Introduction

Pacemaker = its best to think about it just being a generator and leads. The generator creates a pulse, and that pulse travels down the leads into the desired location to have an effect.

Atrial leads = right atrium
Ventricular leads = lay on the posterior or lateral walls of right ventricle

5 letter identification (EM physicians do not need to worry about the last 2 letters):
- first letter → lead location (A = atrial, V = ventricle, D = Dual, O = None)
- second letter → chamber being sensed (same letters as above)
- third letter → response of pacemaker to sensed pulse (T = triggered, I = inhibited, D = both, O = none)

Pacemaker settings

Rate: number of pulses generated per minute.
Sensitivity: minimal activity required to detect a native cardiac impulse (P or R wave). Measured in mV. The lower the number, the more sensitive the pacemaker. A great comparison:

  Sensitivity is like a fence. The higher the fence, the less the pacemaker “sees” over it. Same with sensing- the higher the number, the less sensing. A lower number means more is sensed.
  Asynchronous pacing is coined as sensitivity being so high that the pacemaker virtually does not detect any underlying rhythm.

Output: the pulse generated by the pacemaker. These brief pulses “capture” or initiate depolarization of the paced chamber.

Patients usually carry their device cards with them. These cards are produced by the pacemaker company and have all the needed information for you to run an interrogation of the pacemaker in the ED. An overpowered CXR will also demonstrate lead wire placement and device information. We support using the Pacemaker-ID iPhone app, which is a free download that allows one to snap a photo of the device from the CXR and with much confidence report the device maker.

Indications for pacemaker and/or ICD placement: sinus node dysfunction (most common reason), cardiac resynchronization therapy in late stage heart failure (usually with EF <20-25%), second or third degree AV block, Brugada syndrome, hypertrophic cardiomyopathy, WPW, ARVC, various prolonged QT syndromes, and countless other dysrhythmias.

The workup of these patients requires the following diagnostic investigation:

1. Device information
2. Symptoms associated with device malfunction/misfiring
3. Why the device was placed
4. Date of implant and/or most recent repair or interrogation.

Reading pacemaker EKGs:

Atrial pacemaker- normal rhythm is easy to identify with pacer spike preceding a narrow QRS.
Ventricular pacemaker- LBBB-like pattern with pacer spikes preceding wide QRS complexes.

Early complications of pacemakers

Recent <6 weeks out from implantation: these are exclusively related to the physical placement of the device itself.
- pocket hematoma, infection, upper extremity DVT, pneumothorax, SVC syndrome
- lead displacement: pacemaker fails to capture or is under-sensing. Patient will have recurrent bradycardia and fatigue. If a ventricular pacemaker, deviation from LBBB is suspicious. Hiccups can suggest deviation to the phrenic nerve.

Later complications

Let’s simplify the following issues:
- Output failure: pacemaker fails to produce a pacing spike.
- Capture failure: pacemaker produces spikes but there is no QRS complex following them.
- Undersensing: pacemaker paces asynchronously- it does not interpret the heart’s native rhythm
- Oversensing: pacemaker fails to pace due to interference of other electric signals.

Battery malfunction: rare today thanks to modern pacemaker battery life. Can include palpitations, headaches, fatigue, syncope.
Failure to sense (undersensing): the pacemaker does not detect the patient's myocardial depolarization. Often a high sensitivity number (mV) makes the pacemaker less sensitive. The pacemaker is less likely to see the native P wave or QRS and not deliver a pace. Therefore, this is similar to the pacemaker essentially delivering asynchronous pacing.

Think “failure to Sense” as the QRS being “Sneaky”. The QRS “sneaks past” the pacer spike. The EKG tracing shows a spike following a QRS complex too early.

Intrinsic EKG complex.
Most common cause is lead fracture, displacement, or insulation defects.

Failure to capture: the heart fails to respond to the pacemaker impulse. On EKG tracing, the pacemaker spike will appear but it will not be followed by a QRS complex. They appear to be dissociated.

Common causes are similar to above: lead insulation breaks, displacement, fracture. Other causes include myocardial pathology, electrolyte derangement, or antiarrhythmic drug interference.
Types of failure to capture: intermittent (every now and then) versus absolute/chronic (never).

Oversensing: This results in underpacing. The pacemaker has a low sensitivity number making the pacemaker very sensitive. It inappropriately recognizes even random fluctuating electrical signals as native cardiac activity and therefore the pacemaker activity is reduced. Inappropriate signals include large P waves or T waves, even random skeletal muscle activity. In fact, there can often be reduced pacemaker activity if the patient is asked to move their chest or shoulder muscles.

Failure to pace: the pacemaker does not generate an electrical impulse. As the name implies, it’s a failed pacemaker so therefore there are no pacing spikes. On an EKG tracing, pacemaker spikes will be missing.
Patients have HR lower than the limit designated by pacemaker. Pacemaker over-sensing is the most common cause.
-switch to asynchronous mode to prevent oversensing; place a magnet.

Pacemaker mediated tachycardia: re-entry arrhythmia where the pacemaker itself becomes part of the circuit. The pacemaker becomes the anterograde conduction path, and the AV node is retrograde.
Details of pathophysiology: atrial senses ventricular spike and interprets it as an endogenous atrial depolarization; this triggers another ventricular impulse.
EKG: Rapid wide complex tachycardia.
Tx: place a magnet over the pacemaker- it will go to preset asynchronous rate and terminate the anterograde portion of the circuit. Carotid massage, adenosine have both been described with some success as well.

In any of the cases described above, in the event of device failure and hemodynamically unstable, patient may need transcutaneous or transvenous pacing (follow the stable/unstable bradycardia algorithm).
-Pacer pads should be placed 8 cm away from the device if placed.
-Always strongly consider electrolyte abnormalities as a cause.

Details of what a magnet does when applied:
Magnet applied to site of pacemaker: Starts asynchronous pacing
Magnet applied to site of ICD: Turns off tachyarrhythmia response function (aka disables it)
This is for MOST DEVICES, there is a fair amount of diversity.
References