

Chapter 80 – Implantable Cardiac Devices

Episode Overview:

- 1. List 5 Indications for permanent pacing
- 2. Pacemaker nomenclature what do the 5 letters mean a. What are common Pacemaker types?
- 3. List the causes of pacemaker malfunction (main categories with 2 examples each)
- 4. List the complications of a pacemaker insertion
- 5. What is pacemaker pseudo-malfunction?
- 6. What is pacemaker syndrome, which type of pacer is most commonly involved, and what is the treatment?
- 7. What does magnet application do to a pacemaker? to an ICD?
- 8. Indications for ICD
- 9. Causes of shock delivery in patient with ICD
- 10. Causes of syncope/presyncope in patient with ICD
- 11. Fxns of an ICD

Wise Cracks

- 1. What do you see on ECG when pacer battery dies (2)?
- 2. What is twiddler's syndrome?
- 3. Describe your Approach to LVAD complications

Rosen's in Perspective

It is important to understand how these devices work, and how they can go wrong in our patients presenting to the ED

Transvenous pacemakers have been around since the 1960s! ICDs are increasingly showing mortality benefit in those patients requiring long term anti-dysrhythmics.

LVADs aren't just unicorns anymore, you will see these in your ED!

Pacemaker essentially has 2 core functions: stimulate myocardium electrically and sense intrinsic cardiac electrical activity

3 basic components:

- Pulse generator (with power source)
- Electronic circuitry
- Lead system (connecting pulse generator to endocardium)

Typically leads placed in endocardium of Right Ventricle and Right Atrium, via cephalic or subclavian vein approach. Also can see epicardial leads into left ventricle as in with Cardiac resynchronisation therapy (eg biventricular failure)

Battery type is important - all new systems are lithium batteries. Tend to last 4-10 years depending on function and abilities of unit.

• Lithium batteries tend to gradually lose power,



 versus Mercury-Zinc batteries used to have abrupt and catastrophic unit failure due to sudden power loss.

Most common cause of failure is with electrical circuitry eg. a) lead disruption or breakage resulting in failure to pace or sense; or B) partial fracture resulting in a "make or break" contact with intermittent failure to sense or pace

Leads:

Can be unipolar versus Bipolar

- Bipolar leads: has negative (distal) and positive (proximal) electrodes, separated by approximately 1 cm, within the heart
 - Compatible with ICD, but more prone to lead fracture. Over-sensing rarely a problem
- Unipolar lead has negative electrode contacting endocardium & positive pole is the metallic casing of the pulse generator.
 - Smaller diameter and less prone to lead fracture. Not compatible with ICD as prone to over-sensing

Pacemakers can be confusing... but remember it is programmed to do a set amount of things. Think of it as the pacemaker is always listening to the atria and ventricles. If it does not hear / sense an intrinsic P wave or QRS complex after a set amount of time, it will fire either the atria, ventricle or both depending on its function. If it does sense a P wave or QRS, then it will inhibit its preprogrammed stimulation of the atria, ventricle, or both (ie it will reset its output to prevent competition with intrinsic electrical activity).

ICDs are similar in construction and function, just add a defib function that is done via a coil in the right ventricle and the pulse generator.

1) List 5 Indications for permanent pacing



Box 80-1 P

Class I Indications for Permanent Pacing in Adults

- 1. Third-degree and advanced second-degree AV block at any anatomic level associated with any of the following:
 - Symptomatic bradycardia (including heart failure) or ventricular dysrhythmia presumed to be a result of AV block
 - Symptomatic bradycardia secondary to drugs required for dysrhythmia management or other medical condition
 - Documented periods of asystole lasting more than 3 seconds or an escape rate of less than 40 beats/min or an escape rhythm originating below the AV node in an awake, asymptomatic patient in sinus rhythm
 - Awake, asymptomatic patients with atrial fibrillation and bradycardia a documented pause of 5 seconds or longer
 - After catheter ablation of the AV node
 - Postoperative AV block that is not expected to resolve
 - Neuromuscular disease with AV block (e.g., the muscular dystrophies)
- 2. Symptomatic bradycardia resulting from second-degree AV block regardless of type or site of block
- 3. Asymptomatic, persistent third-degree AV block with awake ventricular rate over 40 beats/min with cardiomegaly or left ventricular dysfunction or if block is below AV node
- 4. Chronic bifascicular or trifascicular block with intermittent third-degree AV block or type II second-degree AV block
- 5. Second or third-degree AV block with exercise in the absence of myocardial ischemia

AV atrioventricular

2) Pacemaker nomenclature - what do the 5 letters mean

-What are common Pacemakers? PSRPA (Poor Second Rate Pacers Atrophy)

Table 80-1 Five-Letter Pacemaker Code						
Letter 1	Letter 2	Letter 3	Letter 4	Letter 5		
CHAMBER PACED	CHAMBER SENSED	SENSING RESPONSE	PROGRAMMABILITY	ANTITACHYCARDIA FUNCTIONS		
A = atrium	A = atrium	$T = triggered^*$	P = simple	P = pacing		
V = ventricle	V = ventricle	I = inhibited	M = multiprogrammable	S = shock		
D = dual	D = dual	D = dual (A and V inhibited)	R = rate adaptive	D = dual (shock pace)		
O = none	O = none	O = none	C = communicating O = none			

*In the triggered response mode, the pacemaker discharges or fires when it recognizes an intrinsic depolarization. As a result, pacemaker spikes occur during inscription of the QRS complex. Because this mode results in high energy consumption and a shortened battery life and because the sensing response can be misinterpreted as pacemaker malfunction, this sensing mode is not used with modern pacemakers.



Table 80-2 Common Permanent Pacemakers					
CODE	INDICATION	ADVANTAGES	DISADVANTAGES		
VVI	Intermittent backup pacing; inactive patient	Simplicity; low cost	Fixed rate; risk of pacemaker syndrome		
VVIR	Atrial fibrillation	Rate responsive	Requires advanced programming		
DDD	Complete heart block	Atrial tracking restores normal physiology	No rate responsiveness; requires two leads and advanced programming		
DDDR	Sinus node dysfunction; for rate responsiveness atrioventricular block and need	Universal pacer; all options available by programming	Complexity, cost, programming, and follow- up evaluation		

3) Causes of pacemaker malfunction (main categories with 2 examples each)

Big shout out to LITF - https://lifeinthefastlane.com/ecg-library/pacemaker-malfunction/

Essentially 3 things:

(1) failure to capture (no pacemaker spikes or spikes not followed by an atrial or ventricular complex)
(2) inappropriate sensing (oversensing or undersensing spikes occur prematurely or do not occur even though the programmed interval is exceeded)
(3) inappropriate pacemaker rate.

Box 80-3 Causes of Pacemaker Malfunction

Failure to Capture

- · Lead disconnection, break, or displacement
- Exit block
- Battery depletion

Undersensing

- Lead displacement
- Inadequate endocardial lead contact
- Low-voltage intracardiac P waves and QRS complexes
- Lead fracture

Oversensing

- Sensing extracardiac signals: myopotentials
- T wave sensing

Inappropriate Rate

- Battery depletion
- Ventriculoatrial conduction with pacemaker-mediated tachycardia
- 1:1 response to atrial dysrhythmias

Failure to Capture -" occurs when paced stimulus does not result in myocardial depolarisation. Multiple causes including electrode displacement, wire fracture, electrolyte disturbance, MI or exit block."



Undersensing - "occurs when the pacemaker fails to sense native cardiac activity. Results in asynchronous pacing. Causes include increased stimulation threshold at electrode site (exit block), poor lead contact, new bundle branch block or programming problems. ECG findings may be minimal, although presence of pacing spikes within QRS complexes is suggestive of undersensing."

Oversensing - "occurs when electrical signal are inappropriately recognised as native cardiac activity and pacing is inhibited. These inappropriate signals may be large P or T waves, skeletal muscle activity or lead contact problems. Abnormal signals may not be evident on ECG. Reduced pacemaker output / output failure may be seen on ECG monitoring if the patient stimulates their rectus or pectoral muscles (due to oversensing of muscle activity)."

Inappropriate rate - when in doubt: put a magnet on it!!!

- Low rate think battery depletion and does not occur abruptly with lithium-iodine batteries.
- Extreme rate ("runaway pacemaker," rare. If seen usually when limits set high (typically 140 beats/minCan cause VF or brady. Need pacemaker change
- An "endless loop" tachycardia may develop during dual-chamber pacing when ventriculoatrial conduction occurs, and the resulting retrograde atrial depolarization results in a stimulated or paced ventricular depolarization. Tx with magnet to terminate loop.

4) List the complications of a pacemaker insertion

- Infection
 - ~%2 incidence
 - Usually staph aureus
 - 20-25% can be blood culture positive. So get cultures
 - ***NEEDLE ASPIRATION UNDER FLUORO ONLY***
 - May cut insulation around pulse generator
- Thrombophlebitis
 - 30-50% incidence!!!
 - But only 1% symptomatic secondary to good collateralization
 - \circ 1/3 of all patients can have complete venous occlusion
 - Watch out for SVC syndrome
 - Dx with Duplex U/S
- Pacemaker syndrome (more later)
 - Loss of AV synchrony

5) What is pacemaker pseudo-malfunction?

Often confused with failure to sense, seen when pacemaker is firing at pre-determined interval, however competing with underlying intrinsic cardiac rhythm.

See figure 80-3 for example



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Figure 80-3. VVI pacemaker with fusion beats (pseudomalfunction). This VVI pacemaker was implanted in a patient with atrial fibrillation and intermittent symptomatic complete heart block. In the lead II rhythm strip, the first five QRS complexes are normal in morphology and irregular, as would be expected in atrial fibrillation. The next two QRS complexes are wide and preceded by a pacemaker spike. This represents normal sensing and pacing. The eighth QRS complex is narrow but preceded by a pacemaker spike. The spikes occur at a fixed and regular interval. In this instance, spontaneous ventricular depolarization had begun at approximately the time the pacemaker discharged. The 12th QRS complex in the sequence represents a fusion beat. Within the QRS complex of the 13th beat, a pacemaker spike is visible. Again, this represents nearly simultaneous conduction of a supraventricular beat and pacemaker electrical discharge. At first glance, this may appear to be failure to sense; however, the pacemaker is functioning normally and competing with the underlying rhythm.

6) What is pacemaker syndrome, which type of pacer is most commonly involved, and what is the treatment?

Typically patients complain of worsening of sx that lead to pacemaker placement in the first place. Secondary to loss of AV synchrony

Eg: syncope or near-syncope, orthostatic dizziness, fatigue, exercise intolerance, weakness, lethargy, chest fullness or pain, cough, uncomfortable pulsations in the neck or abdomen, right upper quadrant pain, and other nonspecific symptoms.

Most commonly seen in VVI pacemakers

Tx: Consult cardiology for interrogation

- If VVI change pacemaker to dual chamber
- If dual chamber already optimise atrial and ventricular pacing
- May need biventricular pacing

7) What does magnet application do to a pacemaker? to an ICD?

Pacemaker: Converts pacemaker into asynchronous pacing mode. No longer inhibited by intrinsic electrical activity

ICD: Deactivates the defibrillator (note should only be done during resuscitation efforts, comfort care or inappropriate delivery of shocks eg in SVTs)

8) List 4 Indications for ICD



Box 80-2 Class I Indications for Implantable Cardioverter-Defibrillator Therapy

- 1. Cardiac arrest resulting from VF or VT not caused by a transient or reversible event
- 2. Spontaneous sustained VT
- 3. Syncope of undetermined origin with clinically relevant, hemodynamically significant sustained VT or VF induced at electrophysiologic study when drug therapy is ineffective, not tolerated, or not preferred
- Nonsustained VT with coronary artery disease, prior myocardial infarction, left ventricular dysfunction, and inducible VF or sustained VT at electrophysiologic study that is not suppressible by a class I antiarrhythmic drug

VF, ventricular fibrillation; VT, ventricular tachycardia.

9) Causes of shock delivery in patient with ICD

Specifically for shock delivery:

- Increase VF / VT (ischemia / electrolyte disturbance / drug effect)
- Displaced or break in ventricular lead
- Recurrent non-sustained VT
- Sensing and Shock of SVT
- Oversensing T-waves
- Sensing non-cardiac signals

10) Causes of syncope/presyncope in patient with ICD (three)

- Recurrent VT with slow shock strength (lead problem / change in defib threshold)
- Hemodynamically significant SVT
- Inadequate backup pacing for bradyarrythmias





Box 80-4

Causes of Implantable Cardioverter-Defibrillator Malfunction

Increase or abrupt change in shock frequency

- Increased frequency of VF or VT (consider ischemia, electrolyte disorder, or drug effect)
- Displacement or break in ventricular lead
- Recurrent nonsustained VT
- Sensing and shock of supraventricular tachyarrhythmias
- Oversensing of T waves
- Sensing noncardiac signals

Syncope, near-syncope, dizziness

- Recurrent VT with low shock strength (lead problem, change in defibrillation threshold)
- Hemodynamically significant supraventricular tachyarrhythmias
- Inadequate backup pacing for bradyarrhythmias (spontaneous or drug induced)

Cardiac arrest

• Assume malfunction, but probably caused by VF that failed to respond to programmed shock parameters

VF, ventricular fibrillation; VT, ventricular tachycardia.

11) Functions of an ICD

Essentially Cardioversion / defibrillation / pacemaker

- Back-up ventricular pacemakers for bradyarrhythmias
- Works via complex computing for rate, rhythm and morphology discrimination

Wise Cracks

1) What do you see on ECG when pacer battery dies (2)?

Intermittent failure to capture versus complete failure to capture

Look for complete absence of pacemaker spikes to spikes not followed by a stimulus-induced complex

Ex:





Figure 80-5. Intermittent failure to capture and slow pacing rate (lead I). This lead I rhythm strip demonstrates intermittent failure to capture of a VVI pacemaker. The first and second pacemaker spikes are followed by wide-paced QRS complexes; the third and fourth spikes are not. The pacemaker spikes occur at a rate of approximately 50/min. The device was programmed to pace at a rate of 75/min. This is a typical example of "end-of-life" pacing characteristics of a depleted battery.

2) What is Twiddler's syndrome?

According to LITFL

"Patient manipulation of the pulse generator (accidentally or deliberately). The pacemaker rotates on its long axis, resulting in dislodgement of pacing leads. Can result in diaphragmatic or brachial plexus pacing (e.g. arm twitching) depending on extent of lead migration."

3) Describe your Approach to LVAD complications

https://canadiem.org/lvads-approach-ed/

Big shout out to Jared Baylis

- 1. Ask the patient or their family for the info card for their device as well as the contact details for their VAD specialist and contact them (In BC, the 24/7 VAD Hotline can be reached at 604-250-2658).
- If unable to obtain blood pressure by NIBP, use Doppler with a manual cuff. Remember that they need a narrowly normal MAP: 70-80 (If it's higher or lower you need to be concerned!)
- 3. If pulse oximetry is not reliable, then pursue cerebral oximetry, ABG, or an arterial line depending on the scenario.
- 4. If hypotensive, obtain a work-up including basic CBC, electrolytes, coagulation panel, chest xray, and ECG. Consider adding hemolytic work up and performing bedside ultrasound. Administer an IV fluid bolus or PO fluids if awake and alert.
- 5. If you suspect infection, draw blood cultures, cover with broad spectrum antibiotics, and resuscitate as appropriate.
- 6. Sustained symptomatic ventricular tachycardias/ventricular fibrillation should be treated urgently with cardioversion. Defibrillator pads should not be placed directly over the LVAD device.
- 7. If there is no "hum" on chest auscultation and/or there are no signs of perfusion, begin chest compressions and contact a cardiac surgeon if one is available on site.
- a. Risk of dislodging LVAD but.. They are dead, so CPR takes precedence.