Managing Pacemakers and Automatic Internal Cardiac Defibrillators for Non-Cardiac Surgery
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Due to the aging population and the increasing frequency of heart failure as well as the expanded indications for Cardiac Implantable Electrical Devices (CIEDs), permanently implanted pacemakers (PMs) and automatic internal cardiac defibrillators (AICDs) are more frequently encountered in the perioperative setting than ever before. No longer are these devices solely in the realm of the cardiac anesthesiologist. Indeed, the anesthesiologist or surgeon may be the most qualified healthcare professional immediately available in the operating room environment to troubleshoot and manage these devices, particularly on nights and weekends. Hence, familiarity with the types of CIEDs available and their indications for placement will aid the anesthesiologist in the formulation of a perioperative prescription for CIED management, proper monitoring of CIED function, and diagnosis of common intraoperative CIED malfunctions.

There exist several myths surrounding the CIEDs in the perioperative period. For example, not every CIED should to be interrogated immediately before or after surgery. Not all AICDs should have the anti-tachydysrythmia monitoring or therapeutic modalities deactivated. Magnets do not suspend all pacing functions, nor do they typically alter underlying PM programming in AICDs. Basic understanding about modern implantable CIEDs and a review of current guidelines for management can dispel much of the discomfort that may accompany caring for these patients. Until the recent past, management advisories from the American Society of Anesthesiologists (ASA) and from the Heart Rhythm Society (HRS) and American Heart Association (AHA) have been somewhat incongruent. In 2011, however, an expert consensus statement jointly sponsored by the above groups and the Society of Thoracic Surgeons was published, along with a practice advisory from the ASA. Familiarity with these documents, from which the following summary is derived, is imperative.

When encountering a patient with a CIED, a proposed checklist encompassing the essential elements of the preoperative CIED evaluation includes the following:
- Date of last device interrogation (should be within 6 months for AICD, 12 months for pacemaker)
- Type of device
- Manufacturer and model
- Indication for device
- Battery longevity (should be >3 months)
- Age of leads (should be > 3 months)
- What is the basic programming mode?
- Is there ICD therapy?
- Is the patient pacemaker dependent?
- What is the underlying rhythm (if determinable)?
- What is the response to magnet placement
• Did any alerts exist during last interrogation?
• Are the last pacing thresholds known?

Much of the above information can be obtained from the patient’s pacemaker wallet card, if available. If not, then it may be readily obtainable by calling the implanting physician’s office or by calling the device manufacturer directly. If the device has been interrogated within the accepted windows, and the patient’s cardiac status has remained stable, there is likely not a need per se for re-interrogation preoperatively. If the patient cannot identify the device (ICD vs. PM), and the device has not been interrogated within the recommended window, then preoperative interrogation is indicated.

Pacemaker nomenclature has remained constant in past years, and follows the formula:
• Position I: chamber paced
  o A = atrium
  o V = ventricle
  o D = dual chamber
• Position II: chamber sensed, as above, with “O” indicating lack of sensing
• Position III: response to sensed event
  o I = inhibits
  o T = triggers
  o D = dual mode of response
  o O = no response
• Position IV: rate modulation
  o R = rate responsive to patient activity
  o O = rate modulation unavailable/disabled
• Position V: location or absence of multisite pacing (frequently omitted, uncommon)

Many pacers are equipped with the ability to switch modes. Paroxysmal atrial tachycardia, for example, may prompt a pacer in DDDR mode to switch to VVI or VVIR as AV-sequential pacing in this event would result in rapid ventricular pacing and potentially result in hemodynamic compromise.

The indication for CIED insertion is clinically relevant for formulation of a perioperative management plan. Common indications provide cues to further questioning about pertinent medical history. For example, the perioperative management plan for a patient with an AICD will be quite different if placed for congenital prolonged QT syndrome than for someone with an ischemic cardiomyopathy and a severely depressed left ventricular ejection fraction. Indications for CIEDs include, but are not limited, to the following:

<table>
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<tr>
<th>Sinus Node Dysfunction</th>
<th>Acquired AV Block</th>
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<tr>
<td>Bifascicular/Complete Heart Block</td>
<td>Post-Infarct</td>
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<tr>
<td>Hypersensitive Carotid Sinus Syndrome</td>
<td>Neurocardiogenic Syncope</td>
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<td>Prevention of Atrial Fibrillation</td>
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<td>Severe Systolic Heart Failure</td>
<td>Hypertrophic Cardiomyopathy</td>
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<td>Congenital Heart Disease</td>
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<td>Detection of/Termination of Ventricular Fibrillation</td>
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<tr>
<td>Detection of/Termination of Cardiac Tachycardias</td>
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Additionally, the date of initial CIED implantation is important, as leads < 3 months old may not be scarred in and remaining battery life depends on age of device and energy consumption, the latter of which is increased by pacemaker dependence and mode of programming. The mode of programming in turn determines expected rate-responsiveness, antitachycardia pacing (ATP) threshold, whether the device can function as an ICD and if so, the trigger necessary to activate a therapeutic shock as well as the pattern and duration of repetitive shocks if the initial defibrillation is unsuccessful.

Pacemaker dependence is defined by the presence of a predominant atrial and/or ventricular pacing spike identified on pre-operative 12-lead ECG or telemetry. Evaluation by telemetry may require the monitor to be placed in a mode that enables detection, and even then, identification of atrial pacing spikes may prove difficult. If so, pacemaker interrogation may be necessary. The ECG obtained during interrogation is derived directly from the leads, and the interrogation device clearly indicates native complexes and paced beats. The pacemaker can also be temporarily paused during interrogation to allow for determination of the patient’s underlying rhythm, which is particularly important information if the planned surgical procedure is likely to cause significant electromagnetic interference (EMI).

Electromagnetic interference, the most likely cause of CIED malfunction intra-operatively, is unlikely to result from bipolar electrosurgery (unless applied to the generator) and from monopolar electrosurgery applied below the umbilicus. If EMI occurs, it may result in PM oversensing or inhibition as well as ICD or ATP inhibition or false arrhythmia detection, possibly resulting in an unnecessary shock. With EMI, devices that use impedance-based technology for rate modulation may respond by pacing at the upper rate. Electroconvulsive therapy, TENS units, and GI electrocautery can produce EMI, and radiofrequency used for ablative procedures produces similar EMI to electrosurgery. Routine monopolar electrosurgery is unlikely to cause generator damage or damage to the lead/tissue interface unless applied directly to the hardware. In contrast, external cardioversion/defibrillation and therapeutic radiation can both cause device reset.

To mitigate the risks of EMI, the current pathway should be removed away from the CIED whenever possible, and bipolar electrosurgery is preferable if adequate for surgical needs. If not, monopolar electrosurgery bursts should be limited to <5 seconds. If a patient has a PM and is PM dependent, then a magnet will place the pacer into an asynchronous mode and deactivate anti-tachycardia pacing and rate modulation. The rate of asynchronous pacing depends on the manufacturer and the remaining battery life. Asynchronous pacing is rarely necessary for procedures on the lower extremities. Conversely, if the magnet mode is triggered on ICDs (unless the magnet switch has specifically been deactivated), then the underlying PM programming is unaffected, but the defibrillation therapies will be deactivated. If a patient is PM dependent, has an AICD, and significant EMI is likely to be encountered intraoperatively, then it would be prudent to reprogram the device to an asynchronous mode with tachy-therapies disabled for the duration of the procedure. It is imperative that resuscitative devices and means of external defibrillation are available until the device is re-programmed after surgery concludes.

Additional basic perioperative monitoring includes:

- ECG (off filter)
- Pulse waveform displayed
- Consideration for increased oxygen demand, as asynchronous mode typically results in HRs in 90s.
- Consider invasive monitoring for HOCM or Bi-V patients
- Appropriate equipment must be on hand to provide backup pacing and/or defibrillation
- External pads

The choice of anesthetic regimen should be dictated by the patient’s underlying physiology as well as the procedure. However, the use of drugs or techniques that suppress the AV or SA node (such as potent opiates, dexmedetomidine, or neuraxial sympathetic blockade) can abolish any underlying rhythm that might be present and render the patient truly PM dependent.

The following algorithm was developed as a guideline for perioperative CIED management at our institution:

The workshop session will include basic instruction about CIED interrogation, and attendees will be given the opportunity to interrogate and reprogram devices during the hands-on session.

References: