To get the most out of the Basic ECG Interpretation Study Day please read this Package prior to attendance. At the study day, you will be required to undertake a pre test so it is important the information has been read properly. If you are not confident in your ECG knowledge and / or it has been a long time since you learned how to do an ECG, do not be overwhelmed by the Learning Package. If there are any aspects you do not understand or are not sure of, bring your questions to the Study Day where they can be answered. The objective of the CNE ECG education is to give you the skills to conduct a good quality ECG and be able to identify abnormalities; this Package and the study day are designed to achieve that objective and have you feeling confident. And may help save a life… Happy reading!

Welcome to the (a)ECG Interpretation learning package. This package has been designed for Division one and Division two nurses in the Grampians and Loddon Mallee regions.

ECGs are a useful tool in cardiac assessment as they give us information about our patient’s heart activity.

More specifically, the ECG waveform represents a sequence of electrical impulses across the myocardium, or heart muscle.

Irregularities or abnormalities can occur at any stage in this sequence, which is why it’s so important to be able to read ECGs correctly.

This package has been designed to teach you about how to correctly interpret rhythm strips and ECGs within the health care environment.

During this package, we’ll learn about many different aspects of ECG interpretation. We’ll cover the following topics:

- ECG Fundamentals
- Rhythm Interpretation
- ECG Interpretation.

In this section of the course, we’ll cover the basics of how an ECG works. We’ll learn about:

- ECG – How it works
- ECG Leads
- ECG Paper
An ECG is a linear graphic recording of the electrical impulses generated in the heart during the cardiac cycle.

The electrical impulses are measured by electrodes on the skin.

Electrodes on different sides of the heart measure the activity of different parts of the heart muscle.

The ECG displays the voltage between pairs of these electrodes, and the muscle activity that they measure.

This indicates the overall rhythm of the heart and abnormalities in different parts of the heart muscle.

It's the best way to measure and diagnose abnormal rhythms of the heart.

In ECG terms, a lead is a combination of electrodes that form an imaginary line in the body along which electrical signals are measured.

In a 12 lead ECG, three groups of leads are used, each looking at different aspects of the heart:

- Bipolar limb leads
- Unipolar limb leads
- Unipolar precordial (chest) leads.

Each lead records the electrical signals of the heart from a particular combination of recording electrodes which are placed at specific points on the patient's body.
The bipolar limb leads are known as leads I, II and III. They are also called standard leads.

The bipolar leads are placed on each of the patient's arms and legs.

They use a single positive electrode and a single negative electrode between which electrical potentials are measured. The bipolar leads view the frontal plane of the heart from these two points.

The unipolar limb leads are known as leads aVR, aVL and aVF.

These leads use a single positive electrode and a combination of the other electrodes to serve as a composite negative electrode.

Like the bipolar leads, unipolar limb leads record electrical activity along the heart's frontal plane, but from a different angle.
The unipolar precordial leads are known as leads V1, V2, V3, V4, V5 and V6. These leads are placed directly on the chest and view the heart’s electrical activity in the horizontal plane. Each of the precordial, or chest leads, can be read as pairs looking at different views of the heart. Leads V1 and V2 have a septal view. Leads V3 and V4 have an anterior view. Leads V5 and V6 have a lateral view.
Now, let’s take a look at the ECG paper.

The ECG paper provides a measurement of the heart’s electrical impulses measured against time.

ECG paper is divided into 1 millimetre small squares and 5 millimetre large squares.

The paper moves through the ECG at 25 mm per second.

This means that, on the horizontal axis, one small square equals 0.04 seconds.

One large square, made up of 5 small ones, equals 0.20 seconds.

On the vertical axis, the paper shows the amplitude of the electrical impulse, which is measured in millivolts (mV).

In this section of the package, we’ll learn about rhythm interpretation.

We’ll cover:

- Determining Heart Rate
- The PQRST Complex
- The P Wave
- The PR Interval
- The QRS Complex
- The T Wave
- Normal Electrical Impulse Conduction
- The Pacemakers of the Heart
- Step-by-step Rhythm Interpretation
Let’s look at how to measure heart rate on an ECG.

First, count thirty large boxes on the ECG paper.

As we’ve learned, each large box equals 0.20 seconds. So 30 large boxes gives you a six second strip.

Next, count the number of beats, or complexes, within the six second strip.

Multiply this number by ten.

This will give you the number of heart beats per minute.

It’s important to note that this method is accurate only to within ten beats per minute.

9 complexes in 6 seconds. 9 x 10 means the heart rate is roughly 90 bpm
Now, let’s look at the PQRST complex.

The PQRST complex is a systematic method of interpreting rhythm on an ECG. In this section of the course, we'll look at:

- The P Wave
- The PR Interval
- The QRS Complex
- The T Wave
- The Pacemakers of the Heart.

Normally, the heart beats with a regular rhythm, generated by the sinoatrial, or SA, node.

The SA node is the heart’s pacemaker – it determines how quickly the heart beats.

The P wave represents the electrical activity of the heart’s atria when the SA node is activated.

So, why is the P wave important?

Firstly, because we can recognise various cardiac arrhythmias by looking at the relationship between P waves and QRS complexes, which we'll learn about shortly.

Secondly, because the shape and duration of P waves may also indicate atrial enlargement.
The duration of the P wave is normally, about 0.08 to 0.10 seconds, covering 2 to 2.5 small squares horizontally on the ECG paper.

The amplitude, or height, of the P wave is 2.55mm or less, covering approximately 2.5 squares vertically on the ECG paper.

The P wave is positive in most leads, which means it's above the baseline, or isoelectric line, on the ECG paper.

It should also be rounded, not peaked, pointy or notched.

The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex.

It represents the time taken for the electrical impulse to spread through the atria and down through the atrioventricular node, or AV node, to the heart’s ventricular muscles.

The AV node is a secondary pacemaker, acting as a back up to the SA node.

The PR interval on an ECG should measure 0.12 to 0.20 seconds, covering 3 to 5 small boxes on the ECG.

If the PR interval is abnormally short or abnormally long, it may indicate a heart problem.

The QRS complex on an ECG represents the electrical activity associated with the activation of the heart’s ventricles. In other words, it shows the depolarisation of the ventricles.

It may have three components:

- The Q Wave
- The R Wave
- The S Wave

The Q Wave is the first negative deflection on the complex.

The R wave is the first positive deflection of the complex.

The S wave is the first negative deflection after the R wave.

We can use the duration, amplitude, and shape of the QRS complex to diagnose cardiac arrhythmias, and other heart diseases.
The QRS complex normally lasts 0.08 to 0.12 seconds. At most, this covers three small boxes horizontally on the ECG.

The normal amplitude, or height, of the QRS complex varies depending on the lead.
In the standard leads, it is not greater than 25mm, or 5 large squares.
In leads V1 and V6, or V2 and V5, it is not greater than 35mm.
In Lead I or aVL, the amplitude should not be greater than 12mm.
We’ll learn about ECG leads in more detail later in the course.

The T wave on an ECG represents the repolarisation, or recovery, of the ventricles.
The T wave should not be greater than 5mm in the standard leads, or less than 10mm in the chest leads.
The T wave occurs in the same direction as the QRS complex.
It should be rounded, not pointed or asymmetrical.
The shape of the T wave can indicate heart disorders.

Okay, let’s recap what we’ve learned about the PQRST Complex.
The P wave represents atrial depolarisation.
The PR interval represents atrial depolarization. It allows a delay at the atroventricular junction, to enable the mechanical contraction of the atria prior to the ventricular contraction.
The QRS complex represents ventricular depolarisation
The T wave represents ventricular repolarisation.
As we learned earlier, the sinoatrial node, or SA node, is the dominant pacemaker of the heart. It has an intrinsic rate of 60-100 beats per minute.

The atrioventricular (AV) node is a secondary pacemaker, and acts as a back up pacemaker to the sinoatrial node. It has an intrinsic rate of 40-60 beats per minute.

The ventricular cells can also act as pacemakers, backing up the AV node. They have an intrinsic rate of only 20-45 beats per minute.

Okay, we've now covered some of the fundamentals of rhythm interpretation.

In this section, we'll learn about (a)rrhythm interpretation in practice, by using the following steps:

- Step One – Calculate the rate
- Step Two – Determine if the rate is regular
- Step Three – Assess for P waves
- Step Four – Measure the PR interval
- Step Five – Determine the QRS duration

Let's look at each of these steps in more detail.

To calculate the heart rate, count the number of R waves in a six second strip, then multiply by ten.

This gives you the number of beats per minute.
Next, we need to determine if the heart rate is regular. The easiest way to do this is to measure the distance between R waves with a separate piece of paper and pen.

Mark one R-R interval on the piece of paper. Use this measurement to gauge if the other R-R intervals on the ECG are an equal distance apart.

To assess for P waves, you need to ask yourself the following questions:

- Are there P waves within the rhythm?
- If yes, is there a P wave prior to every QRS complex?
- Do the P waves look alike?
- Do the P waves occur at a regular rate?

Measure the PR interval by counting the number of squares it covers on the ECG paper.

- A normal PR interval should measure 0.12 to 0.20 seconds, or 3-5 small squares.
- If the PR interval is greater than 0.20 seconds, it's known as a prolonged PR interval.

Measure the QRS complex by counting the number of squares it covers on the ECG paper.

- The normal QRS duration is 0.08 to 0.12 seconds. So the complex should cover 2 to 3 small boxes.

Now, let’s test your understanding of rhythm strip interpretation with a short multiple choice quiz.
Now you've learned the basics of rhythm interpretation, it's time to take a look at ECG interpretation.

In this section, we'll learn about ECG rhythms including:

- Sinus Rhythms
- Atrial Arrhythmias
- Ventricular Arrhythmias
- Other Lethal Arrhythmias
- Acute Myocardial Infarction.

The first group of ECG rhythms we'll learn about are sinus rhythm interpretations. These include:

- Normal sinus rhythm
- Sinus bradycardia
- Sinus tachycardia
- Premature atrial contractions.

Sinus rhythm is a term used in medicine to describe the normal beating of the heart. It has certain generic features that serve as hallmarks for comparison with normal ECGs.

A normal sinus rhythm occurs when an electrical impulse is generated by the SA node and conducted normally through the heart muscle.

It's characterised by a heart rate of 60 to 100 beats per minute.

The rhythm is regular and has normal-shaped P wave, and a normal PR interval, QRS complex, T wave and ST segment.
As we've seen, sinus rhythm is the normal rhythm of the heart. However, there are other rhythms that don't conform to the typical pathways. These rhythms are known as arrhythmias.

Arrhythmia refers to any condition where there is abnormal electrical activity in the heart.

The heartbeat may be too fast or too slow, and may be regular or irregular.

Some arrhythmias are life-threatening medical emergencies that can result in cardiac arrest and sudden death.

Others can be minor, merely causing annoying symptoms such as palpitations.

Others may not be associated with any symptoms at all, but may pre-dispose the patient toward potentially life threatening stroke or embolism.

Sinus bradycardia is defined as a sinus rhythm with a rate less than 60 beats per minute. Essentially, it's a slower than normal heart rate.

Sinus bradycardia occurs when the SA node is depolarising more slowly than normal. However, the electrical impulse is still conducted normally through the heart muscle.

On an ECG, sinus bradycardia has an otherwise normal morphology

Causes of sinus bradycardia include

- Drugs
- Acute Myocardial Infarction
- Raised intracranial pressure, and
- Hypothermia.

It's also a normal finding in healthy people at rest.
Sinus tachycardia is defined as a sinus rhythm with a ventricular rate greater than 100 beats per minute. This means it's a faster than normal heart rate.

In itself, tachycardia is not necessarily an arrhythmia. Increased heart rate is a normal response to physical exercise or emotional stress.

On an ECG, sinus tachycardia has an otherwise normal morphology.

Possible causes of sinus tachycardia include:

- Shock
- Dehydration
- Cardiac failure
- Anaemia
- Pain
- Anxiety
- Substances such as caffeine or amphetamines, and
- Hyperthyroidism.

Premature Atrial Contractions (PACs) appear as an early P wave, often with an abnormal morphology.

PACs are caused by the excitation of an atrial cell, which forms an electrical impulse that is then conducted normally through the AV node and ventricles.

PACs may be followed by a QRS complex. 60% of adults will have some premature atrial contractions in any 24 hour period.

They are generally asymptomatic, which means the person does not know they are occurring.

Causes of PACs include:

- Caffeine
- Nicotine, and
- Alcohol.
Atrial arrhythmias are any abnormal heart rhythms that occur in the heart’s two upper chambers, or atria. They include:

- Atrial fibrillation
- Atrial flutter, and
- Supraventricular tachycardia.

Let’s look at each of these in detail.

<table>
<thead>
<tr>
<th>Atrial fibrillation is the most common form of arrhythmia.</th>
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<tbody>
<tr>
<td>It’s characterised by rapid and chaotic electrical discharges within the atria.</td>
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<tr>
<td>These electrical impulses don’t originate from the SA node, so an ECG will not show any P waves.</td>
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<tr>
<td>As the atrial activity is chaotic, atrial fibrillation results in an irregular heart rate. The rate can range from 60 to 100 beats per minute.</td>
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<tr>
<th>Atrial flutter caused by rapid and regular electrical discharges in a singular ectopic focus between the atria.</th>
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<tr>
<td>While atrial flutter can sometimes go unnoticed, it is often characterised by regular palpitations.</td>
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<tr>
<td>Only some of these electrical impulses are conducted through the AV node, so an ECG will not show any P waves during an atrial flutter – but will show flutter waves instead.</td>
</tr>
<tr>
<td>Atrial flutter waves form a “saw tooth” pattern, as pictured.</td>
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</tbody>
</table>
Supraventricular tachycardia, or SVT, is a rapid rhythm of the heart in which the electrical signal originates at or above the AV node.

It's characterised by a rapid rate of 140 to 250 beats per minute, with a normal width QRS complex.

An ECG will show abnormal P waves in a fixed relationship to the QRS complex. The P waves might be obscured.

Picture above has a pt moving into an SVT from a rhythm of normal rate.

Ventricular arrhythmias are abnormal heart rhythms that originate in the ventricles. It is very important to be able to recognise and identify ventricular arrhythmias as many of them can be lethal.

Ventricular arrhythmias include:

- Premature Ventricular Contractions
- Ventricular Fibrillation
- Ventricular Tachycardia, and

Premature ventricular contractions (PVCs) are an early or extra beat generated from the heart's ventricles. The depolarisation of cardiac cells starts in the ventricle instead of the SA node.
Ventricular fibrillation or VF is a completely abnormal rhythm in which the heart's ventricular cells are excitable and depolarising randomly.

This means the ventricles tremble rather than contract properly.

Ventricular fibrillation is a medical emergency. If it continues for more than a few seconds, blood circulation will stop, and death may occur in a matter of minutes, if the situation isn't quickly reversed.

Ventricular tachycardia (VT) is a fast heart rate which originates in the ventricles.

It's characterised by the absence of P waves and a wide QRS complex – with duration of greater than 0.12 seconds.

The heart rate is greater than 100 beats per minute

The mechanism of VT is usually caused an area of increased automaticity or a re-entrant or pathway looping in a ventricle.

It can sometimes generate an output great enough to produce a pulse, at other times no pulse can be felt.

Picture above shows a patient having a short run of VT (see arrow) in the setting of an ST elevated AMI.

In addition to the ventricular arrhythmias we’ve discussed, other lethal arrhythmias include asystole, and pulseless electrical activity (PEA), also known as Electromechanical Dissociation (EMD).

Asystole is the absence of any electrical activity in the heart. It produces no cardiac output, so appears on an ECG as a nearly flat line.

In PEA or EMD, the heart muscle is still producing electrical impulses. However, the physical mechanics of the heart are not working, and so no output is produced.
Also known as a heart attack, an acute myocardial infarction (AMI) occurs when blood supply to part of the heart is interrupted.

An ECG can be used to classify an AMI into:

- An ST Elevation Myocardial Infarct (STEMI), or
- A Non-ST Elevation Myocardial Infarction (Non-STEMI)

Remember, a normal 12 lead ECG does not always rule out an acute myocardial infarct.

It can be difficult to identify an AMI using an ECG.

When looking at a 12 lead ECG it is important to examine each lead individually and group each of the leads accordingly.

The Inferior section of the heart is viewed by grouping leads II, III and aVF together.

The Septal section of the heart is viewed by grouping leads V1 to V2.

The Anterior section of the heart is viewed by grouping leads V3 to V4.

The Lateral section of the heart is viewed by grouping leads I, aVL, V5 and V6.

The ST segment elevation occurs during the acute phase of a Myocardial Infarction.

On an ECG, it shows as a vertical elevation of the ST segment of the PQRST complex of 2mm or more from the isoelectric line.

ECG below shows a patient with an anterior / septal ST elevated AMI.
An ECG can also help you locate an AMI within the heart. You can determine the location of the AMI from the leads that show the ST elevation. An acute inferior myocardial infarct involves ST elevation of leads II, III and aVF. An acute septal myocardial infarct involves the chest leads V1 and V2. An acute anterior myocardial infarct involves the chest leads V3 and V4. An acute lateral myocardial infarct involves chest leads V5 and V6.

Great, we’re nearly at the end of the course. During the course, we’ve learned about:

- ECG Fundamentals
- Rhythm Interpretation, and
- ECG Interpretation.

You should now have a good understanding of basic ECG interpretation.

Irregularities or abnormalities in heart rhythm can be dangerous and even lethal. Being able to correctly interpret rhythm strips and ECGs is crucial to providing good health care. Looking at the amplitude, morphology and duration of the PQRST complexes shown on the ECG can give you vital clues about the nature and location of heart problems.

Congratulations, you’re at the end of the course. Now, let’s test what you’ve learned in short multiple choice quiz (the pre test).