by as much as 20 to 25 per cent. Therefore this condition, combined with a fast heart rate over a long period of time, can result in heart failure. Chronic atrial fibrillation is associated with an increased risk of death.

Although atrial fibrillation itself isn’t usually life-threatening, it is a medical emergency. Treatment includes medication and other interventions in an attempt to alter the heart’s electrical system.

Digoxin
Digoxin is a cardiac glycoside extracted from the purple foxglove plant, digitalis. A group of pharmacologically active compounds is extracted from the plant’s leaves taken from the second year’s growth. Depending on the species, the digitalis plant may contain several deadly physiological and chemically-related cardiac and steroidal glycosides. Thus, digitalis has earned more sinister names: ‘Dead Man’s Bells’ and ‘Witches’ Gloves’.

The entire plant is toxic (including the roots and seeds), although the leaves of the upper stem are particularly potent, with just a nibble being enough to potentially cause death. Early symptoms of ingestion include nausea, vomiting, diarrhoea, abdominal pain, wild hallucinations, delirium and severe headache. Depending on the severity of the toxicosis the victim may later suffer irregular and slow pulse, tremors, various cerebral disturbances, especially of a visual nature (unusual colour visions with objects appearing yellowish, to green and blue halos around lights), convulsions and deadly disturbances of the heart.

Digoxin is widely used in the treatment of various heart conditions, namely atrial fibrillation, atrial flutter and congestive heart failure that cannot be controlled by other medication. Digoxin preparations are commonly marketed under the trade name Lanoxin. This medicine is highly potent and has a tendency to toxicity in the individual. It is therefore prescribed in micrograms and even then patients may suffer from toxic effects. You may find yourself being asked by a doctor to check digoxin levels in a patient’s plasma.
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The medicine works in two ways. Firstly, it causes a decrease of conduction of electrical impulses through the AV node. Secondly, it increases the force of contraction via inhibition of what is known as the sodium-potassium pump. This is rather like a revolving door in the wall of a cardiac cell which allows two molecules of potassium into the cell and removes three molecules of sodium. In so doing, it restores the chemical balance between the inside and outside of the cell so that it can contract again.

Digoxin inhibits this ‘revolving door’ mechanism which results in an increase in the level of sodium ions in the myocytes (cardiac muscle cells). However, the high level of sodium in the myocyte interferes with another ‘revolving door’. This door works between sodium and calcium, and its action is slowed down, which means that more calcium is retained by the myocyte. By increasing the amount of calcium in the myocyte, digoxin increases the contractility of the cardiac muscle. It also increases vagal activity via its central action on the central nervous system, thus decreasing the conduction of electrical impulses through the AV node.

Digoxin is usually given by mouth, but can also be given by IV injection in urgent situations (the injection should be delivered slowly with the heart rhythm being monitored). The half-life of the drug is about 36 hours. Digoxin is given once daily, usually in 125 or 250mcg amounts. In patients with decreased kidney function the half-life is considerably longer, calling for a reduction in dosing or a switch to a different glycoside (such as digitoxin, which although having a much longer elimination half-life of around seven days, is mainly eliminated from the body via the liver, and thus not affected by changes in renal function).

Effective plasma levels are fairly well defined, 1–2.6mmol/L. In suspected toxicity or ineffectiveness, digoxin levels should be monitored. Plasma potassium levels also need to be closely controlled as people with low potassium levels are more likely to have adverse effects. This is because digoxin and potassium compete for receptors in cardiac muscle tissue; thus if there is less potassium then more digoxin will bind to receptors, increasing the chance of toxicity.

Verapamil

This medicine belongs to a group of drugs known as calcium blockers (also known as calcium channel antagonists). Since calcium channels are especially concentrated in the SA and AV nodes, calcium blockers can be used to decrease impulse conduction through the AV node, thus protecting the ventricles from atrial tachyarrhythmias (fast heart rates).

Initially verapamil may be given by an IV route and, as with digoxin, the dose is given slowly. Generally, verapamil is given with heart and blood pressure monitoring over at least a two-minute period (at least three minutes in the elderly). The dosage is based on the patient’s age, medical condition, body size and response to therapy.

Clinical tip

It is very important that you check that the patient is not currently taking beta blockers as there is a risk of hypotension (low blood pressure) or, even worse, that the heart will stop (asystole) if verapamil is given in this case.

An oral dose of between 40 and 120mg daily is the commonest from of administration. Verapamil prolongs and intensifies the effects of alcohol in the body, therefore the patient should be advised to either avoid or very carefully limit alcoholic beverages when using this medication. Caution is advised when this drug is used in the elderly. It should be used only when clearly needed during pregnancy, and any patient should discuss the risks and benefits with their doctor. This drug is also excreted into breast milk and a decision should be made whether to stop the drug or avoid breast-feeding.
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Clinical tip

Verapamil may cause dizziness and light-headedness especially during the first few days, so it is advisable for patients to avoid activities requiring alertness. It is also important to inform patients that when sitting or lying down they should get up slowly, to allow their body to adjust and minimize any dizziness. The patient may also complain of weakness, fatigue, nausea, muscle cramps, headache, flushing or constipation. However, these effects should disappear as the body adjusts to the medication. If side-effects persist the patient should be advised to see their doctor without delay.

Drugs that act on both supraventricular and ventricular arrhythmias

There are many drugs that act on both supraventricular and ventricular arrhythmias. However, it is not the intention of this book to swamp you with information. Therefore we have made a decision to focus on three common drugs that you will come across in this group in your clinical practice.

Sotalol

The ‘olol’ suffix tells us that this drug comes from a group known as beta blockers. These drugs are used to slow the abnormally fast heart rate in certain arrhythmias, such as atrial fibrillation and atrial flutter. As discussed, these arrhythmias arise from the atrium (upper chambers of the heart) and usually cause the pulse to be rapid and irregular. In addition, beta blockers can prevent certain rhythms altogether, most notably supraventricular tachycardia, an arrhythmia associated with frequent rapid bursts of palpitations. Beta blockers have been shown to prevent arrhythmias that lead to sudden cardiac death. Sometimes, doctors combine beta blockers with other anti-arrhythmics for enhanced effects.

Sotalol is used to help prevent paroxysmal supraventricular arrhythmias. It also suppresses ventricular ectopics (an ectopic heartbeat is an irregularity of the heart rate and heart rhythm involving extra or skipped heartbeats). The medicine also suppresses ventricular tachycardia. This drug is unique in that it is the only beta blocker that substantially prolongs the heart contraction. This mechanism is not fully understood but is believed to be due to a slowing down of potassium ions leaving the cardiac muscle cell.

For acute arrhythmias 20–120mg sotalol can be given by IV; however, this needs to take place over a period of 10 minutes and the patient must have cardiac monitoring throughout. This injection can be repeated if necessary after a six-hour interval. More normally the drug is given orally, and initially the dose is 80mg divided into one or two doses in a 24-hour period. The dose may then be increased approximately every three days to a usual dose of 160–320mg daily, in two divided doses.

Although most patients are able to take beta blockers without difficulty, there are a number of side-effects. These drugs should be used cautiously if the patient has asthma, emphysema or other lung diseases because beta blockers can worsen the wheezing or airway obstruction seen in these disorders. There is a group of ‘selective’ beta blockers available that act on the heart much more strongly than on the lungs and these are useful when mild lung disease is present. Examples include metoprolol, bisoprolol and atenolol. However, sotalol comes under the category of non-cardioselective beta blocker.

A further important side-effect of beta blockers is impotence (or erectile dysfunction) in men. This is a fairly common problem, especially since most men who need beta blockers may already be prone to erectile dysfunction (because of the presence of chronic illnesses such as diabetes, hypertension and atherosclerosis). Beta blockers can also cause blood pressure to become too low, and indeed are used to treat patients suffering from hypertension.

In diabetes, it is possible that a beta blocker could make it harder to notice the symptoms of low blood sugar (see Chapter 8 of Essentials of Pharmacology for Nurses). Beta blockers can still be very
helpful for diabetics, but doctors recommend careful blood glucose monitoring. Finally, beta blockers may cause what we call ‘constitutional symptoms’, that is, feelings of fatigue, mild depression or lack of energy.

It is important to inform the patient of the need to discuss any side-effects with their doctor. It is always a case-by-case issue whether the benefits of a medicine outweigh the side-effects or risk.

**Amiodarone**

Amiodarone is used to correct abnormal rhythms of the heart. Although it has many side-effects, some of which are severe and potentially fatal, it has been successful in treating many arrhythmias where other anti-arrhythmic drugs have failed. Amiodarone is considered a ‘broad spectrum’ anti-arrhythmic medication, which means it has multiple and complex effects on the electrical activity of the heart which is responsible for the organ’s rhythm. Despite its multiple electrophysiological effects, it is generally relegated to a second-line drug because of the high incidence of side-effects and drug interactions. It should only be initiated under specialist supervision.

Amiodarone is sometimes used for ‘drug cardioversion’ of patients in atrial fibrillation, or more controversially to maintain sinus rhythm after cardioversion (where it is more effective than sotalol or propafenone). These techniques are used to return patients to a normal sinus rhythm. There are two types of cardioversion: drug cardioversion and electrical cardioversion. Drug cardioversion uses type 1 anti-arrhythmic medications such as amiodarone to correct irregular heartbeats to a normal rhythm and to slow an overactive heart. Electrical cardioversion (defibrillation) is the choice of most doctors. This technique delivers an electrical current to the heart through two metal plates (paddles) placed on the chest. The sudden burst of electricity through the heart converts the fibrillation back to normal sinus rhythm. Amiodarone is also used after adrenaline in current advanced life support protocols, in shock refractory pulseless ventricular tachycardia (VT) and ventricular fibrillation (VF).

Amiodarone has a structure similar to thyroxine (one of the major hormones produced by the thyroid gland), with high iodine content. It causes little or no myocardial suppression. Amiodarone is best absorbed with food, and is highly lipid soluble, taking many days to reach a steady state if given orally, as it is taken up and stored in adipose tissue, muscle, liver, lungs and skin – in other words, it has a large volume of distribution. IV amiodarone may work more quickly and is the usual route of administration in the acute hospital setting. This drug takes a very long time to be eliminated from the body, the half-life being 58 days. Electrophysiological studies will not usually be undertaken until amiodarone has been eliminated.

The drug works by slowing the heart rate and AV node conduction. The conduction through the AV node comes about as the drug interferes with movement through calcium channels and beta-receptor blockade. There is a slowing of intracardiac conduction as a result of the drug affecting the movement of sodium. Finally, the drug acts on potassium and sodium channels in the cardiac muscle making it more difficult for contraction to take place. In other words, it makes the heart muscle less ‘excitable’.

The dose of amiodarone administered is tailored to the individual and the arrhythmia that is being treated. An oral loading dose is typically 200mg, three times a day for one week, reduced to 200mg twice daily for a further week. A maintenance dose is then prescribed of 200mg daily or the minimum required for controlling the arrhythmia. The IV dose, administered in the coronary care setting initially, consists of 5mg for every kg of body weight, delivered over 20–120 minutes with cardiac monitoring. The drug in this case is administered via what is known as a central line. This is a catheter placed into a large vein in the body (e.g. the subclavian vein in the chest). It is used to administer medications or fluids and to obtain blood tests and cardiovascular measurements such as the central venous pressure. Certain medications, such as amiodarone, are preferably given through a central line.

Severe (sometimes fatal) lung or liver problems have infrequently occurred in patients using this
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drug. It is important that you inform the patient that if they experience any of the following serious side-effects they must seek medical advice as soon as possible: cough, fever, chills, chest pain, difficult or painful breathing, severe stomach pain, fatigue, yellowing eyes or skin, dark urine.

Like other medications used to treat irregular heartbeats, amiodarone can infrequently cause the condition to become worse, and, due to the lingering amount of this drug in the body, heartbeat problems may occur months after the patient has stopped taking the drug. Patients should therefore be advised to seek medical advice if their heart continues to pound, skips a beat, is beating very fast or very slowly, or they feel light-headed or faint.

This drug may also cause serious vision changes such as seeing halos and blurred vision. Very rarely, cases of permanent blindness have been reported. Again, patients should seek medical help if such symptoms present. Due to the iodine content of amiodarone, abnormalities in thyroid function are common. Both under- and overactivity of the thyroid may occur and measurement of free thyroxine (FT4) alone may be unreliable in detecting such problems. Therefore thyroid stimulating hormone levels should be checked every six months.

The pharmokinetics of numerous drugs, including many that are commonly administered to individuals with heart disease, are affected by amiodarone. For example, cyclosporine, flecainide, procainamide, quinidine and simvastatin This is because amiodarone inhibits the action of cytochrome P450, a liver enzyme that helps break down drugs. This means that the drugs take longer to be excreted from the body. As a result the drug could build up to levels that are toxic if given alongside amiodarone.

In particular, doses of digoxin should be halved in individuals taking amiodarone. Amiodarone also potentiates the action of warfarin. Individuals taking both of these medications should have their warfarin dose halved and their anticoagulation status (measured as the prothrombin time (PT) and International Normalized Ratio (INR)) measured more frequently. The effect of amiodarone in the warfarin concentration can be as early as a few days after initiation of treatment, or delayed by a few weeks.

Flecainide

Flecainide acetate is a type of medicine used to regulate the rate and rhythm of the heart. The heart’s pumping action is controlled by electrical signals that pass through the heart muscle. The electrical signals cause the two pairs of heart chambers (left and right atria and ventricles) to contract in a regular manner that produces the heartbeat. If the electrical activity in the heart is disturbed for any reason, irregular heartbeats (arrhythmias) of various types can result. These can seriously undermine the pumping action of the heart and result in inefficient blood circulation around the body. Flecainide helps to treat arrhythmias by decreasing the sensitivity of the heart muscle cells to electrical impulses. This slows and regulates the electrical conduction in the heart muscle, which helps to restore disturbances in the heart rhythm. There are several different types of arrhythmia. This medicine may be given in the form of tablets or injection, depending on which type of arrhythmia is being treated.

Flecainide infrequently produces very serious, new and irregular arrhythmias. Therefore, it should be used in carefully selected patients to treat life-threatening irregular heartbeats only. The oral dose will be initiated by the cardiologist and ventricular arrhythmias are initially treated with a dose of 100mg being given twice a day. After a period of three to five days the dose is lowered to the lowest to control the abnormal heart rhythm. Slow IV injection in hospital may be administered but this would only be carried out under cardiac monitoring and with resuscitation equipment at hand.

Drugs that act on ventricular arrhythmias

We will only consider one drug under this heading: lignocaine hydrochloride (see also Chapter 3 of Essentials of Pharmacology for Nurses). This drug affects the movement of sodium into cells. It is used intravenously for the treatment of ventricular arrhythmias (for acute myocardial infarction, digitalis
poisoning, cardioversion or cardiac catheterization). However, a routine prophylactic administration is no longer recommended for acute myocardial infarction because the overall benefit of this measure is not convincing. Usually an IV injection of 100mg is administered over a period of a few minutes. The dose may be less in low-weight patients or those who have poor circulation. Following the initial dose the cardiologist will commence the patient on a slow IV regimen in order to control the life-threatening arrhythmias.

**Drugs used in cardiac resuscitation**

Cardiac arrest is the cessation of normal circulation of the blood due to failure of the heart to contract effectively, and if this is unexpected can be termed a sudden cardiac arrest. In adults, sudden cardiac arrest results primarily from cardiac disease (of all types, but especially coronary artery disease). In a significant percentage of people, sudden cardiac arrest is the first manifestation of heart disease. Other causes include circulatory shock from non-cardiac disorders (especially pulmonary embolism, GI haemorrhage and trauma), respiratory failure and metabolic disturbance (including drug overdose).

In children, cardiac causes of sudden cardiac arrest are much less common. Instead, predominant causes include trauma, poisoning and various respiratory problems (e.g. airway obstruction, smoke inhalation, drowning, infection and sudden infant death syndrome).

Only a small number of drugs are indicated during cardiac arrest and we have already discussed two that can be used — adenosine and amiodarone. Two further drugs will be considered in this section: adrenaline and atropine.

**Adrenaline**

Adrenaline is a natural stimulant made in the adrenal glands, which lie just above the kidneys. It is carried in the bloodstream and affects the autonomic nervous system, which controls functions such as the heart rate. Adrenaline is the body’s activator, and is released in response to anxiety, exercise or fear. This is the basis of the so-called ‘fight-or-flight’ reaction. When an individual is threatened, the options are usually either to stand and fight or to run away as fast as possible. Both responses require extra supplies of blood and oxygen in the muscles. Fright causes the brain to send signals to the adrenal glands which start pumping large amounts of adrenaline into the bloodstream. This increases the heart and breathing rates in preparation for the ensuing action.

The effects of adrenaline are harnessed in a cardiac arrest situation and it is the first drug given in all causes of cardiac arrest. Adrenaline concentrates the blood around the vital organs, specifically the brain and the heart, by peripheral vasoconstriction. These are the organs that must continue to receive blood to increase the chances of survival following cardiac arrest. Adrenaline also strengthens cardiac contractions as it stimulates the cardiac muscle. This further increases the amount of blood circulating to the vital organs, and also increases the chance of the heart returning to a normal rhythm.

Adrenaline can be given repeatedly during a cardiac arrest until the condition of the patient improves. The Resuscitation Council recommends that it is given as soon as possible after a cardiac arrest has been identified. This can be repeated every three to five minutes. Even though in a cardiac arrest situation care is being administered rapidly, it is still vital to document the time, route and amount of adrenaline being administered.

The suggested administration route is by central line, as this allows the drug to reach the cardiac tissue more rapidly. If this is not available, adrenaline may be administered through a cannula in a peripheral vein.

**Clinical tip**

If adrenaline is administered through a cannula, the cannula should be flushed with at least 20ml of 0.9 per cent sodium chloride after the drug has been given. This will ensure the entry of the drug into the circulation.
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Manufacturers suggest that adrenaline may be injected directly into the heart through the chest wall if no other route is available. This can be a difficult procedure and should only be attempted by a competent clinician and when all other attempts to gain access have failed.

Once an organized rhythm has been established the use of adrenaline must be reassessed, as excess amounts can cause the patient to develop ventricular fibrillation. It is also important to understand that adrenaline reacts with sodium bicarbonate to produce solid material. For this reason these two drugs should not be administered through the same IV route without adequate flushing with 0.9 per cent sodium chloride.

Atropine
The vagus nerve is part of the parasympathetic nervous system which in turn is part of the autonomic nervous system. However, unlike the action of the fight-or-flight system the parasympathetic system is responsible for slowing the heart. The drug atropine blocks the actions of the vagus nerve on the heart, making it useful when a patient has a very slow heart rate (bradycardia). Blocking the vagus activity should help to speed up the cardiac rate.

This drug should be administered intravenously and the dose depends on the heart rhythm. For bradycardia a dose of 0.5mg should be given and repeated every five minutes until a satisfactory heart rate is achieved. Atropine is no longer recommended for routine use in asystole or pulseless electrical activity.

Wolff-Parkinson-White syndrome
Wolff-Parkinson-White syndrome involves episodes of rapid heart rate (tachycardia) caused by abnormal electrical pathways (circuits) in the heart, which are often present from birth. It is also sometimes referred to in textbooks as ‘pre-excitation syndrome’. A ‘syndrome’ is simply a collection of symptoms described by the patient.

As described earlier in this chapter, normally the electrical stimulus of the heart travels through the upper chambers (atria) and then through the AV node where it is delayed before continuing into the lower chambers or ventricles. In Wolff-Parkinson-White syndrome there is an ‘accessory’ or extra AV conduction pathway which bypasses the normal conduction delay of the AV node and causes a rapid heart rate to be initiated in the upper chambers (a supraventricular tachycardia), called a re-entrant tachycardia. An atrioventricular re-entrant tachycardia occurs when this system of cardiac conduction is short-circuited in a way that allows an impulse to create a self-perpetuating and uncontrolled fast heart rhythm. If the rate is too fast, its efficiency falls and symptoms such as blackouts, fainting, chest tightness or shortness of breath can result. The extra pathway in Wolff-Parkinson-White syndrome can often be located very precisely.

Wolff-Parkinson-White syndrome occurs in around 4 in 100,000 people, and is one of the most common causes of fast heart rate disorder in young children and adolescents. The person concerned may be totally unaware of the condition, or symptoms may include palpitations (sensation of feeling heart beat), dizziness, light-headedness or fainting. There may also be chest pain, tightness or breathlessness.

Examination during an episode of palpitation usually reveals a pulse rate of 150 per minute in the presence of a normal or low blood pressure. Investigations can include ECG and continuous ambulatory ECG monitoring in an attempt to demonstrate diagnostic findings. Medications may be used to control or prevent rapid heartbeat. These include adenosine, anti-arrhythmics and amiodarone.

Case studies

Mrs Walker is a 72-year-old woman who has been admitted to the medical unit following a general deterioration in her health and ability to carry out most of the activities of living independently.
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She doesn’t think through daily problems as quickly as before, she makes mistakes balancing her cheque book, she is more sedentary, fatigues easily and is winded when carrying her shopping. On examination she has oedema, her blood pressure is 160/90, her pulse is 88 beats per minute and her weight is 75kg. Her current medications are glipizide (2.5mg daily), lisinopril (20mg daily), atorvastatin (40mg daily), aspirin (75mg daily), felodipine (5mg daily) and hydrochlorothiazide (25mg daily).

- Her daughter approaches you for information regarding atorvastatin. What responses would you give?

2) Four years ago, when he was in his late fifties, Geoff began to feel breathless and tight-chested on his daily walk to work. ‘It was just over a mile and I enjoyed the exercise, particularly in the nicer weather, but in the spring I just wasn’t feeling right,’ he remembers. After a few days of discomfort, which wore off as soon as he sat down at his desk in the council offices where he worked, Geoff decided to see his doctor. ‘I actually thought I had a chest infection,’ he says. He was immediately started on daily aspirin treatment to thin his blood and prevent him having a heart attack if a blood clot got caught in the most narrowed coronary artery. ‘I was also given a drug called glyceryl trinitrate, which is delivered by spraying it into your mouth, like a breath freshener,’ says Geoff.

- Geoff wants you to recap how his GTN is helping him. What would you say?

Key learning points

Introduction

- Cardiovascular disease costs the NHS in the UK nearly £15 billion annually.

Atherosclerosis

- Atherosclerosis is a degenerative disease that results in narrowing of the arteries.

Cholesterol

- Cholesterol itself is not harmful, but high blood cholesterol can be dangerous.

Normal cholesterol level

- The DH recommends that cholesterol levels should be less than 5mmol/L.

Lipid regulating drugs

- Lowering the amount of low-density lipoproteins and raising the levels of high-density lipoproteins slows the progression of atherosclerosis and may even cause a reduction in its formation.

Statins

- Statins block the enzyme in the liver that is responsible for making cholesterol.
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**Fibrates**
- Fibrates lower blood triglyceride levels by reducing the liver’s production of VLDLs and by speeding up the removal of triglycerides from the blood.

**Bile-acid binding resins**
- Bile-acid binding resins work by binding to bile in the digestive tract.

**Angina**
- This is chest discomfort that occurs when there is a decreased blood oxygen supply to an area of the heart muscle.

**Glyceryl trinitrate**
- Belongs to a group of drugs called nitrates that contain the chemical nitric oxide and has the effect of making the veins and arteries relax and widen (dilate).

**Isosorbide mononitrate and dinitrate**
- These drugs will not be effective in a person who is having an angina attack.

**Electrical conduction through the heart**
- The normal heart begins with an electrical impulse from the SA node, located high in the right atrium.

**Contraction of cardiac muscle**
- In order for the myocardium to contract, sodium must enter the muscle cell.

**Paroxysmal supraventricular tachycardia**
- A regular, fast heart rate that begins and ends suddenly and originates in heart tissue other than that in the ventricles.

**Adenosine**
- Slows down the electrical impulses through the atrioventricular node.

**Atrial fibrillation**
- An irregular and often rapid heart rate that commonly causes poor blood flow to the body and symptoms of heart palpitations, shortness of breath and weakness.

**Digoxin**
- Increases the force of contraction via inhibition of the sodium-potassium pump.
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**Verapamil**
- Belongs to a group of drugs called calcium blockers (calcium channel antagonists).

**Sotalol**
- Comes from a group of drugs known as beta blockers and is used to help prevent paroxysmal supraventricular arrhythmias, ventricular ectopics and ventricular tachycardia.

**Amiodarone**
- Considered a ‘broad spectrum’ anti-arrhythmic medication.

**Flecainide**
- Helps to treat arrhythmias by decreasing the sensitivity of the heart muscle cells to electrical impulses.

**Drugs that act on ventricular arrhythmias**
- Lignocaine is used intravenously for the treatment of ventricular arrhythmias.

**Adrenaline**
- The first drug given in all causes of cardiac arrest.

**Atropine**
- Blocks the actions of the vagus nerve on the heart.

**Wolff-Parkinson-White syndrome**
- Involves episodes of rapid heart rate (tachycardia) caused by abnormal electrical pathways (circuits) in the heart, which are often present from birth.

**Calculations**
1. A patient is ordered 30mg of Diltiazem hydrochloride. 60mg tablets are available. How many tablets will you give?
2. A doctor has prescribed 0.25mg of digoxin. You have 125mcg tablets in stock. How many should you give?
3. A doctor has prescribed a patient 125mcg of digoxin. You have digoxin elixir 50mcg per ml. How much should you administer?
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4 A patient with cardiovascular disease is taking six tablets per day. How many will they take in a week?

5 How many ml of digoxin liquid containing 50mcg/ml are required to give a dose of 62.5mcg?

6 An infusion pump contains 50mg of glyceryl trinitrate in 100ml. You are asked to deliver a dose of 4mg per hour. What is the rate in ml per hour?

7 You are required to give a patient GTN as a continuous IV infusion at 25mcg/minute. You have prepared a 50mg in 50ml infusion. What rate should you set the infusion pump at, in ml/hr, to deliver this dose?

8 A patient is prescribed an amiodarone infusion of 400mg in 200ml and the flow rate is 35ml/hr. What would the hourly dose be?

9 A patient on the cardiovascular ward is receiving an IV infusion. The patient is to receive 1L of fluid over the next five hours. What volume of fluid (in ml) will they receive each hour?

10 Digoxin elixir contains 50mcg in 1ml. How much would you need to give a dose of 0.1mg?

For further assistance with calculations, please see Meriel Hutton’s book *Essential Calculation Skills for Nurses, Midwives and Healthcare Practitioners* (Open University Press 2009).

Multiple choice questions

1 The government recommends that cholesterol levels should be:

a) 5mmol/L
b) Less than 5mmol/L
c) More than 5mmol/L
d) Dependent on the individual

2 Statins work by

a) Raising the metabolic rate
b) Blocking the absorption of cholesterol
c) Blocking the production of bile
d) Blocking the enzyme in the liver that is responsible for making cholesterol

3 Fibrates reduce the liver’s production of

a) Very low density lipoproteins
b) Low-density lipoproteins
c) High-density lipoproteins
d) All of the above

4 Colesevelam is an example of

a) A bile-acid binding resin
b) A statin
c) A fibrate
d) A nitrate
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5 Glyceryl trinitrate is not administered orally because
a) The drug molecule is too big to be absorbed by the body
b) Stomach acid destroys the drug
c) It has a bad taste
d) Most of the drug is destroyed by the first pass effect

6 Digoxin is given daily as its half-life is
a) 4 hours
b) 16 hours
c) 36 hours
d) 8 hours

7 Which of the following drugs is a calcium channel blocker?
a) Digoxin
b) Verapamil
c) Isosorbide mononitrate
d) Amiodarone

8 Amiodarone has a high
a) Sodium content
b) Magnesium content
c) Calcium content
d) Iodine content

9 Lignocaine is used to treat
a) Both supra and ventricular arrhythmias
b) Supra-ventricular arrhythmias
c) Ventricular arrhythmias
d) Heart block

10 In cardiac arrest atropine is given because
a) It is naturally occurring
b) It stimulates parasympathetic activity
c) It is a more potent drug than adrenaline
d) Blocking vagus activity could help speed up cardiac rate
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Recommended further reading