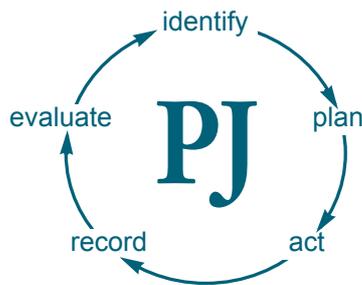


HEART DISEASE

# (8) ARRHYTHMIAS: PART 1

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*The diagnosis and management of cardiac arrhythmias is a complex process. This article gives a brief overview of common arrhythmias and highlights strategies, including drug therapies, that may be considered in their management*



## identify gaps in your knowledge

1. What does “sinus rhythm” mean?
2. Name three types of arrhythmia and describe their implications.
3. What therapies are commonly employed to manage arrhythmias?

Before reading on, think about how this article may help you to do your job better.

The Royal Pharmaceutical Society’s areas of competence for pharmacists are listed in “Plan and record,” (available at: [www.rpsgb.org.uk/education](http://www.rpsgb.org.uk/education)). This article relates to “common disease states and their drug therapies” (see appendix 4 of “Plan and record”).

An arrhythmia is any abnormality in heart rate (HR) or rhythm. Some arrhythmias are benign, but others can cause sudden death. It is estimated that 5.3 per cent of people are managing an arrhythmia at any given time. Many arrhythmias remain undiagnosed.

Contraction of heart muscle is controlled by an electrical system. Specialised cells (pacemaker cells) in the myocardium trigger electrical activity, which travels across the atria into the ventricles, stimulating contraction and hence controlling the rate and rhythm of the heart. An arrhythmia is caused by a disturbance in the electrical conduction system. Panel 1 (p369) provides background information on cardiac contraction.

Arrhythmias can be described in terms of where they occur or their effect on heart rhythm. For example, the term “supraventricular arrhythmia” encompasses disturbances of rhythm arising above the AV node (atrial arrhythmias) and those arising at the AV junction or within the AV node itself and the term “ventricular arrhythmia” refers to disturbances in rhythm arising within the ventricles. Changes in HR may be referred to as “bradycardia” (slow rate) or “tachycardia” (fast rate).

Common symptoms of arrhythmia include dizziness or lightheadedness, palpitations, chest pain and fatigue. Some arrhythmias can result in loss of consciousness secondary to hypotension or compromise blood supply to the major organs because blood no longer circulates effectively. A small number of patients may be at risk of cardiac arrest. The best way to diagnose an arrhythmia is to use an electrocardiogram (ECG). The P wave indicates atrial depolarisation, the QRS complex indicates ventricular depolarisation and the T wave ventricular repolarisation (see Figure 1).

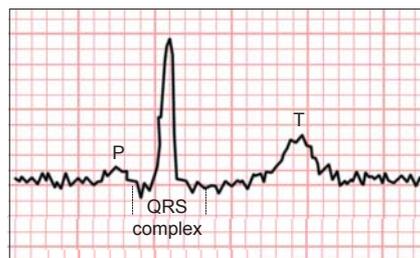


Figure 1: An ECG maps electrical activity within the heart

of successful procedures, such as radiofrequency (RF) ablation (see Panel 2), has decreased the role of drugs in managing arrhythmias. However use of RF ablation in the United Kingdom is limited because there are few specialists who can perform the procedure and there is a risk of several complications (eg, stroke). Cost is also an issue.

A wide variety of anti-arrhythmic drugs exists and they are commonly classified according to the Vaughan Williams system, which divides anti-arrhythmic drugs into groups according to their actions. Class I anti-arrhythmics (eg, quinidine, disopyramide, flecainide) block the sodium channels. This group can be further subdivided (IA, IB, IC) according to their effect on repolarisation. Class II anti-arrhythmics (eg, propranolol, sotalol) primarily consist of the beta-blockers. These agents reduce the arrhythmogenic effects of circulating catecholamines, delay depolarisation and also close calcium channels by an indirect mechanism. Class III agents (eg, amiodarone, bretilium) block potassium channels and hence prolong the action potential, delaying repolarisation, while class IV (eg, verapamil, diltiazem) block calcium channels at the AV node, delaying conduction to the ventricles. A number of additional agents are not classified within the Vaughan Williams system (eg, adenosine, digoxin). Alternatively, anti-arrhythmics can be described as those used primarily for the management of supraventricular arrhythmias and those targeting ventricular arrhythmias (although there is some overlap between the two groups).

### BRADYCARDIA

Bradycardia is defined as an HR less than 60 beats per minute (bpm). However, in situations where HR is lower than expected, a relative bradycardia could be said to exist. For example, an HR of 70bpm during an episode of acute illness, such as sepsis or acute myocardial infarction (MI) might be considered unusually low.

Sinus bradycardia occurs where the SA node fires at a slow rate, so HR falls. Sinus node disease is present when the SA node fails to generate an electrical impulse. Bradycardias can also be caused by failure of the AV node to conduct electrical impulses to the ventricles (AV node disease, commonly referred to as “heart block”) or neurocardiogenic syncope, which encompasses excess vagal nerve activity (“vasovagal syndrome”) and carotid sinus hypersensitivity.

If the pacemaker function of the SA node fails and HR falls significantly, secondary pacemakers take over. Initially, the AV node

### MANAGEMENT OF ARRHYTHMIAS

In many cases arrhythmias occur as a result of heart disease (eg, cardiomyopathies) and management may focus on addressing the underlying cause. Strategies to manage arrhythmias include drug therapy, electrical cardioversion (see Panel 2, p370) and the insertion of pacemaker or defibrillator devices. Anti-arrhythmic drugs work by modifying the electrical activity of the heart. The advent

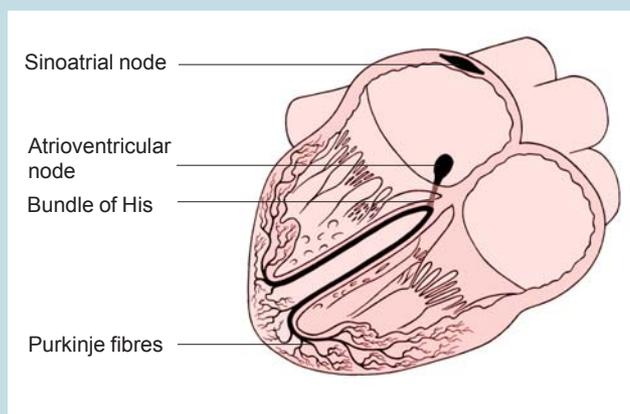
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## PANEL 1: CARDIAC CONTRACTION

**The conduction system** Four structures conduct electrical impulses through the cardiac muscle: the sinoatrial (SA) node, the atrioventricular (AV) node, the bundle of His (or AV bundle) and the Purkinje fibres. In the healthy heart, the SA node (located in the right atrium) acts as the cardiac pacemaker by generating electrical impulses, hence the term “sinus rhythm” for a normal rhythm.

**Electrical activity** The movement of electrolytes, in particular potassium, sodium and calcium ions, is key to myocardial contraction. In the resting state an uneven distribution of these ions exists, with a greater concentration of potassium ions inside cells and more sodium and calcium ions outside cells. In specialised pacemaker tissues, this imbalance creates a negative electrical charge of approximately  $-60\text{mV}$  (the “membrane potential”) across the cell membrane. Changes in membrane permeability gradually allow sodium and potassium ions to flow into cells, leading to a change in the membrane potential. When there is a large enough voltage change across the cell membrane (ie, when a “threshold potential” of about  $-40\text{mV}$  is reached) voltage-sensitive calcium channels open to allow an influx of calcium ions. This leads to the development of a positive membrane potential, a process known as depolarisation. As these events occur in the pacemaker cells, adjacent non-pacemaker cells are triggered to depolarise and a wave of electrical activity is conducted throughout the myocardium.

Impulses arising in the SA node travel across both atria, and into the AV node, which is sited between the right atrium and ventricles. From the AV node the current then passes down the bundle of His and via the Purkinje fibres throughout the ventricles. After depolarisation, redistribution of the intra and extracellular ions restores the resting membrane potential (repolarisation). Contraction of the myocardial cells occurs at the point of depolar-



isation. The atria contract significantly earlier than the ventricles because conduction through the AV node is slower than through atrial or ventricular pathways.

**Control of heart rate** Resting heart rate (HR), controlled by the SA node, is around 70bpm. HR is adjusted by the autonomic nervous system. For example, during exercise sympathetic stimulation of the SA node increases the influx of calcium ions. This allows cells to reach threshold potential quicker, and the rate of contraction therefore increases. Conversely, parasympathetic stimulation via the vagal nerve increases the outflow of potassium ions. Cells therefore take longer to reach the threshold potential and heart rate decreases.

**Secondary pacemakers** Cells in the AV node, the bundle of His and the Purkinje fibres can also generate action potentials, but these impulses are usually overridden by the SA nodal rate because the SA node generates action potentials more quickly.

maintains HR between 30 and 40bpm (known as a “junctional rhythm”). If this fails, cells further down the conduction system (eg, bundle of His) will maintain a “ventricular escape rhythm” of between 20 and 30bpm to ensure a degree of cardiac output.

In most cases, sinus node disease is idiopathic, possibly related to fibrosis of the conduction tissues, but known causes include acute MI or cardiomyopathies. AV node disease is also frequently idiopathic but can occur secondary to acute MI, congenital defects and infection, after surgery (especially following valve replacement) and following drug therapy (eg, beta-blockers, verapamil or digoxin).

Acute episodes of bradycardia can lead to sudden loss of consciousness or lightheadedness, while chronically the condition is associated with fatigue and lethargy. Depending on the aetiology, bradycardia can be associated with episodes of tachycardia and palpitations (the “tachy-brady syndrome”) or hypotension.

Following diagnosis, any reversible cause of bradycardia should be excluded. These include excess vagal tone, drug therapy and electrolyte or metabolic imbalance (eg, hypothyroidism). Acute bradycardia associated with vasovagal episodes can be treated with atropine, which blocks vagal nerve activity. Chronic treatment is generally through insertion of a pacemaker unit, which is programmed to keep HR above a specified level. Permanent pacemaker (“PPM”) units are frequently used for patients with sinus node disease or certain types of heart block. If the underlying cause of a bradycardia is reversible or unlikely to be sustained, pacing may be used temporarily. Indications for temporary pacing are an HR of less than 40bpm, symptoms of low cardiac output associated with angina or evidence of associated ventricular arrhythmias.

### TACHYCARDIAS

Tachycardia is defined as an HR greater than 100bpm. Supraventricular arrhythmias can arise from the atria (eg, sinus tachycardia, atrial fibrillation, atrial flutter and atrial tachycardia) or from the atrioventricular junction (often referred to as supraventricular tachycardias). The most common supraventricular arrhythmia, atrial fibrillation, will be covered in the second part of this article along with ventricular tachycardia.

**Sinus tachycardia** Sinus tachycardia (ST) occurs when the SA node fires at a rapid rate. It is a normal response to exercise and some drugs (particularly atropine, nicotine, thyroxine, salbutamol and aminophylline). ST can be present in many conditions, including hypotension, anaemia, thyrotoxicosis, hypovolaemia, pulmonary emboli and shock, and is only considered inappropriate where there is no obvious precipitant. In most cases, ST can be addressed by treating the underlying cause, for example, using antibiotics to treat infections, fluid replacement to correct hypotension and hypovolaemia and beta-blockers and antithyroid agents to manage thyrotoxicosis. Management of inappropriate ST relies on the use of rate-controlling agents such as beta-blockers or calcium channel blockers. In some cases, RF ablation may be necessary to modify the sinus node activity.

**Sinus node re-entry tachycardia** Sometimes, a “re-entry circuit” (a localised “circling” of the electrical impulse) develops within the myocardial tissue and results in rapid firing of the SA node. This is known as “sinus node re-entry tachycardia” and accounts for about 5 per cent of atrial tachycardias. It is diagnosed primarily by ECG and electrophysiological studies (see Panel 2). The tachycardia often stops abruptly, but this can be expedited with the use of adenosine, verapamil or beta-blockers. RF ablation can also be used. The use of beta-blockers and rate-controlling calcium channel blockers can prevent this type of tachycardia recurring.

**Atrial flutter** Atrial flutter involves a re-entry circuit within the right atrium, which drives electrical activity within the left atrium. The resultant atrial rhythm is rapid (usually 300bpm) and regular, and flutter waves can be seen in a saw tooth pattern on ECG (see Figure 2, p370). In atrial flutter the rapid atrial contractions are associated with a regular ventricular response. Usually the ventricles beat once for every two, three or four atrial flutter waves. Irregularity in the atrial or ventricular rate usually indicates atrial fibrillation rather than atrial flutter.

The unusual conduction pathways operating in atrial flutter generally disturbs atrial contraction and results in stasis of blood within the atria. Anticoagulation is therefore recommended to

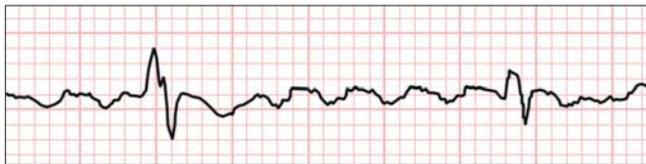


Figure 2: In atrial flutter, atrial activity is seen as rapid flutter waves between each complex

prevent the formation of localised thrombi and reduce the risk of secondary thromboembolic events.

Drugs that slow AV node conduction can be used to control the ventricular response to the rapid flutter waves. Conversely, drugs that reduce atrial rate should be avoided because if atrial rates slow sufficiently, 1:1 conduction of the flutter waves to the ventricle may be possible. This can result in rapid ventricular rates and significantly compromise cardiac output. For example, if flutter waves (300bpm) conduct to the ventricles at a ratio of 2:1, the ventricular rate is 150bpm. Slowing the atrial rate to 220 bpm could allow conduction of flutter waves to the ventricles at a ratio of 1:1, resulting in a ventricular rate of 220bpm.

Direct current (DC) cardioversion can be used to convert atrial flutter to sinus rhythm. Because a return to normal rhythm could dislodge any clots that have formed, patients undergoing elective DC cardioversion, must be adequately anticoagulated for one month before and after the procedure to reduce the risk of MI or stroke. DC cardioversion is generally only successful in treating flutter of short duration. Persistent atrial flutter can often be successfully treated by RF ablation of the focus (the source of electrical impulses) or conduction pathway.

**Atrial tachycardia** Tachycardias can arise anywhere in the atria. Atrial tachycardias, other than atrial flutter and atrial fibrillation are rare and most often caused by the presence of a single ectopic atrial focus (a focus in the atria that depolarises faster than the SA node) or the creation of a re-entry circuit.

During a true atrial tachycardia, the atrial contraction rate is regular and usually between 150 and 200bpm. Atrial tachycardia can occur with structural heart disease, cardiomyopathies or cor pulmonale (ie, as a result of chronic obstructive lung disease) or following acute MI or digoxin toxicity. This type of arrhythmia often responds poorly to drug therapy, although agents that control atrial rate (including those from class IA, class IC or class III) can be tried. The choice of drug is based primarily on the presence or absence of left ventricular dysfunction. If the left ventricle is impaired, class IA and IC are contraindicated (proarrhythmic effects

## PANEL 2: GLOSSARY

**Electrical cardioversion** In electrical cardioversion the aim is to disrupt the abnormal electrical conduction pathways in order to convert an arrhythmia to sinus rhythm. This involves the delivery of a low voltage shock to the heart through the chest wall (eg, using paddles). More than one shock is needed in some cases. The procedure can be painful so the patient is given a short-acting anaesthetic.

**Radiofrequency ablation** Radiofrequency (RF) ablation is a procedure whereby a catheter with an electrode at its tip is guided to the site on the myocardium that is responsible for the generation or conduction of abnormal impulses. RF energy is then transmitted locally to destroy the affected tissue and remove the conduction pathway. The procedure is done under mild sedation and local anaesthetic. It has a high success rate and patients can return to normal activities in a few days.

**Electrophysiological studies** An electrophysiological study is used to investigate the exact location and characteristics of an arrhythmia in detail (eg, the focus responsible for generating an atrial tachycardia can be pinpointed in order to carry out RF ablation). This is achieved by placing several electrodes on the heart surface (via a catheter) and mapping electrical activity.

## action: practice points

Reading is only one way to do CPD and the Society will expect to see various approaches to CPD in a pharmacist's portfolio.

1. Do you know the difference between pacemaker and non pacemaker cardiac cells? Refer to a standard textbook.
2. Speak to a patient being treated for an arrhythmia. What symptoms did he or she experience? Does the patient know what type of arrhythmias he or she has?
3. Make sure you understand all the terms in this article — explain them to a colleague.

## evaluate

For your work to be presented as CPD, you need to evaluate your reading and any other activities. Answer the following three questions:

What have you learnt?

How has it added value to your practice? For example, have you applied this learning or had any feedback?

What will you do now and how will this be achieved?

are possible). Sotalol can be used in mild left ventricular dysfunction, while amiodarone is more appropriate in moderate to severe dysfunction. In addition, drug therapies to control the resulting ventricular rate can be used, including beta-blockers or rate-controlling calcium channel blockers. RF ablation may be required to control recurrent atrial tachycardia.

**AV junction tachycardias** Most junctional tachycardias are caused by the presence of a re-entry circuit either within the AV node or via a "remote accessory pathway" (rather than conducting down the AV node and bundle of His, the impulses take an abnormal route). They usually present with atrial rates of between 120 and 260bpm. The degree of symptoms experienced primarily depends on the resultant ventricular rate — patients with more rapid rates generally present with palpitations, hypotension and breathlessness, while those with less rapid rates may not report any significant symptoms.

Acute treatment may initially involve vagal manoeuvres, such as carotid sinus massage to reduce vagal nerve activity, or the "Valsalva manoeuvre", in which the supine patient is asked to breath out hard with a closed glottis for 15 seconds, and then asked to relax. These relatively simple techniques can result in a return to sinus rhythm in up to 70 per cent of patients. In more resistant cases the drug of choice is adenosine, which blocks conduction across the AV node. This will terminate arrhythmias caused by re-entry via the AV node, and will help to identify the presence of accessory pathways or underlying atrial flutter waves. However, adenosine can precipitate bronchospasm and must therefore be avoided in asthmatics. Verapamil may be a suitable alternative where adenosine is contraindicated, but ventricular tachycardia must be excluded first. Following restoration of sinus rhythm, some patients can return to normal activities without the need for chronic therapy. Suppression of recurrent supraventricular tachycardias can be achieved using a wide range of drugs, but beta-blockers or rate-controlling calcium channel blockers may be safer than options such as propafenone or amiodarone. RF ablation to break re-entry circuits or accessory conduction pathways is increasingly performed.

**Wolff-Parkinson White syndrome** Wolff-Parkinson White syndrome is a specific supraventricular tachycardia, where an accessory pathway conducts electrical activity directly from the atria to the ventricles and allows a circuit to form around this pathway and the AV node. This is a serious condition, particularly if it occurs in conjunction with atrial fibrillation, which can lead to rapid, potentially fatal, ventricular rates. Every effort should be made to prevent the development of atrial fibrillation in these patients. RF techniques may be used to ablate the accessory pathway.