Perioperative Management of Pacemakers and Implantable Cardioverter-Defibrillators

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• None
Objectives

• State indications for pacemaker and ICD placement.

• Explain the NASPE/BPEG codes for pacemakers and ICDs.

• Describe common pacing modes and enhanced device features.

• Explain the proper use of magnets with regard to pacemakers and ICDs and assess the response of the device to magnet placement.
Objectives, cont’d

• Create a perioperative device management plan based on recent practice advisories from the ASA and HRS.

• Identify sources of electromagnetic interference in the operating room and describe how EMI interacts with implantable electronic cardiac devices.
Objectives, cont’d

• Prepare a device management plan for procedures with high risk of EMI.

• Identify problems with pacing that can occur intra-operatively and explain steps to correct these problems.

• Choose a device management strategy for true surgical emergencies in which a complete pre-op device interrogation is not feasible.
From the UH Case Files

• Friday night at 23:00
• 55 y/o M. BMI=40, myasthenia gravis and “pacemaker”
• Pt knows little about his device
• Dr. Sanabria wants GA for emergency appendectomy
• T=37.1 C, VSS. WBC=20K. Receiving IV abx.
• What is your plan for his cardiac device?
Pacers and ICDs by the Numbers

- More than 2,500 PM models by 26 companies
- 300,000 PM placements yearly in U.S.
- Nearly 3 million U.S. patients have PMs
- More than 250,000 U.S. patients with ICDs
- More than 100,000 devices will be placed this year

Permanent Pacing Indications

- Sinus nodal dysfunction (Can’t form an impulse)
- AV block (Can’t conduct the impulse)
- Hypersensitive carotid sinus and neurocardiogenic syncope
- Pacing to inhibit tachyarrhythmias
- Hypertrophic cardiomyopathy
- Dilated cardiomyopathy
- Other highly specific conditions

NASPE/BPEG Codes

• Position I: pacing chamber
• Position II: sensing chamber
  • O = None
  • A = Atrium
  • V = Ventricle
  • D = Dual (atrium and ventricle)

Rozner MA in Miller’s Anesthesia, 7th ed. pp. 1392-1393
NASPE/BPEG Codes, cont’d

• Position III: response to sensing
  • (O) None = Pacer will pace at set rate
  • (I) Inhibited = Pacer does not pace as long as it senses activity
  • (T) Triggered = Emits a pulse in response to a sensed event
  • (D) Dual = Inhibited & Triggered

Ibid.
NASPE/BPEG Codes, cont’d

• Position IV: programmability
  • R = rate modulation
    – Increased rate in response to exercise
  • O = none

Ibid.
Enhanced Features

• Available sensors include:
  • Vibration
  • Motion
  • Minute ventilation
  • QT interval
  • RV pressure

• Sensitivity and rates of response are programmable

Ibid.
Enhanced Features, cont’d

- Opportunity for pt harm in OR if activated
- Think about the possibilities:
  - Skin prep
  - Pressure on generator
  - MV increase during bag-mask
NASPE/BPEG Codes, cont’d

- Position V: Multisite pacing
  - None, atrial, ventricular or dual
Pacemaker Terminology

• **Threshold**: Minimum current required to pace the atrium/ventricle

• **Sensitivity**: Voltage level that must be exceeded to detect a P or R wave
  – Lowering the sensitivity makes the device MORE sensitive to native P/R waves

• **Capture**: Pacing current causes ventricular contraction
Common Pacing Modes

- DDD
- VVI
- VDD
- DDI
- VOO
- DOO

Rozner, pp. 1392-1393
Asynchronous Pacing

• No sense, no inhibition
• Pacing at set rate regardless of events
• Can be used in presence of EMI
• May protect patient; will not protect device
Biventricular Pacing

• AKA, cardiac resynchronization therapy
• Dilated cardiomyopathy
  • Goal: improve systolic function and decrease CHF sx
  • Many pts also have ICD indications
• HOCM
  • Mitigate outflow tract obstruction by pacing LV in a bundle branch pattern
  • Septum depolarizes after other segments rather than in early systole

Rozner MA, p. 1393.
Quiz Time: Magnets

• T/F: Magnet-activated switches in pacemakers were created for use emergencies.
Quiz Time: Magnets

• T/F: All pacemakers revert to asynchronous pacing at 80 bpm when a magnet is placed over them.
Magnet Switches

• Produce behavior that demonstrates remaining battery life
• Not intended for use in emergencies or in presence of EMI
• Some models will indicate pacing safety threshold measures
• No uniform device response to magnet application

Rozner, pp. 1393-1395
Magnet Switches, cont’d

- Magnet switches can be programmed to OFF
- Best way to determine magnet response is by calling the manufacturer
- Devices with programmable magnet switches can only reliably be assessed by interrogation

Ibid.
Magnet Switches, cont’d

- Some devices will perform Threshold Margin Test when magnet applied
  - Failure to capture means inadequate safety margin
- Removing a magnet from a dual-chamber pacer can occasionally cause pacemaker-mediated tachycardia

Ibid.
Pacemaker Induced-Tachycardia

- Caused by retrograde P waves conducted during asynchronous ventricular pacing
- Causes pacing at Upper Tracking Limit
- Tx: Reapply, then remove the magnet
ICD Indications

- Prior VF arrest or sustained VT
- Genetic arrhythmias
- Long/short QT syndromes
- Cardiogenic syncope
- Non-hospitalized transplant candidates
- Primary prevention in high-risk individuals

Epstein AE et al.
NASPE/BPEG Code for ICDs

• Position I: Shock chamber
• Position II: Antitachycardia pacing chamber
• Position III: Tachycardia detection
  • E = electrocardiogram
  • H = hemodynamic
• Position IV: Anti-bradycardia pacing chamber
How does an ICD work?

• Measures R-R interval
• If ICD detects enough short R-Rs: antitachy pacing or shock
• Charge time: 6-15 seconds
• Typical device delivers 6-18 shocks per event
• >10% of shocks are inappropriate
• If R-R too long: antibradycardia pacing

Rozner, p. 1402-3
Antitachycardia Pacing

Lee KL and Lau CP. Implantable Defibrillators. Crawford Cardiology: 3rd ed, p. 899
Quiz #2: ICDs and Magnets

• T/F: Placing a magnet over an ICD will disable its anti-tachycardia function.
Magnets and ICDs

- Most ICDs suspend antitachycardia detection and tx when magnet applied
- Some devices can be programmed to ignore magnet
- Some Guidant ICDs have had magnet function permanently disabled due to switch issue
- No reliable way to verify magnet placement

Rozner, p. 1403-4
Magnets and ICDs, cont’d

• Antitachycardia function can be permanently disabled in some Bos Sci/Guidant/CPI devices after 30 seconds of magnet placement

• Generally, magnets do not affect antibradycardia pacing or rate

• Best way to determine response: Interrogate device or call manufacturer

Rozner, p. 1403-4
About the Evidence

- No controlled trials exist
  - Case reports and small case series
- Practice advisories assist decision-making
- Not supported by the same level of evidence as standards or guidelines
- Clinical judgment must be your guide
Pre-op Evaluation

• ASA: Case reports suggest incomplete pre-op evaluation is a factor in adverse outcomes

• HRS: “[P]lacing a magnet without analyzing the patient’s situation is no longer acceptable given the complexity of both the CIEDs and patients who have these devices.”

Four questions

1. Does the patient have an implantable cardiac device?
2. If so, what type and features?
3. Is the patient dependent on the device for antibradycardia pacing?
4. Is the device working?

ASA, p. 249
Does the Patient Have a Device?

- Interview
- Medical records
- Device card
- Look for scars/palpate
- CXR
- EKG or rhythm strips
What Type and Features?

• Medical records
• Device card
• CXR

Ibid.
ICD
Is the Patient Pacemaker Dependent?

• History/medical record of symptomatic bradyarrhythmia
• History of successful AV node ablation and subsequent CIED placement
• Interrogation showing no spontaneous ventricular activity when device set to VVI at lowest rate
Pacer Dependent?, cont’d

- Know if your patient is device dependent
- Know the underlying rhythm
- Patients who are not pacemaker dependent may become so intraoperatively

Crossley, p. 1126
Is the Device Working?

• Ideal: Comprehensive device evaluation
• Minimum:
  • Are pacing impulses present?
  • Do they actually create a beat?

ASA, p. 249
Pacing Impulses on EKG
Pre-op: HRS Recommendations

• Patients with pacemakers undergoing elective surgery: device check w/in last 12 months
• ICDs or CRT devices: within last 6 months
• Team that manages CIED should provide a management prescription
  • In most cases, no clinic visit needed

Crossley, p. 1125-27
What to Tell the Device Team?

- Type of procedure
- Anatomic location
- Position
- Requires monopolar cautery?
- Other EMI present?
- Requires cardioversion/defibrillation?
- Surgical venue
- Post-op plans
- Unusual circumstances (surgery near device/leads, etc.)

Ibid.
What Should the Device Team Tell You?

- Date of last interrogation
- Type of device
- Manufacturer and model
- Device indication
- Document battery longevity > 3 mos
- Any leads < 3 mos old?
- Programming
- Is pt pacer dependent?
- How does device respond to magnet placement?
- Any alert status on generator or lead(s)?
- Last pacing threshold
  - Document adequate safety margin

Ibid.
Pre-op: Is EMI Likely to Occur?

• EMI causes device malfunction
  • Pacer inhibition
  • Unneeded tachyarrhythmia tx
  • Device reset
• Less common with newer devices and bipolar leads
• Can damage device with nearby cautery

Crossley, p. 1117
Monopolar Cautery (aka, Bovie)

- Most common source of EMI in OR
- Short bursts (4-5 sec max) are unlikely to cause hemodynamic compromise in most patients
- ICDs require several seconds of sustained high-rate sensing before they will discharge
- HRS: Limited electrocautery use may be safer than reprogramming or magnet use

Crossley pp.1117-18
Monopolar Cautery, cont’d

- Greatest risk when current path crosses leads
- Keeping current pathway away from leads significantly reduces risk
- If surgery below umbilicus, oversensing is unlikely
- HRS recommendations:
  - Magnet for ICDs when procedure below umbilicus
  - Pacer-ICDs must be reprogrammed
  - For procedures on lower extremity, no reprogramming or magnet necessary regardless of pacer dependency
  - Don’t rely on noise-reversion mode in OR

Crossley, p. 1117-20
Change to Asynchronous?

- HRS: “It is generally best to make a pacemaker asynchronous only if significant inhibition is observed, even if the patient is pacemaker dependent.”
Bipolar Cautery

- Electrical forceps, each limb is an electrode
- Coagulation only
- Minimal chance for adverse CIED interaction
OR Preparation if Risk of EMI

- Magnet immediately available
- Equipment for urgent cardioversion and emergent pacing immediately available
- Continuous monitoring

Crossley, p. 1119-20, 1130
Intra-op: Monitoring

- EKG that detects pacing discharges
- Pulse oximeter or arterial line
- Basically, be able to confirm that the device is working and that pacer impulses are producing ventricular systole at all times

Crossley, p. 1129-30
Procedure-Specific Concerns

- Generally contraindicated: MRI, spinal cord stimulators, TENS units
- Therapeutic Radiation
  - Device must be carefully shielded
  - Strategically placed lead apron is not enough

Crossley, p. 1121-23
Lithotripsy

- Pulse generator must be out of lithotripter field
- Disable atrial pacing if lithotripter fires on EKG’s R wave
- Terminate procedure if arrhythmias develop
- Magnet only if inhibition occurs
- Overall risk is low

Rozner, p. 1400
Electroconvulsive Therapy

- May have oversensing from seizure
- Stimulus is brief (1-2 seconds)
- Unlikely to see hemodynamically significant inhibition of pacing
- Concern if pacer-dependent, especially if unipolar lead configuration
  - Reset device to asynchronous mode

Crossley, p. 1121
ECT, cont’d

• Sinus tachycardia from sympathetic discharge could trigger inappropriate ICD tx
  • Unlikely with standard programmed ICDs
  • Know the ICD tachycardia detection rate
  • Verify that magnet switch is on prior
  • Magnet immediately available

• Pretreating with short-acting BB may help

Ibid.
Radiofrequency Ablation

- Avoid direct contact with device and leads
- Keep RF path as far from both as possible

Crossley, p. 1123
Cardioversion

- Ideal: current path perpendicular to device electrodes
- Anterior-posterior orientation of pads most likely to achieve this
- Have > 8 cm btw anterior pad and device
- Rare to have abnormal device function as a result

Crossley, p. 1120
Central Line Placement

- Keep guidewire out of ventricle in pt w/ICD
- Arrhythmias can trigger device therapy
- Touching device electrodes can trigger device
- Increased chance of dislodging a lead if inserted w/in last 3 months

Crossley, p. 1130
Tissue Expanders

• Some breast implants have magnets to direct needles used to fill them with fluid
• Should not be used in patients with pacers or ICDs

Crossley, p. 1122
Concerns in Bi-V Pacing

- Can cause long QT and Torsades
- Loss of ventricular pacing can cause immediate drop in CO
- Need rapid access to defibrillator if no ICD
- TEE intraop?
  - Only monitor that will tell you if BiV pacing behavior is lost

Rozner, p. 1393, 1398
Intraoperative Pacing Problems

• 3 causes of PM failure:
  • Generator failure
  • Lead failure
  • Failure to capture

Rozner, p. 1400-2
Generator Failure

• Rare in a device evaluated pre-op
• Highest risk is with procedure near/at generator site
Lead Failure

- Has been reported during pt repositioning
- Can have under- or oversensing or failure to capture

Ibid.
Failure to Capture

• May be caused by lead failure
• Changes in myocardium that lengthen refractory period or increase energy required for depolarization

• Examples:
  • Myocardial ischemia/infarction
  • Acid-base or electrolyte abnormality
  • Abnormal levels of antiarrhythmics

Ibid.
Managing Pacemaker Failure

• If pt has perfusing rhythm and stable VS, can observe while making a plan to fix problem

• If inadequate perfusion:
  • Apply magnet if PM is known to revert to asynchronous mode
  • Initiate temporary pacing (transcutaneous, transvenous)
Inadequate Perfusion, cont’d

• Sympathomimetics will decrease depolarization threshold and increase chronotropicity
• Seek and correct causes of myocardial ischemia
• Check electrolytes, acid-base status and levels of antiarrhythmics
• If none of these succeed, consider having a surgeon place epicardial leads

Ibid.
Transcutaneous Pacing

Click Here For Pacing Simulation Video
True Surgical Emergencies

- Identify the device type
- All pts should have pacing/defibrillation pads placed in AP position and connected
- Is the patient pacing?
- If spikes in front of all/most P waves and/or QRS complexes, assume pt is pacer-dependent

Crossley, p. 1127-29
Yes: Patient is Pacing

• Short cautery bursts ok

• Pacemaker only
  • Place magnet over device if:
    – Surgery above umbilicus
    – Extensive electrosurgery
    – If position inhibits rapid application of magnet
  • If surgery below umbilicus, have magnet immediately available

Ibid.
Yes: Patient is Pacing, cont’d

• Pacing via ICD
  • Place magnet to suspend anti-tachy functions unless operation is on lower extremities
  • Monitor closely for pacer inhibition
  • The only way to put an ICD into asynchronous pacing is via reprogramming

Ibid.
No: Patient is not Pacing

- Pacemaker only
  - Have magnet immediately available
  - If brady/tachy during procedure, apply magnet
- ICD
  - Apply magnet to suspend anti-tachy functions
  - Short cautery bursts
If Time Even More Limited…

- Pacer/defib pads in AP position
- Apply magnet

Ibid.
Post-Operative Management

- Interrogate device
- Restore/modify previous settings as appropriate
- Case reports of threshold increases, safety mode resets, and appearance of elective replacement indicator
- Back-up pacing and defibrillation equipment stays w/pt in PACU

ASA, p. 253
Who Can Help?

- Boston Scientific 800-227-3422
- Medtronic 800-505-4636
- St. Jude Medical 800-722-3774
Who Can Help at UH?

EP service pager: 36219
After hours: Contact CICU fellow
Case Example

• 27 y/o F with dilated cardiomyopathy (EF=30%) and pacer-ICD placed 1 year ago s/p perioperative v fib arrest at CCF following cholecystectomy. BMI=55, severe OSA. Presenting for EAB at 14 weeks. Surgeon tells you he will not need any electrocautery.
Case Example

• 83 y/o M with DDDR pacemaker placed following an episode of symptomatic bradycardia. Presenting for laser lithotripsy.
From the UH Case Files

• Friday night at 23:00
• 55 y/o M with BMI=40, myasthenia gravis and “pacemaker”
• Pt knows little about his device
• Dr. Sanabria wants GA for emergency appendectomy
• T=37.1 C, VSS. WBC=20K.
• What is your plan for management of his implantable electronic cardiac device?