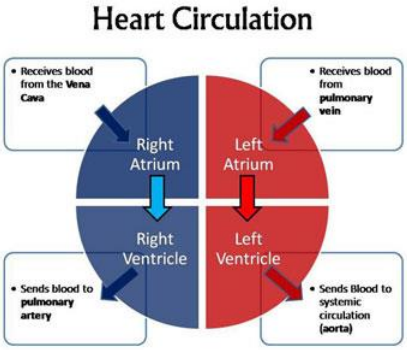
CRITICAL CARE OF THE CARDIAC PATIENT WEBINAR VET 2017

The Heart

The heart is undoubtedly the most important organ in the body. Unfortunately, when it is not functioning properly, it can have dire consequences. Below is a very simplified diagram of the heart



The **Right Atrium** receives deoxygenated blood (note it is blue in the diagram) from the vena cavae (cranial and caudal). The blood then travels from the atrium to the **Right Ventricle** (through the *tricuspid valve*). The right ventricle then pumps the blood into the pulmonary artery (through the *pulmonic valve*), which goes to the pulmonary circulation where it is oxygenated (and turns red). The blood returns from the lungs via the pulmonary vein into the **Left Atrium** (there is no valve here), which then pumps blood into the **Left Ventricle** (through the *mitral valve*). The left ventricle has the biggest job, pushing blood into the systemic circulation via the aorta, to perfuse the body.

When the heart stops working the way it should (or perhaps there is a congenital problem which has always been there and perhaps acutely worsens), it usually falls into one of three categories:

1 Structural abnormality: valve defects, septal defects
2 Chamber abnormality: atrial or ventricular enlargement, atrophy
3 Problem with the conduction system of the heart (arrhythmias)

As a disease progresses, it can cause changes in each of the three categories. For example, Dilated Cardiomyopathy, a disease commonly seen in Dobermans and giant breeds, begins with dilation of the left ventricle, as the ventricle dilates, the mitral valve will also change in structure, leading to a murmur, and finally, arrhythmias occur due to the dilation (a very simplified picture).

There are four methods we use in the diagnosis of heart disease and they include:

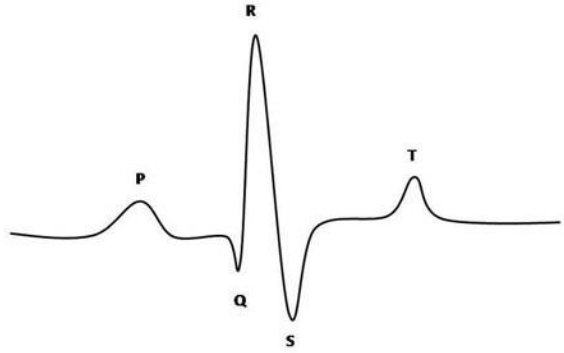
1 Auscultation
- This is the front-line diagnostic, an irregular rhythm or a murmur will often prompt further diagnostics
- This skill should be developed and utilized by every technician. At every opportunity, take a moment to auscult the heart and lungs; palpate the pulses at the same time to determine any pulse deficits.

2 Thoracic Radiographs
- May be used for cardiac or pulmonary evaluation or for many other purposes. Generally can identify some chamber abnormalities (such as cardiomegaly), or signs of congestive cardiac disease.

3 Electrocardiography
- A primary diagnostic tool, will identify if the rhythm is abnormal, can also give more subtle information such as chamber enlargement. A very important tool!

4 Echocardiography
- Provides information on all aspects of the heart including structure and function of

the valves and chambers, arrhythmias. Provides a full picture of the heart. This is probably the most important diagnostic tool for providing a definitive diagnosis.



The Sinus Beat:

This image shows a typical sinus beat on an ECG as shown in Lead II. The normal sinus ECG complex involves 3 distinct wave forms: P-wave, QRS complex (which is actually three waves in close relation to one another), and the T-wave.

The P-wave reflects atrial depolarisation. The QRS complex is the ventricular depolarisation. The T-wave is the ventricular repolarisation. This is important to understand, as p-wave abnormalities indicate atrial dysfunction, while QRS abnormalities signify ventricular dysfunction.

The heart is a muscle, and muscles are driven by electrical stimuli. In the case of the heart, we have a conduction system that includes:

The Sino-Atrial (SA) Node:
- Coordinates all electrical activity in the heart
- The cells of the SA node do not require direct stimulation of the nervous system to initiate an action potential this is the primary pacemaker

The Atrio-Ventricular (AV) Node:
- Transmits electrical stimuli from the atria to the ventricles
- Allows coordination between atrial and ventricular contraction
- Moderates the contraction of the ventricles when there is excessive atrial stimulation

The Bundle of HIS:
- A short electrical route connecting the AV node and the Bundle Branches.

The Bundle Branches:
- Transfers electrical current from the Bundle of His to the left and right ventricles

The Purkinje Fibres:
- The terminal fibres of the bundle branches in the myocardium

Abnormalities in the conduction system of the heart lead to cardiac arrhythmias, which are represented on the ECG.

So, when we look at the normal sinus rhythm, we are looking at a representation of normal conduction in the pattern just discussed. Usually, we use lead II for most simple ECG's in

veterinary patients. We have a variety of other leads that we can use if we have a sophisticated enough machine, but Lead II is the most common and provides the most *normal* looking sinus beat. Other limb leads include I and III, which we may use on occasion, usually if we can't get Lead II to give us a nice view.

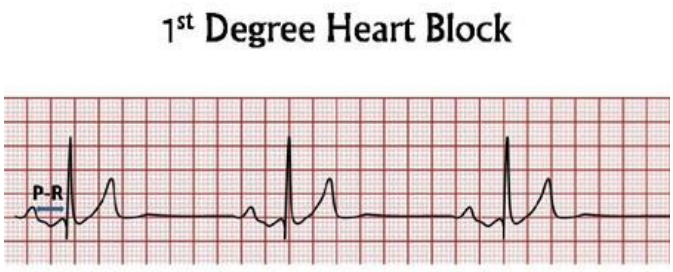
So, what is Lead II? Most modern ECG's have three electrodes (also commonly called leads, although this is a slight misnomer). Some machines have a fourth electrode which is green and is simply a ground, it doesn't contribute any electrical information. The typical leads are marked:
Red: RA (right arm in human terms), placed on the right forelimb in our patients
Yellow: LA (left arm), placed on the left forelimb
Green: LL (left leg), placed on left hind limb

With the three lead system, two leads are active, and the third acts as the ground. When a signal is dropped, in my experience it is most likely caused by the active leads, so as an example, in Lead II, the RA and LL are active. Try to add some more gel or alcohol to these two leads and it will often help your tracing. If not, then put more gel or alcohol on the ground lead.

Cardiac arrhythmias can be atrial or ventricular in origin, and are common cardiac emergencies. Arrhythmias may occur in bursts, episodes, or be sustained for long periods of time. Depending on the type of arrhythmia, treatment will vary and the rapidity and criteria for treatment will vary. Let's discuss some common arrhythmias by dividing them into two categories: Bradyarrhythmias (arrhythmias with a slow rate) and tachyarrhythmias (arrhythmias with a fast rate)

Bradyarrhythmias: These are arrhythmias characterised by a slow heart rate.

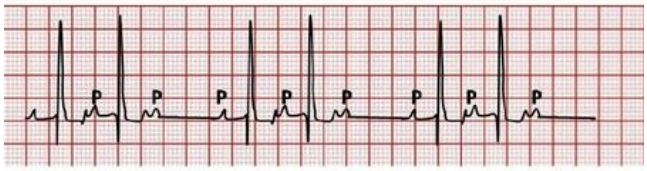
First Degree Heart Block
1st Degree Heart Block is caused by prolonged conduction through the A-V node, resulting in a prolonged P-R interval. This may be normal for the patient, and is rarely treated unless the patient is extremely bradycardic. The patient is responsive to atropine and glycopyrrolate. This arrhythmia can be associated with drug therapy, and is also seen in hyperkalemic patients.



This is 1st Degree Heart Block, characterized by a prolonged P-R interval, but otherwise normal looking strip. Does not cause hemodynamic change.

Second Degree Heart Block
2nd Degree Heart Block comes in two forms; 1) Mobitz Type I, and 2) Mobitz Type II. Of the two, Mobitz type II is the more serious condition. Mobitz Type I is often a transient condition often seen when a patient has increased vagal tone (abdominal pain, vomiting) and is often seen after an insufficient dose of glycopyrrolate.

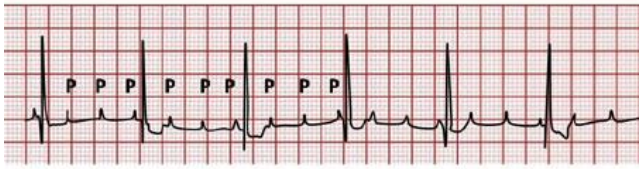
2nd Degree Heart Block



This is 2nd Degree Heart Block, Mobitz Type I. We see p-waves that are not followed by a QRS complex. This type rarely causes significant hemodynamic change.

Characteristics include: lone p-waves without an accompanying QRS complex, and a slightly longer P-R interval following the blocked beat.
Type I is responsive to glycopyrrolate or atropine, and will resolve immediately. It is also known as Wenckebach.

2nd Degree Heart Block

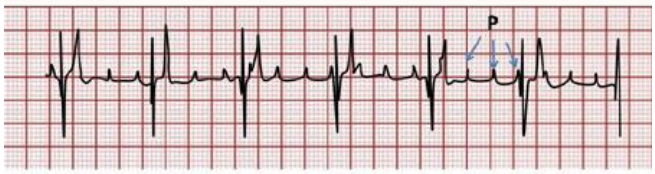


This is 2nd Degree Heart Block, Mobitz Type II. We see p-waves that are not followed by a QRS complex. This type is more serious than type I and often results in reduced cardiac output.

Mobitz Type II is a potentially more serious condition where again, there are lone P-waves without an accompanying QRS complex (which may occur in multiples) and a consistent P-R interval. It can lead to severely reduced cardiac output if the ventricular rate is very low, and is NOT responsive to atropine or glycopyrrolate. This condition may require a pacemaker placement.

3rd Degree Heart Block

3rd Degree Heart Block



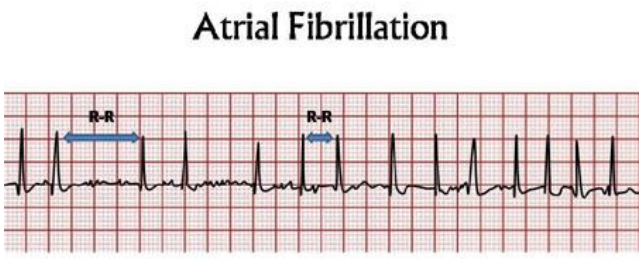
This is 3rd Degree Heart Block. There are p-waves that are not followed by a QRS complex. The QRS's appear bizarre due to their ectopic foci, and are not associated with the P-waves.

3rd Degree Heart Block has a somewhat similar appearance to 2nd Degree, Type II, often with multiple P-waves before a QRS. The difference is that the P-waves have no association with the QRS complex...in other words; the QRS's appear at random. The QRS's that do appear are called escape beats, and are initiated from foci within the ventricles.
This rhythm is usually not responsive to atropine, and most often requires placement of a pacemaker.

Tachyarrhythmias

Atrial Fibrillation

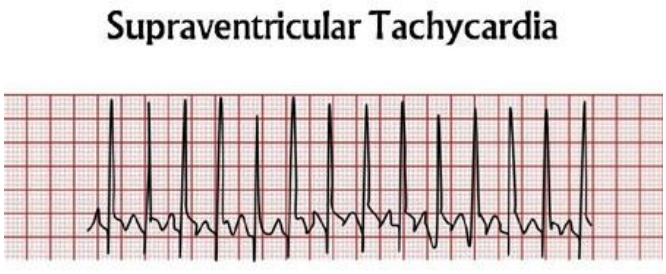
Atrial fibrillation results when many foci fire repeatedly within the atria. This gives the characteristic undulating baseline.



This strip shows the hallmarks of a-fib including the undulating baseline, lack of distinct P-waves, and variable R-R interval.

The activity of the atria causes increased ventricular firing, resulting in a rapid ventricular rate with an irregular rhythm. This is the arrhythmia that has been likened to the "tennis shoe in the dryer" on auscultation. Often at very fast rates, it is difficult to discern from SVT, as the rhythm may appear regular...if the rate slows slightly it becomes easier to see that it is indeed irregular. A-fib is typically seen in disorders causing atrial dilation, such as cardiomyopathy.

Supraventricular Tachycardia
As the name implies, this arrhythmia occurs *above the ventricles...*meaning in the atria.



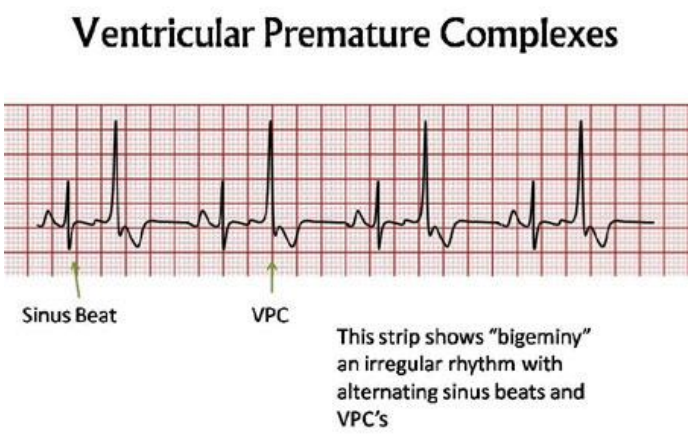
SVT is generally a very rapid rate of 150-300 bpm which can occur in bursts or be sustained. This strip shows SVT at a rate of 225 bpm.

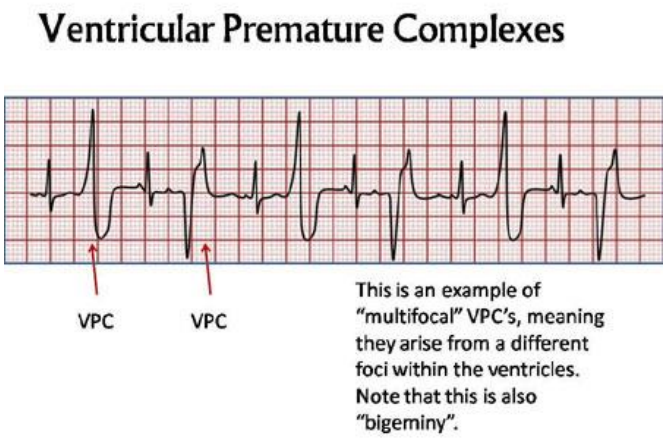
SVT is caused by ectopic foci within the atria. The complexes can be very tall and narrow, and often it is difficult to discern P and T waves...there is often a single wave between

QRS's that encompasses both the P and T-wave. SVT can be an extremely rapid rate, often in the high 200's to 300's. It is caused by bursts of premature atrial contractions (APC's) that can be transient or sustained. When sustained, cardiac output is severely compromised, and patients can deteriorate quickly. SVT may be broken by increasing vagal tone, i.e. performing "vagal maneuvers" such as carotid sinus massage or putting pressure on the eyeballs. Calcium channel blockers such as diltiazem are often administered to break the SVT.

Supraventricular Premature Contractions
SVPC's are the components of supraventricular tachycardia when they occur singly or in small groups. They originate the same as SVT from ectopic foci in the atria.

Ventricular Premature Contractions VPC's are premature beats that originate from foci within the ventricles. Multiple foci will lead to VPC's with different structure, termed multifocal VPC's.



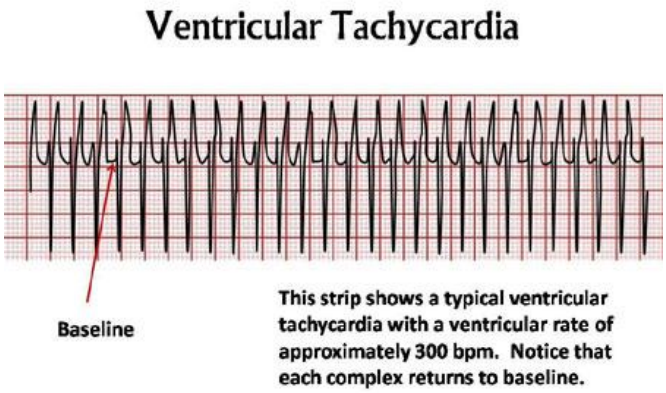


VPC's are usually followed by a pause, before the next sinus beat. Therefore the R-R interval of the sinus beat to the VPC is shorter, than the R-R of the VPC to the following sinus beat.

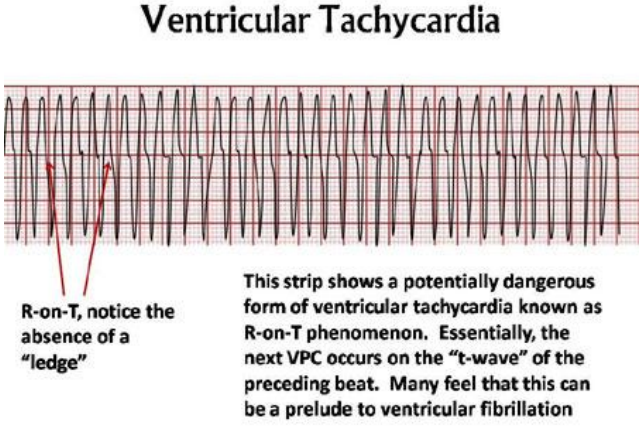
VPC's can be caused by heart pathology, myocardial hypoxia, following myocardial trauma (common following HBC), they can be associated with pain, acidaemic states, and the use of some drugs. Typically, VPC's are treated with lidocaine, and if this is ineffective, procainamide.
Sometimes, it is difficult to differentiate between SVPC's and VPC's. Treatment options for

the two arrhythmias differ and in some cases, the wrong treatment can worsen the condition. Several criteria exist for differentiating SVPC's and VPC's.

Ventricular Tachycardia
Ventricular Tachycardia is defined as runs of 3 or more VPC's in a row. This is a very common arrhythmia in veterinary patients, and every technician should be very familiar with it. It is rapid, often between 150-300 bpm.



V-tach is characterized by wide, bizarre QRS complexes, without an obvious P-wave. The rhythm is usually regular, and there is usually marked reduction in cardiac output. This is evident especially when measuring direct arterial pressures, as you can often see the pulse waves disappear altogether.
There are several criteria for treating V-tach. Some runs of VPC's and slow V-tach may go untreated; however, it is important to know what point you should treat. There have actually been studies done that have found that treated VPC's/V-tach may cause increased mortality, so, we do want to be cautious with treatment. It has been found that lidocaine and procainamide can be proarrhythmic as well as antiarrhythmic. The concern can be that some forms of untreated V-tach can move into ventricular fibrillation.
So, at present, the criteria are simply: Treat if:
1 The patient is symptomatic: i.e. the patient has markedly decreased cardiac output causing syncope or organ dysfunction.
2 The rhythm is at risk of becoming V-fib.
3 Sustained V-tach at a rate greater than 160-180 bpm.

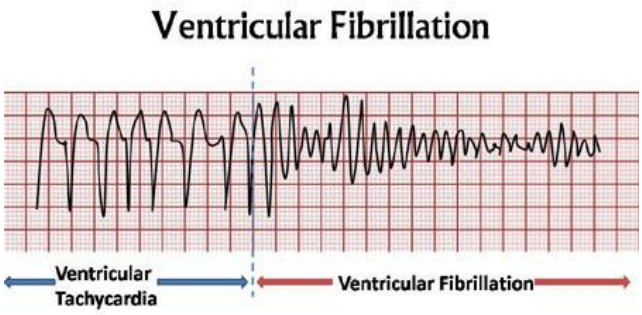


There is no doubt that Figure 13 is the strip of a patient that is at risk for entering V-fib. We have variation in the height of the QRS complexes, we have R-on-T phenomenon, and we

have an extremely fast rate. In contrast, Figure 12 shows a rapid V-tach, but the complexes are all the same. We would have to see how this is affecting the patient before treating.

Ventricular Fibrillation

V-Fib is a very interesting rhythm. It is the rhythm we are hoping to induce in arrested patients, so we can defibrillate them. In dogs, it rarely occurs spontaneously, and it is estimated that only about 10% of arrests fibrillate, compared to close to 50% in humans.



This strip shows the progression of ventricular tachycardia into ventricular fibrillation. Notice the erratic signature of the v-fib.

V-fib is recognized by its complete erratic rhythm with no discernable or identifiable waveforms. In fact, you may assume that the there is a disconnection or a problem with the machine...make sure you check your patient before the machine!!

Summary

It is important to recognise how the varying pathophysiology of the individual cardiac diseases impacts on critical care. Most cases can be successfully managed in general practice, but it is essential to appreciate that some cases may require more intensive care and support, and consideration should be given to referral to a centre with specialists even if the condition is relatively uncomplicated.