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Intracavitary ECG Technology to Determine Catheter Tip Position

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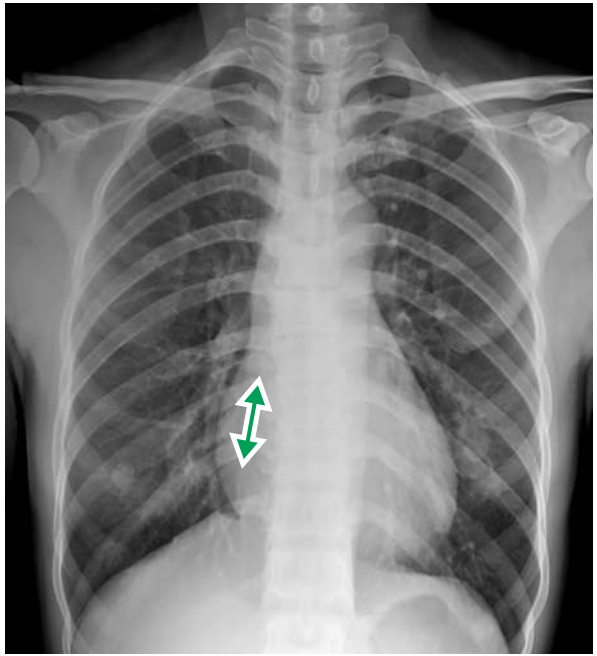
The importance of Vascular Access Device tip position

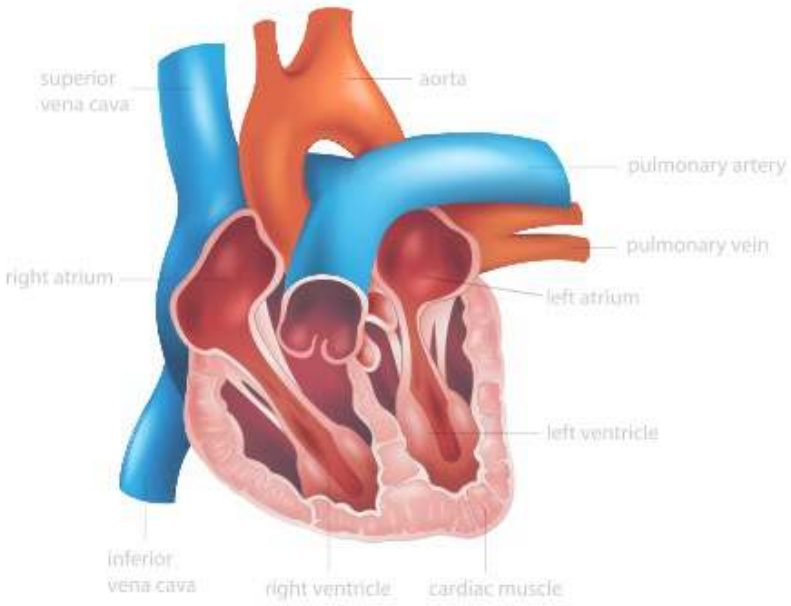
- The ideal catheter tip position is in the lower Superior Vena Cava (SVC) / Upper Right Atrium



The Superior Vena Cava (SVC)

The SVC is created by a merger of the right and left brachiocephalic veins and terminates by joining the right atrium.

One complication of Vascular Access Devices is tip malposition. This can be a catheter tip terminating in the small veins of the SVC or lower down into the lower atrium or in the innominate vein.



Complications of incorrect tip positioning

TOO SHORT	TOO LONG
Venous Thrombus	Arrhythmias
Malfunction	Atrial Perforation
Fibroblastic Sleeve	Tricuspid Damage
Caval Perforation	Cardiac Tamponade (very rare)

Methods to determine tip location

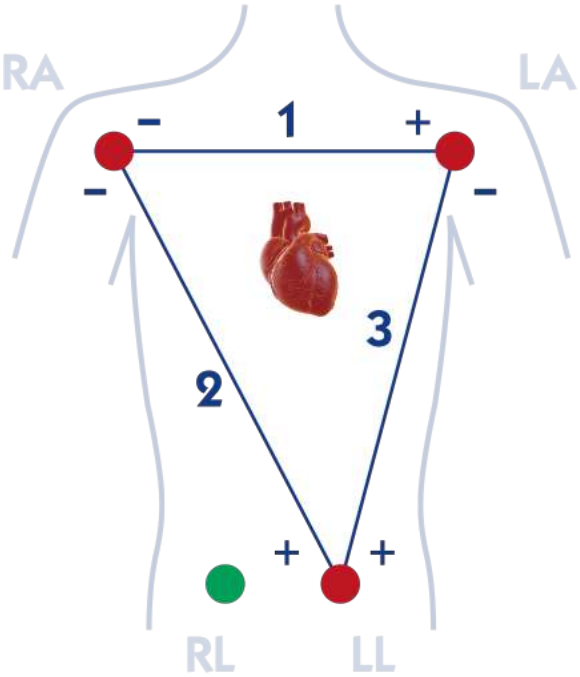
- Post device insertion chest x–ray
- Transoesophageal Echocardiogram (TOE)
- Fluoroscopy (under x-ray guidance)
- Intracavitary (IC) Electrocardiogram guidance

IC-ECG Technology for confirmation of catheter tip position

- This method is based on the principle of advancing the catheter towards the right atrium
- This leads to predictable variations of width of the P wave.

IC-ECG method

- ECG guidance uses an Intracavitary lead II ECG
- The Intracavitary electrode is the catheter tip
- Based on changes of the P wave during insertion
- CAJ = CT = Maximal P
- To understand the principles, you need to understand the basics of sinus rhythm and the PQRS complex



Sinus Rhythm
The PQRS complex

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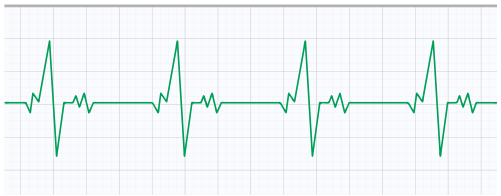
Sinus Rhythm

- Sinus rhythm is the name given to the normal rhythm of heart where electrical stimuli are initiated in the SA node, and are then conducted through the AV node and bundle of His, bundle branches and Purkinje fibres

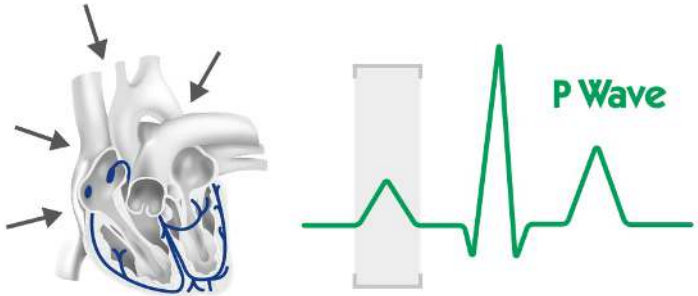
- Depolarisation and repolarisation of the atria and ventricles show up as 3 distinct waves on ECG.
  A unique labelling system is used to identify each wave



- Although the diagram shows 5 waves, we will concentrate on 3 waves. You will not always see a Q wave or an S wave on an ECG
- This is why only 3 waves are emphasised when you are first learning.

The P-Wave

- The first wave (P wave) represents atrial depolarisation
- When the valves between the atria and ventricles open, 70% of the blood in the atria falls through with the aid of gravity, but mainly due to suction caused by the ventricles as they expand
- Atrial contraction is required only for the final 30% and therefore a relatively small muscle mass is required and only a relatively small amount of voltage is needed to contract the atria.

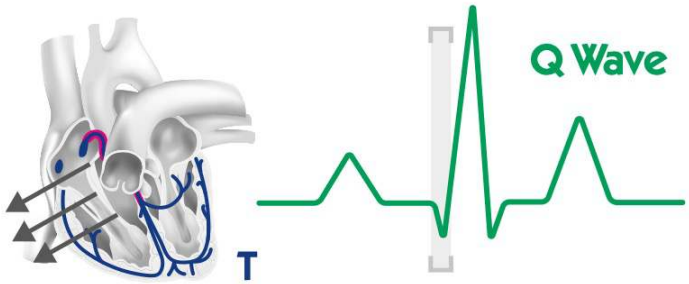


Sinus Rhythm

- After the first wave there follows a short period where the line is flat. This is the point at which the stimulus is delayed in the Bundle of His to allow the atria enough time to pump all the blood into the ventricles
- As the ventricles fill, the growing pressure causes the valves between the atria and ventricles to close. At this point the electrical stimulus passes from the Bundle of His into the bundle branches and Purkinje fibres
- The amount of electrical energy generated is recorded as a complex of 3 waves known collectively as the QRS complex
- Measuring the waves vertically shows voltage. More voltage is required to cause ventricular contraction and therefore the wave is much bigger.

The Q Wave

- This picture shows a small negative wave immediately before the large QRS complex. This is known as a Q wave and represents depolarisation in the septum
- Whilst the electrical stimulus passes through the Bundle of His, and before it separates down the two bundle branches, it starts to depolarise the septum from left to right
- This is only a small amount of conduction (hence the Q wave is less than 2 small squares), and it travels in the opposite direction to the main conduction (right to left) so the Q wave points in the opposite direction to the large QRS complex.

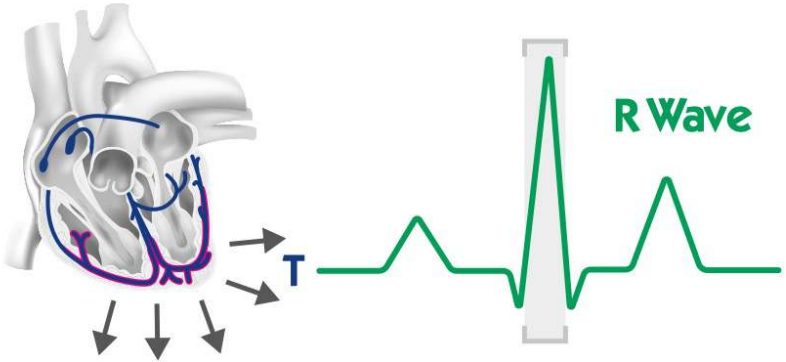


The R Wave

- The QRS complex is made up of three waves. These waves indicate the changing direction of the electrical stimulus as it passes through the heart's conduction system
- The largest wave in the QRS complex is the R wave.

The R Wave

- As you can see from the diagram, the R wave represents the electrical stimulus as it passes through the main portion of the ventricular walls
- The wall of the ventricles are very thick due to the amount of work they have to do and, consequently, more voltage is required
- Therefore the R wave is by far the biggest wave generated during normal conduction.
- More muscle means more cells
- More cells means more electricity
- More electricity leads to a bigger wave



The S Wave

- You will also have seen a small negative wave following the large R wave. This is known as an S wave and represents depolarisation in the Purkinje fibres
- The S wave travels in the opposite direction to the large R wave because, as can be seen on the earlier picture, the Purkinje fibres spread throughout the ventricles from top to bottom and then back up through the walls of the ventricles.

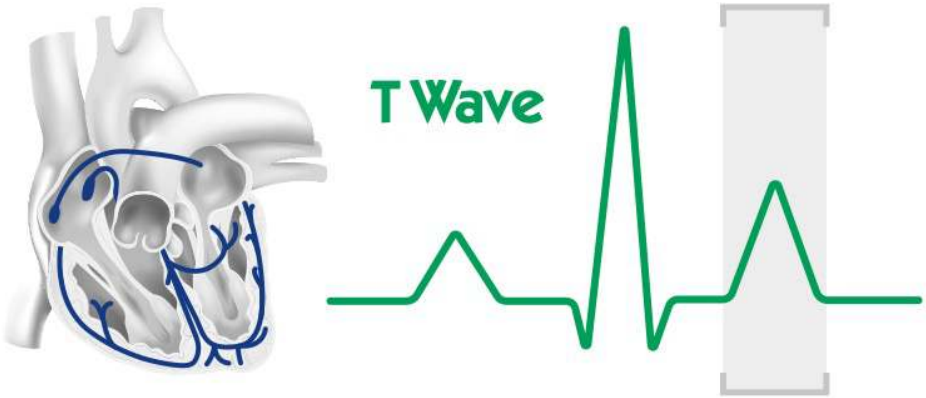
The S Wave

So now it is possible to break down the QRS complex into 3 distinct waves:

- Q wave representing septal depolarisation
- R wave representing ventricular depolarisation
- S wave representing depolarisation of the Purkinje fibres.

The T Wave

- Both ventricles repolarise before the cycle repeats itself and therefore a third wave (T Wave) is visible representing ventricular repolarisation.



The ST Segment

- There is a brief period between the end of the QRS complex and the beginning of the T Wave where there is no conduction and the line is flat
- This is known as the ST segment and it is a key indicator for both myocardial ischaemia and necrosis if it goes up or down.

The ST Segment

- So now you can see the 3 phases of the cardiac cycle which represents one heartbeat
- The previous example shows a rhythm strip of sinus rhythm. Here you can clearly see how each heartbeat is made up of 3 distinct waves: a P Wave; QRS Complex, and T Wave
- When you have a lot more experience you will be able to evaluate all 5 waves, but for now stick to 3.

Watch the following video

Cardiac conduction system and its relationship with ECG

IC-ECG guidance principles

- Tip of the catheter enters the lower third of the SVC
- The P Wave begins to rise

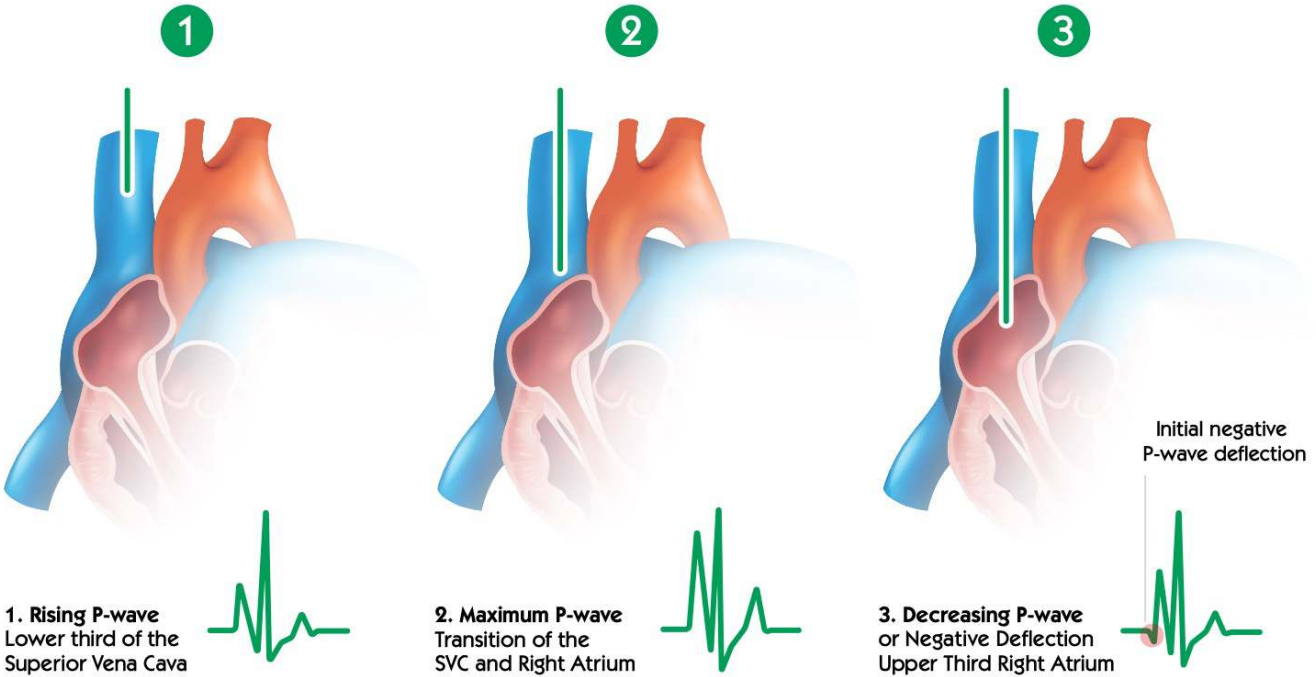
ECG guidance principles

- The tip reaches the transition between the SVC and the Right Atrium
- The P Wave reaches it’s maximum height
- Tip is in the Cavoatrial Junction (CAJ)

IC-ECG guidance principles

- The tip passes the CAJ
- The P Wave decreases or becomes biphasic (negative then positive)

IC-ECG guidance principles



Benefits of IC-ECG

- No radiation
- Cost savings due to no x-ray or x-ray reporting
- Reduced need for reinsertions / repositioning
- Staff time savings
- Treatment delay reduced (no waiting for tip position confirmation)
- No need for patient transfer to another department
- Holistic approach for staff inserting device

Conclusion

- The use of IC-ECG for the confirmation of catheter tip positioning avoids the need for a confirmatory chest x-ray. The delay before the catheter can be used is also reduced. Finally this technology can reduce staff time and costs.

A knowledge of basic ECG (sinus rhythm and cardiac conduction) is necessary to understand the principle of this technology.