The Weekly Probe

15th April 2016 **Volume 13 Issue 10**

Measles Alert – A recent notification has been received regarding 4 recent cases of measles in NSW. The main message was to be alert for such cases. In this case the message was to "be alert to travellers who may have been exposed in youth hostels – this population is likely highly mobile. However, suspect measles in people with fever and rash **irrespective** of travel history".

THIS WEEK

Cardiac Pacemakers

A 78yo lady presents with chest tightness. She is noted to have a PR 128. What is going on? (PS- no response to carotid sinus massage or other vagal maneuvers) .

The ECG shows a broad complex tachy ~ 130 yet note that each ventricular beat is preceded by a ventricular pacing spike. Either the pacemaker is malfunctioning and firing off more rapidly, or more likely, it is sensing an atrial tachyarrhythmia rhythm and firing a subsequent ventricular beat. This atrial tachy could be a primary atrial tachy or a re-entrant event. (see next "pink ECG" re progress)

Taking a step back let's look at pacemakers. With a rising number of elderly patients, expanding indications and an improvement in technology, we are seeing an increase in the number of patients

who present with pacemakers and associated problems, so we should have a basic grasp on potential issues.

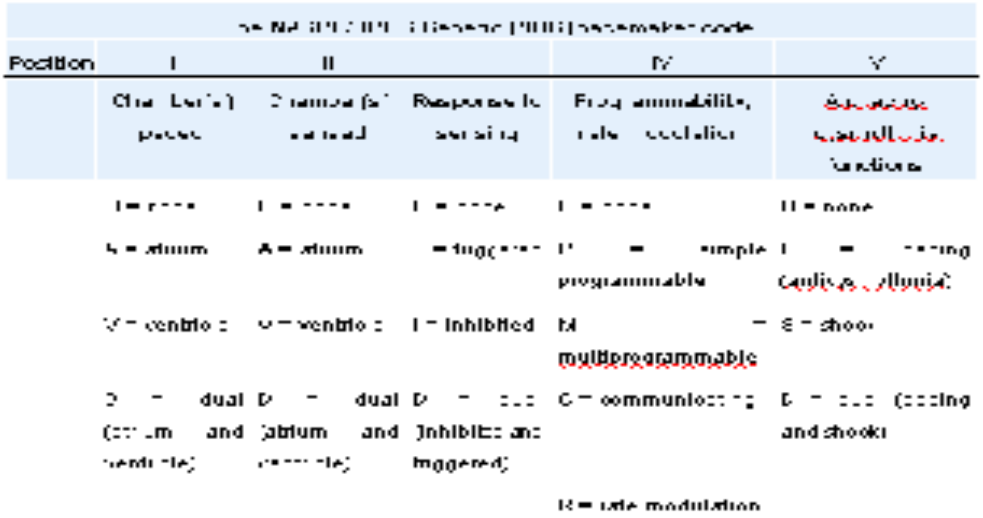
This review summarises an article by Chan and Cardall in Emergency Clinics of nth America 2006 (179-194) so if you want more details you can get the full article via CIAP - http://www.mdconsult.com/das/article/body/109149163-2/jorg=journal&source=&sp=15894874&sid=0/N/505720/1.html?issn=0733-8627 .

Pacing Modes

As pacemakers have evolved and assumed more functions and capabilities, a five position code has been developed by the Americans and the poms.

- Position I indicates the chambers being **paced**, atrium (A), ventricle (V), both (D, dual), or none (O).
- Position II gives the location where the pacemaker **senses** native cardiac electrical activity (A, V, D, or O).
- Position III indicates the pacemaker's **response** to sensing—triggering (T), inhibition (I), both (D), or none (O). Older versions of the code only designated these three positions, and pacemakers still are commonly referred to in terms of these three codes – one way to remember PS-R – chamber Paced / chamber Sensed / Response.
- Position IV indicates two things: the programmability of the pacemaker and the capability to adaptively control rate (R)- allows the pacemaker to increase the rate to meet physiological demands such as with exercise. “C” -ability to communicate with external equipment (ie, telemetry) “M” - multiprogrammable capability.
- Position V identifies the presence of antitachydysrhythmia functions, including the antitachydysrhythmia pacing (P) or shocking (S). The code does not designate how these functions are activated or if they are activated automatically or manually by an external command

From a practical standpoint, most pacemakers encountered in the ED are AAIR, VVIR, DDD, DDDR, or back-up pacing modes for cardioverter-defibrillator devices.



Position	I	II	III	IV	V
	Chamber(s) paced	Chamber(s) sensed	Response to sensing	Programmability, rate modulation	Antitachydysrhythmia functions
	O = none	O = none	O = none	O = none	O = none
	A = atrium	A = atrium	T = triggered	P = simple programmable	P = pacing (antitachycardia, antifibrillation)
	V = ventricle	V = ventricle	I = inhibited	M = multiprogrammable	S = shock
	D = dual (atrium and ventricle)	D = dual (atrium and ventricle)	D = dual (inhibited and triggered)	C = communicating	D = dual (pacing and shock)
				R = rate modulation	

Examples

1) AAI – senses & paces in atrium – Triggering of an atrial impulse is none is sensed within a pre-programmed time. Following this impulse there is a refractory period in which the pacemaker is insensitive to stimuli such as the QRS. If, following the refractory period, it senses atrial activity, it inhibits itself from stimulating the atrium.
2) DDD - In DDD pacing the atrium and the ventricle are sensed and paced or inhibited, depending on the native cardiac activity sensed. Most common form of dual-chambered pacing as that it preserves AV synchrony (atrium empties then ventricle empties improving cardiac output / efficiency). If the pacemaker does not sense any native atrial activity after a preset interval, it generates an atrial stimulus. An atrial stimulus, whether native or paced, initiates a period known as the AV interval. During the AV interval the atrial channel of the

pacemaker is inactive, or refractory. At the end of the present AV interval, if no native ventricular activity is sensed by the ventricular channel, the pacemaker generates a ventricular stimulus. Following the AV interval, the atrial channel remains refractory during a short, post-ventricular atrial refractory period (PVARP) so as to prevent sensing the ventricular stimulus or resulting retrograde P waves as native atrial activity (see Ed's case comment below) .

3) Mode switching – However if a patient who has a DDD pacemaker were to develop supraventricular tachycardia, the pacemaker might pace the ventricles at the rapid rate based on the atrial stimulus (up to the preprogrammed upper rate limit). To prevent this, most DDD pacemakers now use mode switching algorithms, whereby if a patient develops an atrial tachydysrhythmia, the pacemaker switches to a pacing mode in which there is no atrial tracking, such as VVI. On cessation of the dysrhythmia, the pacemaker reverts to DDD mode, thus restoring AV synchrony without being complicit in the transmission of paroxysmal atrial tachydysrhythmias

ECG findings of normal pacemaker

The pacemaker produces a signal which is usually evident on the ECG- these may not be visible in all leads & note pacing artifacts are much smaller with bipolar electrode systems than with unipolar leads.

Typically, pacing leads used to pace the atrium are implanted in the appendage of the right atrium and leads to pace the ventricles toward the apex of the right ventricle. Atrial pacing appears as a small pacemaker spike just before the P wave. The P wave is usually of a normal morphology.

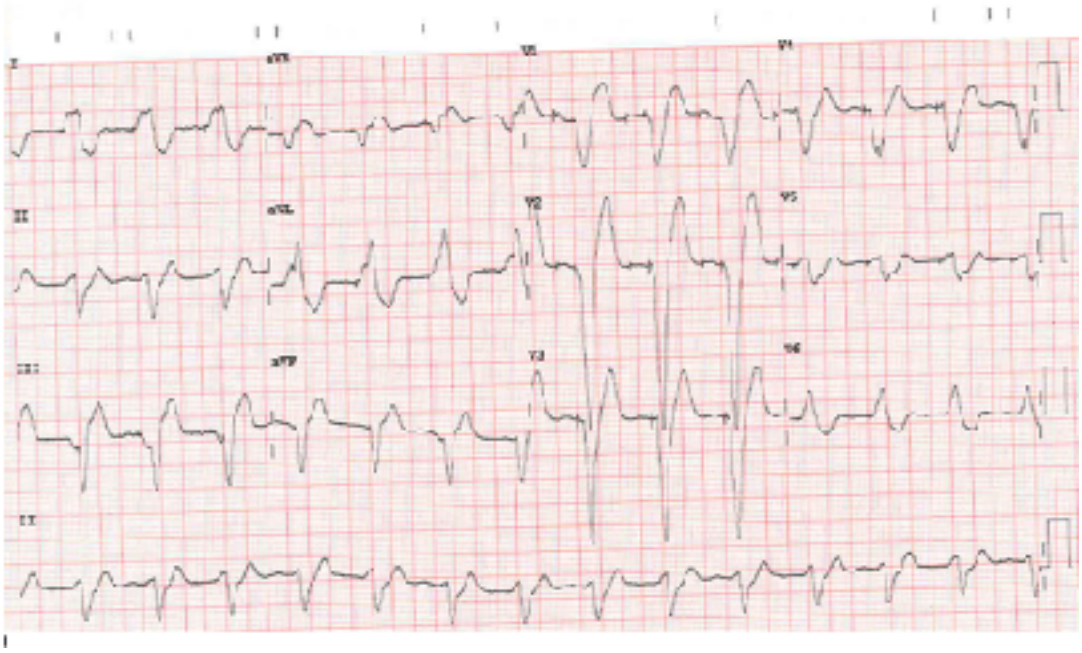
In contrast, the ventricular paced rhythm (VPR) is abnormal as the ventricular pacing lead is placed in the right ventricle- the ventricles contract from right to left, rather than by the regular conduction system- thus the QRS morphology is similar to a LBBB. Usually the ventricular lead is placed near the apex, causing the ventricles to contract from apex to base, yielding leftward deviation of the QRS axis on the ECG. If the lead is implanted toward the right ventricular outflow tract, depolarization forces travel from base to apex, resulting in a right axis deviation. Occasionally patients have epicardial rather than intracardiac pacemaker leads. If the ventricular epicardial lead is placed over the left ventricle, the ventricular paced pattern is that of a right bundle branch block. Note the ST segment/T-wave complex are in an opposite direction to the main QRS vector / direction.

Abnormal Pacemakers

Abnormal functioning of a pacemaker can be life-threatening for some pts – get a 12- lead ECG. Pacemaker interrogation by the tech – many patients carry a card with the date and type of PPM inserted with contact numbers. Also some manufacturers will place a ID number of the generator which is visible on the CXR- the CXR may also show lead dislodgement, migration, or fracture.

MAGNET A magnet can also be placed over the pacemaker – this will typically switch the pacemaker over to the programmed rate which it will do asynchronously – paced NOT sense – IT WILL NOT TURN IT OFF - this is helpful in assessing pacemaker capture (but not sensing), evaluating battery life, treating pacemaker-mediated tachycardia, and assessing pacemaker function when the native heart rate is greater than the pacing threshold.

In this case a magnet was applied with the rate returning to 85 – not sensed yet paced at a preprogrammed rate – atrial and ventricular pacing spikes seen. Note there is no background atrial arrhythmia. When the magnet was removed the patient reverted straight back to the previous broad complex tachy, requiring reapplication of the magnet with the same effect. However flecainde was withheld then reduced with no further arrhythmias or adjustment of the PPM



Differing opinions existed on this case, yet all the info suggests that the atrial lead was sensing a re-entrant ventricular beat triggering a ventricular pacing spike.

This is described as a pace-maker mediated tachycardia (PMT) – (not to be confused with the other PMT) – can occur in dual chamber pacemakers with atrial sensing - results from a re-entrant tachy – a retrograde premature ventricular complex occurs after the atrial refractory period and is sensed in the atrium as a native atrial beat – this then triggers the ventricular pacer – this then conducts up the retrograde pathway forming a re-entrant loop – note this cannot exceed the maximum programmed rate of the pacemaker (usually 160-180 per min). The ECG appearance is a regular ventricular paced tachy at or less than the programmed rate – to treat use a magnet or vagal manoeuvres / adenosine.

Ed B reports a similar case which was treated by altering the sensitivity of the atrial lead, which altered the chance a retrograde beat was sensed, reducing the chance of a re-entrant arrhythmia.

Other problems with the PPM include:

a) **Other pacemaker arrhythmias**

1) Run-away pacemakers – rare nowdays - rapid discharges up to 400/min – use magnet , reprogram or disconnect / cut leads!

2) Lead fracture or dislodgement arrhythmias – see subclavian crush syn (probe 2012 no.6) - leads bouncing loosely on ventricular wall can also produce arrhythmias –replace, remove or reposition

3) Sensor-induced tachys – some have rate modulation to adjust the rate to meet physiological demands (4th position on the classification) – but sometimes may pace when stimulated by loud noises, vibration or sleeping on the side of the implant – usually benign and less than the max rate set.

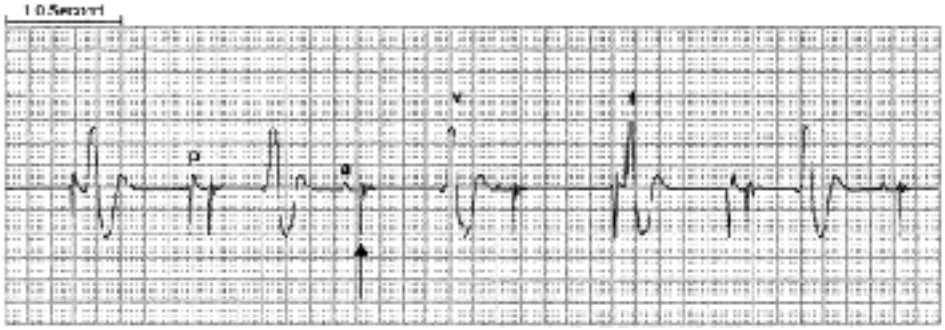
4) Pseudomalfunction –occurs when the pacing spikes arre occurring yet not seen (esp dual lead systems) – other times there may be a 2:1 blocks or Wenkebach like pictures when there is an acceleration of the native atrial rate falling within the refractory period of the atrial sensor.

5) Pacemaker syndrome – from suboptimal AV synchrony or AV dyssynchrony – leading to bad haemodynamics / perfusion. Check ECG synchrony – may see drop in BP when rhythm goes from native atrial rhythm to paced atrial rhythm.

b) **Failure to pace** - failure to deliver a stimulus in a situation in which pacing should occur- causes including pacing lead problems, battery or component failure, and electromagnetic interference (such as from MRI scanning or cellular telephones). Most commonly due to oversensing, an inappropriate sensing of electrical signals by the pacemaker such as from nearby skeletal mm or native cardiac signals eg atrial sensing of a QRS as a atrial activity. Failure to pace manifests on the ECG by an absence of pacemaker spikes at a point at which pacemaker spikes would be expected. In dual-chambered pacing symptoms, isolated atrial or ventricular failure to pace may be evident.

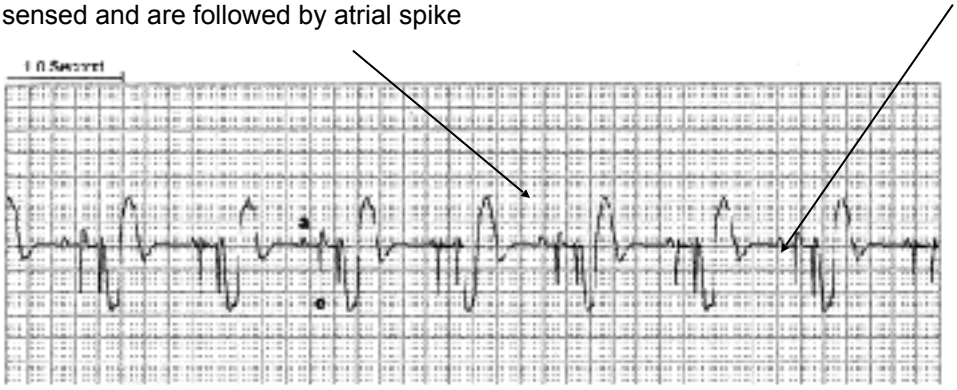
Editor: Peter Wyllie

c) Failure to capture - Failure to capture refers to the condition in which a pacing stimulus is generated but fails to trigger myocardial depolarization. On the ECG, failure to capture is identified by the presence of pacing spikes without associated myocardial depolarization, or capture.(see arrow below).



May be from a low current from a failing battery may cause failure to capture as a result of insufficient voltage to trigger depolarization, the most common cause of failure to capture is elevation in the threshold voltage required for myocardial depolarization, also known as exit block- can be caused by maturation of tissues at the electrode–myocardium interface in the weeks following implantation.

d) Undersensing - when the pacemaker fails to sense or detect native cardiac activity. - changes in the amplitude, vector, or frequency of intracardiac electrical signals can result in undersensing. All of the causes for failure to capture also can cause undersensing, as can new bundle branch blocks, premature ventricular contractions (PVCs), or atrial or ventricular tachydysrhythmias. Most cases of undersensing can be remedied by programming the pacing system to a higher sensitivity. Look at the ECG to see if the pacemaker is responding appropriately. See below the native atrial beats are not sensed and are followed by atrial spike



ACLS protocols, including defibrillation, may safely be executed in patients with pacemakers in place. Sternal paddles are placed at a safe distance (10 cm) from the pulse generator.

IMPLANTABLE DEFIBRILLATORS

An Implantable Cardioverter Defibrillator (ICD) senses a ventricular rate that exceeds the programmed cut-off rate of the ICD and then performs cardioversion/defibrillation. Alternatively, the device, if so programmed, may attempt to pace rapidly for a number of pulses to attempt pace-termination of the ventricular tachycardia. Note that newer devices are a combination of ICD and pacemaker in one unit.

Complications are similar pacemakers- including operative failures, sensing and/or pacing failures, inappropriate cardioversion, ineffective cardioversion/defibrillation, and device deactivation.

Mechanical failures are identical to those found in regular pacemakers. Sensing problems are also seen eg there may be appropriate failure to treat is when a device has a cut-off rate of 180 bpm. If VT occurs at 160 bpm, the device, appropriately, fails to cardiovert the patient since the rate of the dysrhythmia is below the programmed rate cut-off.

Inappropriate cardioversion is the most frequent complication – pt very aware of as it provokes pain and anxiety. This should be considered if a patient presents in atrial fibrillation or if a patient has received multiple shocks in rapid succession without premonitory symptoms. For example, if, as in the example given above, the patient develops atrial fibrillation with a ventricular response of greater than or equal to 180 bpm, the device delivers therapy. Newer devices have certain enhancements that allow discrimination between such rhythms. Causes, other than a supraventricular dysrhythmia,

include T-wave oversensing, lead fracture, lead insulation breakage, electrocautery, MRI, and electromagnetic interference.

Use of a magnet over the ICD inhibits further shocks – similar to the pacemakers as discussed above. In some older devices, application of a magnet produces a soft beep for each QRS complex. If the magnet is left on for approximately 30 seconds, the ICD is disabled and a continuous tone is generated. To reactivate the device, the magnet must be lifted off the area of the generator and then replaced. After 30 seconds the beep returns for every QRS complex.

Failure to deliver cardioversion is caused by failure to sense, lead fracture, electromagnetic interference, and inadvertent ICD deactivation.

Management includes external defibrillation or cardioversion and antidysrhythmic medications. If external defibrillation is required, attempt to keep the generator out of the shock wave. Defibrillation that affects the generator may cause total failure of the device. However, do not withhold therapy because of fear of damaging the ICD. Note that the rescuer may feel a mild shock wave if the patient's internal defibrillator activates during chest compressions- no reports of harm to the rescuer.

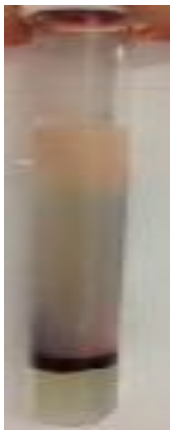
Ineffective cardioversion may be due to inadequate energy output, rise in the defibrillation threshold (which may be due to antiarrhythmic medications, eg, amiodarone, flecainide, phenytoin), myocardial infarction at the lead site, lead fracture, insulation breakage, and dislodgment of the leads.

Many ICDs deliver a programmed set of therapies per dysrhythmic episode. Note that initial therapy for ventricular tachycardia may be overdrive pacing rather than simple cardioversion, as mentioned earlier..

Refs: emedicine / Chan and cardall in Emergency Clinics Nth America 2006 (179-194)

NEXT WEEK'S CASE

A 45yo type 1 diabetic man presents with abdominal pain and vomiting. The lab reports problems with the sample yet reports a lipase of 983- the other results will "take time" What could be going on? Hint below is a picture of the yellow top tube (serum) What additional tests do you order and how do we treat this?



JOKE / QUOTE OF THE WEEK

"It sort of makes you stop and think, doesn't it."

Editor: Peter Wyllie

Please forward any funny and litigious quotes you may hear on the floor (happy to publish names if you want)

THE WEEK AHEAD

Tuesdays - 12:00 – 13:45 Intern teaching -Thomas & Rachel Moore
Wednesday 0800-0900 Critical Care Journal Club. ICU Conf Room / 12.00-1.15 Resident MO in Thomas & Rachel Moore
Thursday 0730-0800 Trauma Audit. Education Centre / 0800-0830 MET Review Education centre / 1300-1400 Medical Grand Rounds. Auditorium.

Editor: Peter Wyllie