# 6 • Abnormalities in the conduction system

Abnormalities in the conduction system are associated with faults in either the generation of the impulse from the SA node or abnormalities in conduction through the specialised conduction tissue, i.e. the AV node, bundle of His and Purkinje system.

## Sinus arrest and block

When there is a failure of the SA node to generate an impulse, i.e. the SA node has temporarily arrested – it is referred to as **sinus arrest**. **Sinus block** (also referred to as sinoatrial exit block) is when the electrical impulse from the SA node to the atria is blocked. These bradyarrhythmias can result in bradycardia and/or asystole.

### *ECG characteristics*

There is a pause in the rhythm with neither a P wave nor therefore a QRS–T complex, i.e. the baseline is flat (except for movement artifact if present). If the pause is only twice the R–R interval (or multiples of), it suggests sinus block. However, if the pause is greater than two R–R intervals (but not exact multiples of) it suggests sinus arrest (Fig. 6.1). Long periods of arrest or block are often followed by ventricular ectopic escape complexes. Note: in comparison with atrial standstill (see p. 42), sinus arrest produces a 'flatline' that is intermittent, whereas atrial standstill results in a sustained absence of P waves.

### *Clinical findings*

A pause in the heart rhythm will be heard on auscultation (with no palpable pulse); it will effectively sound as if the heart has briefly stopped. With sinus block it will be a very short pause that can be difficult to discern from a normal pause such as in respiratory sinus arrhythmia. With sinus arrest the duration of the pause will depend upon the duration of the period of sinus arrest and if this is occurring episodically or not.

## Sick sinus syndrome

This is a term for an abnormally functioning SA node and is probably better termed **sinus node dysfunction**. This 'umbrella' term

**Figure 6.1** (a) ECG showing intermittent sinus arrest, from a 13-year-old West Highland White terrier with idiopathic pulmonary fibrosis (25 mm/sec and 10 mm/mV).

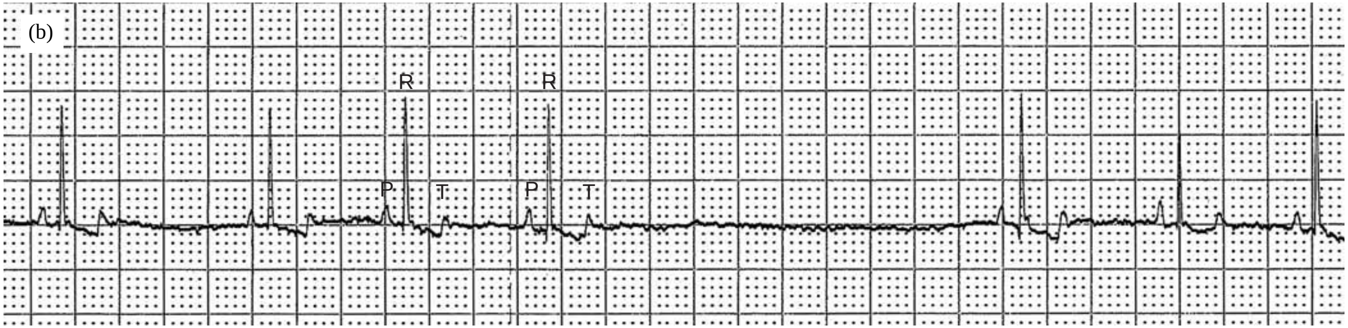


**Figure 6.1** (b) ECG from a Lakeland terrier with sinus arrest – there is a 2-second pause (25 mm/sec and 10 mm/mV).

refers to any abnormality of sinus node function including severe sinus bradycardia and severe sinus arrest. In some situations the profound bradycardia alternates with a supraventricular tachycardia, this is termed the '**bradycardia–tachycardia syndrome**'. Sick sinus syndrome has been reported to occur most commonly in female miniature Schnauzers of at least 6 years of age and West Highland White and Cairn terriers. It has not been recorded in cats.

### *ECG characteristics*

The electrocardiographic features are therefore quite variable and include persistent sinus bradycardia or episodes of sinus arrest without escape beats. One feature of sick sinus syndrome is that during long periods of sinus arrest there is often a failure of rescue escape beats. In the bradycardia–tachycardia syndrome there are periods of bradycardia such as sinus arrest, alternating with a supraventricular

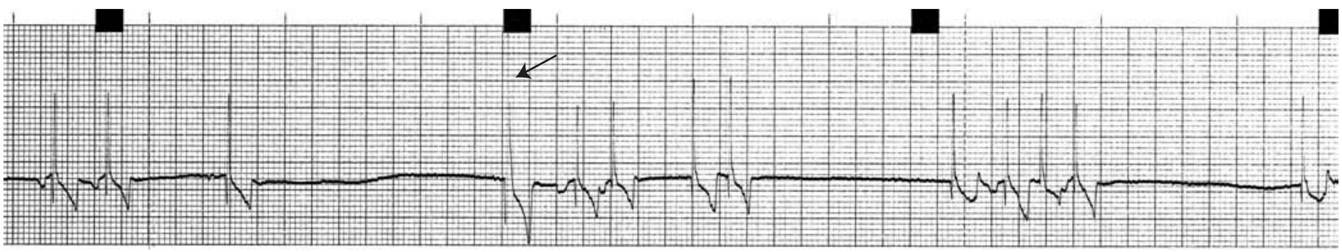

**Figure 6.2** ECG from a 10-year-old miniature Schnauzer with sick sinus syndrome. This tracing shows periods of sinus arrest alternating with supraventricular premature complexes. There is one ventricular escape present (arrowed) (25 mm/sec and 10 mm/mV).

tachycardia (Fig. 6.2). The bradycardia may be unresponsive to an injection of atropine.

### *Clinical findings*

The findings on auscultation are very variable, from a markedly slow heart rate, to a variable rhythm, or with long pauses (associated with sinus arrest). The bradycardia–tachycardia syndrome sounds like periods of slow heart rate alternating with periods of very fast heart rate, and not necessarily with any regularity. There may be pulse deficits during the tachycardic episodes and no pulse produced during the periods of arrest.

## Atrial standstill

In atrial standstill there is an absence of any atrial activity, which can be confirmed by fluoroscopy or echocardiography (there is no A wave on an M-mode of the mitral valve or no atrial contraction inflow on Doppler studies). This occurs due to a failure of atrial muscle depolarisation, i.e. the SA node may produce an impulse, but the atria are not depolarised and remain inactive. If this occurs due to hyperkalaemia, the impulses are conducted from the SA node by internodal pathways to the AV node, thus there is a sinoventricular rhythm. If this occurs due to myocardial disease, the internodal pathways are also diseased and thus a nodal (or junctional) escape rhythm develops in these cases. Both of these rhythms look similar on ECG.

### *ECG characteristics*

The electrocardiographic feature is of the absence of P waves, usually with a slow (less than 60/min) escape rhythm (Fig. 6.3). The quality of the ECG has to be excellent (i.e. the baseline must be flat without any artifacts) to diagnose the absence of P waves confidently. The QRS complexes are often of a relatively normal shape (junctional escape), but sometimes with a slightly prolonged duration. In a few cases the escape rhythm can be ventricular. Note: in comparison with sinus arrest (see p. 40), atrial standstill results in a sustained absence of P waves, whereas sinus arrest produces an intermittent 'flatline'.

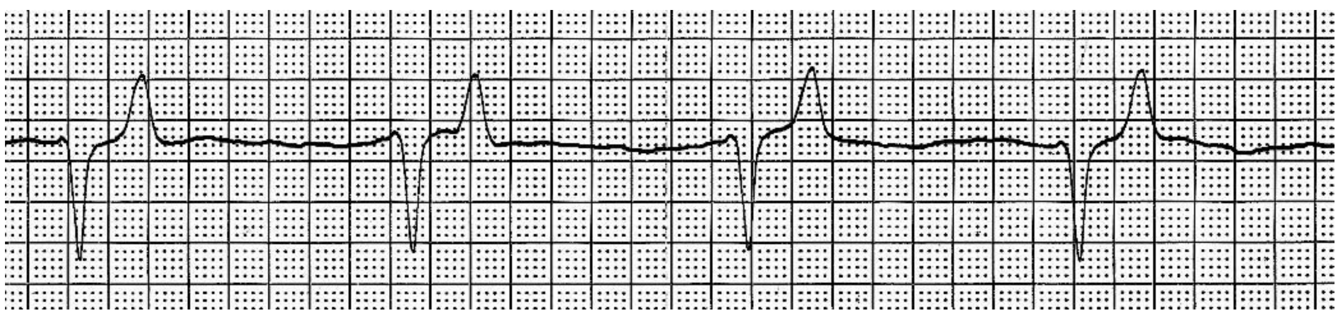

**Figure 6.3** (a) ECG from a Cavalier King Charles spaniel with atrial standstill with a ventricular escape rhythm at 70/min. Note the absence of P waves. The absence of atrial activity can be confirmed by echocardiography (50 mm/sec and 10 mm/mV).

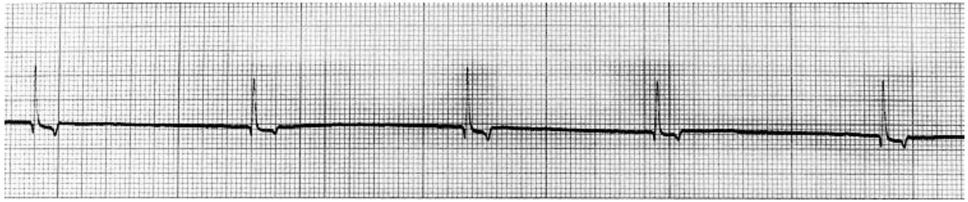

**Figure 6.3** (b) ECG from a 7-year-old West Highland White terrier with atrial standstill (due to hyperkalaemia) with a junctional rhythm at 40/min (25 mm/sec and 10 mm/mV).

### *Clinical findings*

The normal heart sounds will be heard (and associated pulse felt) in association with ventricular depolarisation. The rate will vary in each case, although generally it is slower than normal (often less than 60/min). Note: in comparison with heart block (see below), no atrial contraction sounds are heard.

## Heart block

This is the failure of the depolarisation wave to conduct normally through the AV node; the correct term is therefore AV block. Heart block is often used as a synonymous term for AV block. AV block may be partial (first or second degree block) or complete (third degree block).

### First degree AV block

First degree AV block occurs when there is a delay in conduction through the AV node and there is usually a sinus rhythm.

### *ECG characteristics*

The P wave and QRS complexes are normal in configuration, but the PR interval is prolonged (Fig. 6.4).

### *Clinical findings*

No abnormality will be appreciated on auscultation or palpation of the pulse, and it cannot be distinguished from a normal sinus rhythm.

### Second degree AV block

Second degree AV block occurs when conduction intermittently fails to pass through the AV node, i.e. there is atrial depolarisation that is not followed by ventricular depolarisation.

### *ECG characteristics*

The P wave is normal, but there is either an occasional or frequent failure (depending on severity) of conduction through the AV node resulting in the absence of a QRS complex (Figs 5.9, p. 30, and 6.5).

Second degree AV block can be classified further. When the P–R interval increases prior to the block it is termed **Mobitz type I** (also known as **Wenckebach's phenomenon**). But when the P–R interval remains constant prior to the block, this is termed **Mobitz type II** and the frequency of the block is usually constant, i.e. 2:1, 3:1 and so on.


**Figure 6.4** (a) ECG from a dog showing a prolonged P–R interval, i.e. 1st degree AV block (50 mm/sec and 10 mm/mV).

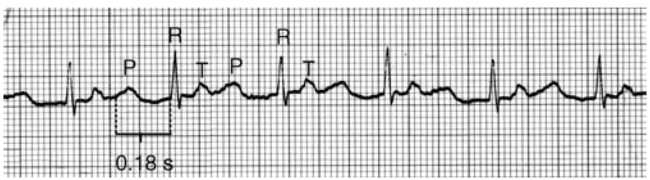


**Figure 6.4** (b) ECG from a cat showing a prolonged P–R interval, i.e. first degree AV (heart) block (50 mm/sec and 10 mm/mV).

### *Clinical findings*

There will be occasional pauses in the rhythm associated with the absence of ventricular depolarisation. On very careful auscultation the atrial contraction sounds ('A' sound or S4) can often be appreciated as a faint noise in association with atrial depolarisation.

## Complete (third degree) AV block

Complete AV block occurs when there is a persistent failure of the depolarisation wave to be conducted through the AV node. A second pacemaker below the AV node (i.e. the block) discharges to control the ventricles. This second pacemaker may arise from:

- lower AV node or bundle branches producing a normal QRS (i.e. junctional escape complex) at approximately 60–70/min;
- Purkinje cells producing an abnormal QRS–T complex (i.e. ventricular escape complex) at approximately 30–40/min.

### *ECG characteristics*

On the ECG, P waves can be seen at a regular and fast rate but the QRS–T complexes are at a much slower rate, and usually fairly regular. The P waves and QRS complexes occur independently of each other

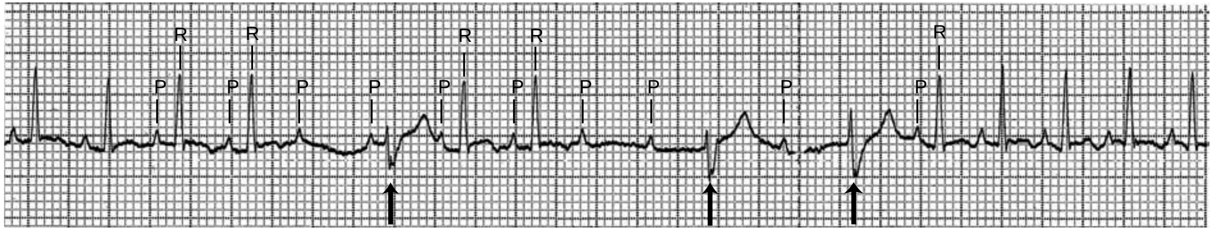


**Figure 6.5** (a) ECG from a 7-year-old cat with intermittent failure of AV nodal conduction through the ventricles (non-conducted waves), i.e. second degree heart block. Following the consequential pauses in ventricular depolarisation, ventricular escape complexes occur (arrowed) (25 mm/sec and 20 mm/mV).

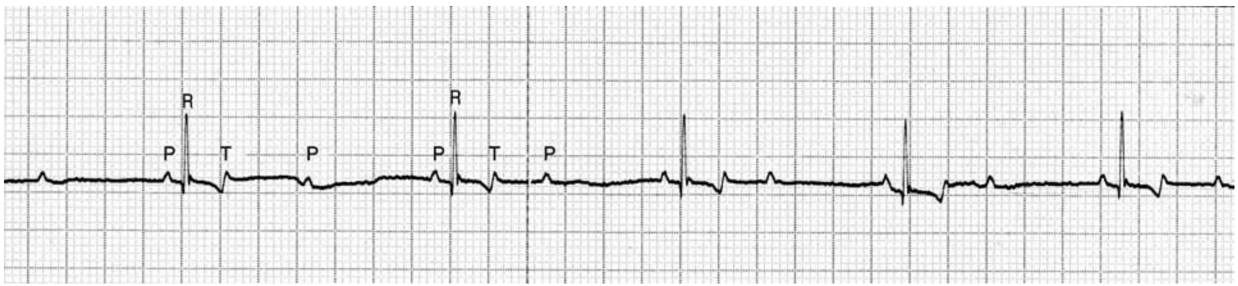


**Figure 6.5** (b) ECG from a 9-year-old Labrador with second degree AV block (25 mm/sec and 5 mm/mV).

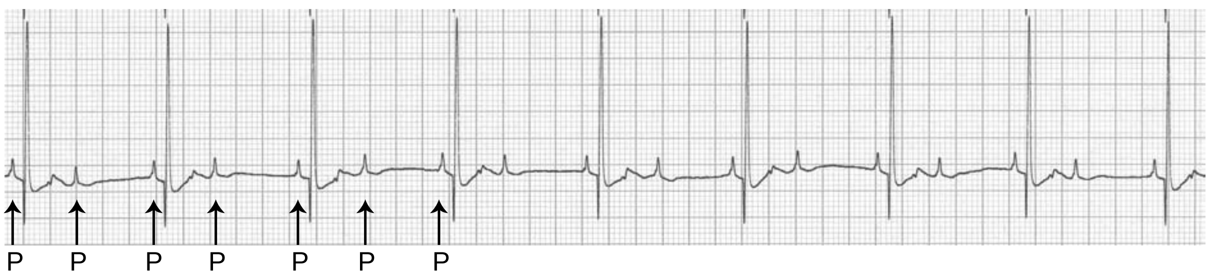


**Figure 6.5** (c) ECG from an 11-year-old mixed breed dog with second degree AV block. The first few P waves are arrowed (25 mm/sec and 10 mm/mV).

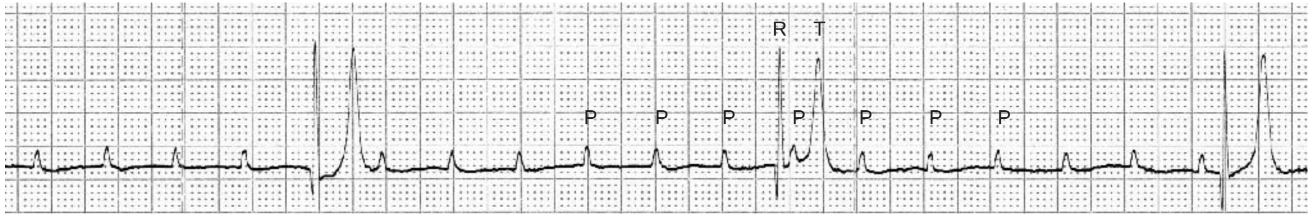


**Figure 6.6** (a) ECG from an 8-year-old Labrador with third degree AV block (complete heart block) with a ventricular escape rhythm of 45/min (50 mm/sec and 10 mm/mV).


**Figure 6.6** (b) ECG from a 10-year-old Collie dog with complete heart block with a slow ventricular escape rhythm at 30/min (25 mm/sec and 10 mm/mV).


**Figure 6.6** (c) ECG from a 14-year-old Siamese with complete AV block. The first few P waves are arrowed. Note that in the first half of the tracing, the T waves merge with some of the P waves, which makes this look like a sinus rhythm initially.

(Fig. 6.6). This is best demonstrated by plotting out each P wave and each QRS complex on a piece of paper (Fig. 15.1 on page 98).

### *Clinical findings*

In many cases the ventricular escape rhythm associated with complete heart block is very regular (metronomically so), although slow. So a regular slow bradycardia is heard with normally a good palpable pulse (sometimes the escape rhythm is not regular). On very careful auscultation (sometimes using the bell of the stethoscope) the atrial contraction sounds (S4) can be faintly heard at a faster rate and not related to the normal lubb-dub of ventricular contraction.