

# UCSF Anesthesia Resident Pearls: Cardiac Implantable Electronic Devices: Pacemakers and ICDs

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# UCSF Anesthesia Resident Pearls: Anesthesia and Cardiac Implantable Electronic Devices

## **Intro:**

Your first time approaching a cardiac implantable electronic device (CIED) can be a humbling experience. What do the letters mean? What does the magnet do? What is the difference between a pacemaker and an implantable cardioverter defibrillator (ICD)? The questions may be numerous. As Anesthesiologists, our role in the management of patients with a CIED is critical, and requires a basic understanding of how the different types of CIEDs function. It also requires us to know how things we do, and what things the surgeons do, can alter their function. This tutorial is in no way intended to be a comprehensive review of CIEDs engineering, but more of a guide as to how we should approach patients with them, and the steps we should take in the pre-op, intra-op, and post-op periods to ensure a safe anesthetic encounter.

## **STEP 1: Questions to ask yourself**

### **WHY, WHAT, WHERE, and WHEN???**

**WHY?** Why does the patient have a CIED? Understanding why your patient has a pacemaker or an ICD cannot be understated. It will help you determine how critical the function of this device is to your patient's survival, what underlying rhythm you can expect if it malfunctions, and the potentially life saving steps you should take if trouble arises. A pacemaker placed for third degree heart block is vastly different than one placed for neurocardiogenic syncope. Look to the tables below for CIED indications.

#### **Indications for Permanent pacemaker**

<b>1)</b> Acquired AV Block: (3 <sup>rd</sup> degree and symptomatic 2 <sup>nd</sup> degree)
<b>2)</b> After MI: Persistent 2 <sup>nd</sup> or 3 <sup>rd</sup> degree AV block, infranodal AV block with LBBB.
<b>3)</b> Sinus node dysfunction: Symptomatic sinus pause arrest, chronotropic incompetence, sinoatrial exit block, and symptomatic sinus bradycardia.
<b>4)</b> Neurocardiogenic syncope: Reserved for the cardioinhibitory variants of vasovagal syncope and carotid sinus hypersensitivity.
<b>5)</b> Bifasicular or Trifasicular block with symptoms.
<b>6)</b> Cardiac resynchronization therapy (CRT) for heart failure.

#### **Guidelines for ICD therapy**

<b>1)</b> Cardiac arrest due to V fib or V tach not due to a transient reversible cause.
<b>2)</b> Spontaneous sustained VT in association with structural heart disease, or not amenable to pharmacologic treatments.
<b>3)</b> Syncope of undetermined origin with hemodynamically significant VT or VF induced at EP study when drug therapy is ineffective, not tolerated, or not preferred.
<b>4)</b> Nonsustained VT in patients with coronary artery disease, prior MI, L ventricular dysfunction and inducible VF or sustained VT at EP study that is not suppressible by a Class 1 antiarrhythmic agent.

**WHAT?** What type of CIED does your patient have? ICDs and Pacemakers are two very different things. While an ICD can function as a pacemaker, a pacemaker can never function like an ICD. Look to the table below for comparisons.

Pacemakers	ICDs
1. Can sense underlying cardiac activity and provide electrical stimulation to the heart when it is absent or too slow. 2. A magnet, when placed over the device, typically sets the pacer to an asynchronous (fixed-rate) mode. 3. Magnet placement is not always necessary and should be based on the type of surgery, and the likelihood for electromagnetic interference (EMI).	1. May or may not have pacing capabilities built into the ICD. 2. Analyzes the underlying heart rhythm and can provide anti-tachycardia pacing (ATP) or defibrillation if necessary. 3. Has a larger generator than a pacemaker 4. A magnet deactivates ICD function and should always be used in surgeries in which electromagnetic interference is possible. 5. A magnet will <u>not</u> change antibradycardia pacing mode (if present).

**ICD terminology**

**NASPE/BPEG Generic Defibrillator (ICD) Code:**

Position I	Position II	Position III	Position IV
Shock Chamber	Antitachycardia Pacing Chamber	Tachycardia Detection	Antibradycardia Pacing Chamber
O=None A=Atrium V=Ventricle D=Dual (A+V)	O=None A=Atrium V=Ventricle D=Dual (A+V)	E=Electrogram H=Hemodynamic	O=None A=Atrium V=Ventricle D=Dual (A+V)

**Pacemaker terminology**

**WHAT?** What chambers are being paced and what is the pacemaker’s response to the patient’s own intrinsic cardiac electrical activity?

**NASPE/BPEG Generic Pacemaker Code:**

Position I	Position II	Position III	Position IV	Position V
Pacing Chamber	Sensing Chamber	Response to Sensing	Programmability	Antitachycardia Functions
O=None A=Atrium V=Ventricle D=Dual (A+V)	O=None A=Atrium V=Ventricle D=Dual (A+V)	O=None I=Inhibited T=Triggered D=Dual (I + T)	O=None P=Programmable M=Multiprogrammable C=Communicating R=Rate Modulation	O=None P=Pacing S=Shock D=Dual (P + S)

### **NASPE/BPEG Generic Pacemaker Code:**

So what is the take home message from pacemaker terminology?? **PSR: Pacers Sense Rhythm!!! [Paced(I), Sensed(II), Response(III)].** The hardest part of pacemakers to understand is the third position, the pacemaker's response function. Position III tells us the pacer's response to sensing. Position III is directly tied to position II and without sensing there can be no response to sensing. What does triggered, inhibited, or dual mean?? The **triggered** function is rarely used as a standalone response and suffice to say is used solely for diagnostic purposes. **Inhibited** refers to the pacers ability to cease electrical output (stop pacing) when intrinsic cardiac activity is sensed. **Dual** refers to the pacers ability to either initiate a cardiac contraction (pace the heart) in the event that the patient's heart fails to do so, or inhibit pacer output when the patient's own intrinsic electrical activity (a heart beat) is sensed. An example of this would be the **DDD** mode where the pacer senses an atrial contraction from the patient, then inhibits its atrial pacing output, but where failure of that atrial signal (P-wave) to travel across the AV node (AV block) would trigger the pacer to initiate a QRS complex. Had that atrial impulse traveled across the AV node causing a QRS complex, the pacer's V output would have been inhibited. Thus in a **DDD** mode, the pacer has both the ability to initiate or inhibit based on what is sensed.

Why is it important that the pacemaker be able to sense intrinsic electrical activity?? This is important to avoid the R on T phenomenon, and its dreaded consequence, either VT or VF. This phenomenon can potentially occur when a pacing spike falls on the T wave and triggers ventricular tachycardia or ventricular fibrillation. When pacers are placed in an asynchronous mode (VOO, DOO) the pacemaker will pace at a set rate without regard to intrinsic electrical activity, or the patient's own heart beat. The letter (O) means **None**; that the pacer is set to ignore native electrical activity. In this situation, by default the III position is O or None because there cannot be a response if no chamber is sensed. You never want to leave a patient in the VOO or DOO modes, unless you are absolutely sure there is no possibility of the patient's heart producing a QRS complex. As Art Wallace would say, these are the 007 modes in that you have the license to kill when leaving a patient in these modes. That being said, magnets place most pacemakers into an asynchronous mode that is perfectly acceptable for the operating room, and actually preferred. This mode prevents the pacemaker from sensing electromagnetic interference and interpreting it as intrinsic cardiac activity thereby stopping its pacing function, and leaving the patient with NO cardiac impulses. NOT GOOD.

**WHERE??:** Where is the pacemaker generator located and where do the leads go?? This can easily be determined by manual palpation of the chest wall and, or, a chest radiograph. Unless contraindicated, they are typically placed in the left upper chest, above the clavicle, with the lead wires entering the left subclavian vein. Why is this important?? This helps you to determine where the grounding pad for the Bovie pad should be placed, and where defibrillator pads can be located, should they become necessary. The electrical current from a Bovie travels from the site of cautery in an arc that exits through the grounding pad. If that arc falls in the path of the device, the CIED function could be altered either temporarily during Bovie interference, or permanently. For this reason the grounding pad should be placed as close to the surgical site as possible and at least 15cm away from the CIED. Bipolar or ultrasonic scalpels should be used if possible. If the location of the CIED, or the type of

CIED is in doubt, a chest radiograph can confirm its location, and sometimes help to identify the manufacturer, if an identifying code can be seen on the generator. With this code you can call the company to determine what specific device your patient has.

**When??:** When was the device implanted and when was it last interrogated? Interrogating a pacemaker involves placing a wand from the company over, or near the pulse generator, which allows the cardiologist to determine battery level, the integrity of the leads, and device settings. The cardiologist may alter the settings of the device if indicated. Interrogation confirms the magnet setting, and ensures that the device is set to function as necessary during OR procedures and throughout the perioperative period. As mentioned before, electrocautery can alter the function of pacemakers and can change the basic programming. This is why it's a good idea to interrogate the device before and after surgery. If the patient has a cardiologist they should be contacted prior to the day of surgery to arrange for preop and postop interrogation. If the patient's cardiologist is not available, the electrophysiology service, if one exists, should be called, or a company rep can be contacted to interrogate the device before and after surgery.

**Magnets- what do they do?:** It is important to understand the underlying reason for magnet application. First of all, magnets can be obtained from the anesthesia techs and are usually attached to the side of the anesthesia carts. The effects of magnet placement vary by company and by device. Contacting the manufacturer regarding the device's response to a magnet is the most definitive way to confirm how a magnet will affect that CIED. Magnet application over a pacemaker was originally designed to determine remaining battery life. Nowadays, the magnet can have other functions as well. Most frequently, a magnet placed over a pacemaker (a pacemaker that is not an ICD) will cause the pacemaker to start fixed rate pacing at a rate predetermined by the company. As a rule of thumb, magnets placed over an ICD will suspend tachyarrhythmia detection, but not affect the pacing mode. Removing the magnet will revert the device to the original mode, however you cannot guarantee this will occur if the device was subjected to electrocautery during a surgical procedure. Hence postop CIED interrogation is important. There are certain procedures that are known to interfere with these devices more. Look to the following list:

- \*Any procedure involving the use of Unipolar electrocautery
- \*Radiofrequency ablation
- \*Lithotripsy
- \*MRI procedures
- \*Electroconvulsive therapy
- \*Radiation therapy
- \*TENS (Transcutaneous Electrical Nerve Stimulation)
- \*Neuromonitoring; SSEPs or MEPs
- \*Central line placement

In cases where none of the above procedures or surgical instruments is planned, magnet application may be unnecessary. This should be considered on a case-by-case basis. If there is little or no potential for CIED interference, there may be no indication to place a magnet

over the device. Nevertheless, a magnet should be immediately available, should unanticipated CIED activity occur.

**Emergency situations:** In any patient with underlying cardiac electropathology, a defibrillator should always be available. Defibrillator pad placement should always be as far away from the pulse generator as possible, and when used, oriented in a perpendicular plane to the leads i.e. Anterior Posterior (Zoll Pads). In the case of ICDs, the magnet should first be removed allowing restoration of the devices function before any attempts at external defibrillation. Normally, it takes about 30 seconds for an ICD to detect a tachycardia, charge, then deliver a shock. In the case of life threatening arrhythmias in the OR, delivering a shock with external pads may be faster, and more reliable.

**How can we affect CIED function?** One of the most common questions regarding pacemakers is how can we affect the function of these devices? For starters, general anesthesia has never been shown to affect the function of these devices. Nor has regional anesthesia been shown to be safer for CIEDs. However, the OR presents several situations that could result in altered CIED function. Potassium derangements can change the resting membrane potential of the myocytes and increase pacing thresholds. A myocardial infarction, acid base abnormalities, antiarrhythmic drugs such as lidocaine, severe or prolonged hypoxia, and hypercarbia, can all alter pacing thresholds, thus affecting pacing function. Therefore, maintaining physiologic parameters as close to normal is preferred. Avoiding a gross metabolic derangement is always a good goal, as well as developing a disaster plan with your attending before the case begins.

**What about Central line placement??:**

During central line insertion, if the metal guide wire contacts the CIED lead system, there may be enough noisy artifact to trigger inappropriate pacing, theoretically even enough noise to deliver an unnecessary shock. Consideration should be given to either avoiding a metal guide wire, or deactivating the ICD during central line placement. The femoral vein might be a safer option even if the internal jugular or subclavian veins may be preferred.

**CIED Checklist:**

**Preop (Why, What, Where, When):**

- Why was it inserted? What was the indication for CIED placement? Did the patient's symptoms resolve, or disappear after the CIED placement?
- What type of device is it? What will the magnet do? What will it not do?
- If a pacemaker, is the patient being paced?
- Where is the pulse generator?
- When was the last interrogation?

## **Intraop:**

- Obtain a Magnet.
- Enable the monitor to sense pacing spikes. Accessed under the EKG menu.
- Defibrillator and zoll pads available. Attach them to the patient if there is a high risk for life threatening arrhythmias.
- Use Bipolar or Ultrasonic scalpels if possible.
- If unipolar cautery is necessary, discuss the ramifications of unipolar cautery with the surgeon, and ask about its anticipated use and duration.
- Place the grounding pad at least 15cm away from the pulse generator, and as far away as possible. Place the grounding pad in such a way that the pulse generator is not in the path of the line from the surgical site to the grounding pad.
- Make plans for electrical emergencies, backup pacing, or defibrillation.
- Have emergency drugs such as Epi, Isoproterenol and Atropine ready.

## **Postop:**

- Evaluate CIED function postop. Restore the appropriate CIED functionality .
- Continuous ECG monitoring in the PACU.
- Access to emergency equipment such as defibrillators should be available.

## **Terminology:**

**CIED:** Cardiac Implantable Electronic Device, includes pacers, ICDs, & CRT devices.

**ICD:** Implantable Cardioverter Defibrillator

**CRT:** Cardiac Resynchronization Therapy: Biventricular pacing that can be a pacer alone or included as the pacing modality of an ICD.

**ATP:** Anti Tachycardia Pacing

**Asynchronous = Fixed-Rate:** Electrical impulse is produced at a constant rate and ignores underlying patient intrinsic cardiac activity.

**Synchronous = Inhibited:** The pacemaker senses whether an underlying P wave or QRS complex comes from the patient's heart. If there is no electrical activity coming from the patient, the pacemaker generates the appropriate (programmed) cardiac rhythm.

**\*\*Guidant (Boston Scientific) 800-CARDIAC (2273422)**

**\*\*Medtronic 800-MEDTRONIC (6338766)**

**\*\*St Jude Medical 800-722-3774**

**\*\*Biotronik 800-547-0394**

## **Additional resources:**

[www.cardiacengineering.com/pacemakers-wallace.pdf](http://www.cardiacengineering.com/pacemakers-wallace.pdf)

<http://anesthesia.ucsf.edu/shapiro/>

For a more detailed explanation in an easy to read format: *Cardiac Pacemakers Step by Step: An Illustrated Guide. By S. Barold, R. Stroobandt, A. Sinnaeve.*

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