An update on the management of implanted cardiac devices during electrosurgical procedures

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Electromagnetic currents including those induced during electrosurgical procedures or video capsule endoscopy can interfere with implantable cardiac rhythm control devices, including permanent pacemakers (PPMs) and implantable cardioverter-defibrillators (ICDs). Current recommendations for the management of these cardiac devices are based on consensus statements published by individual societies, many of which are conflicting or outdated. This article summarizes previous recommendations and provides an update of the management of implantable cardiac devices during electrosurgical procedures.

The indications for implantable cardiac rhythm control devices are rapidly expanding, and, as a result, endoscopists are encountering patients with such devices more frequently. These devices sense the intrinsic electrical activity of the heart and deliver electrical impulses to correct a variety of cardiac rhythm disorders. Thus, they may be vulnerable to electromagnetic signals that are not cardiac in origin, including electrosurgery. To date, there is very little in the way of guidelines and appropriate management of these devices as they pertain to electrosurgery. This article illustrates the underlying mechanism of electromagnetic interference and summarizes and updates the recommendations for appropriately managing various implanted cardiac devices during endoscopic procedures that require the use of electrosurgical current.

ELECTROMAGNETIC INTERFERENCE

ICDs and PPMs sense cardiac electrical activity using electrodes placed in the heart can detect changes in cardiac electrical activity. A fully subcutaneous ICD system is now available that senses via the device and a subcutaneously placed electrode. It is possible for these systems to detect electrical currents produced by an electrosurgical device as being intrinsic cardiac activity. Oversensing may lead to inappropriate reprogramming of the device, inhibition of pacing by a PPM, or inappropriate antitachycardia pacing or shocks by an ICD.

Endoscopic electrosurgery is often used in polypectomy, fulguration of tissue, sphincterotomy, and coagulation of bleeding vessels. Endoscopists routinely use electrocautery to perform these procedures and, depending on the scenario, will choose among unipolar, bipolar, or multipolar devices. With unipolar electrosurgical devices, electromagnetic current emanates from an electrode at the tip of the instrument and moves through the patient to the grounding pad and back to the single electrode on the instrument. With bipolar and multipolar devices, there exist 2 or more electrodes at the tip of the instrument from which the current is both generated and received, allowing the induced current to only flow through the area close to the tip of the instrument. The electromagnetic field that is created by the flow of the current creates electromagnetic interference that can affect implanted cardiac devices.

Pacemakers

PPMs may be indicated for the treatment of symptomatic bradycardia, atrioventricular block, syncope, and heart failure. As the indications for permanent pacing, particularly in heart failure, continue to expand, so does the endoscopist’s exposure to patients with implanted pacemakers. Various medical societies and pacemaker manufacturers have published guidelines on how to appropriately manage pacemakers in the setting of potential electromagnetic interference (EMI). During the preoperative period, all of the guidelines agree that it is important to determine whether a patient is pacemaker dependent, which is defined as those patients in whom adequate hemodynamic stability or cardiac rhythm cannot be maintained without assistance from the pacemaker (ie, those who have complete atrioventricular block or no spontaneous ventricular activity when the pacemaker is inactivated or those in...
whom bradyarrhythmia results in syncope or hypoten-
sion). In a pacemaker-dependent patient undergoing elec-
trosurgery, interrogation and reprogramming of the pacemaker should occur immediately before and after the procedure.1,2,7

The American College of Cardiology Foundation and the American Heart Association (ACCF/AHA) differ from the American Society for Gastrointestinal Endoscopy (ASGE) in their views on perioperative management of pacemaker-dependent patients undergoing electrosurgery. The ACCF/AHA guidelines specifically recommend that the pacemaker be reprogrammed to an asynchronous mode (VOO or DOO) throughout the entire procedure. External pacing can also be effective as long as it too is set to the asynchronous mode that will be unaffected by cautery. Asynchronous pacing refers to regular, uninhib-
it ed pacing in which the pacemaker has no sensing capa-
bility; therefore, any interference detected as a result of electrosurgery will not result in a pacemaker response. Asynchronous pacing can be achieved by programming the pacemaker in the VOO mode, in which a single ventricle generates or in DOO mode, in which both the atrium and ventricle generate a fixed interval rate with no relationship to a spontaneous rhythm. Conversely, the ASGE guidelines indicate that reprogramming is only needed in pacemaker-dependent patients and in those in whom prolonged electrocautery is anticipated such as in the treatment of gastric antral vascular ectasia or radiation proctitis.1,4,5

The consensus among most guidelines is that no further intervention is required if a patient is not pacemaker dependent or in procedures in which there will not be pro-
longed use of electrosurgery. Additionally, it is recom-
dended that the ground plate should be positioned in a such a way so that the current pathway does pass through or near the implanted pulse generator system and that bipolar electrosurgery with short, intermittent, and irregular bursts at the lowest feasible energy levels be used whenever possible.1,4,5

**IMPLANTABLE CARDIAC DEFIBRILLATORS**

ICDs have been shown to reduce mortality in patients who have survived a cardiac arrest secondary to ventricu-
lar arrhythmia (secondary prevention) and in selected patients with left ventricular systolic dysfunction despite optimal medical management (primary prevention).8 The indications for placement of an ICD continue to expand, however, as studies demonstrate benefit in expanding patient populations. As a result, it is imperative for endo-
scopists to update their understanding of the equipment and potential EMI that may occur with use of electrosurgery.

ICD systems include the pulse generator, which consists of a titanium case, battery, electronics, voltage converters, capacitors, and 1 to 3 leads. In a single-chamber system, a single lead is placed in the right ventricle (Fig. 1). A dual-chamber system consists of a pulse generator and leads in the right atrium and right ventricle (Fig. 2). Resynchronization systems require leads in the right atrium, right ventricle, and coronary sinus. ICDs sense and pace the heart similarly to pacemakers. In addition, ICDs are designed to sense abnormally fast rhythms, distin-
guish among various mechanisms, and then deliver appropriate pacing or shock therapy.9

Electrocautery is a technique commonly used by endo-
scopists to perform a polypectomy or sphincterotomy of the biliary or pancreatic sphincter.10 ICDs detect tachyar-
rhythmias by sensing a number of R-R intervals above a preprogrammed rate threshold, which is typically in the range of 150 to 200 beats per minute during a 3- to 5-
second interval. The specific criterion does vary slightly among different manufacturers and models. Generally speaking, the signal generated during electrosurgery is 1600 times the sensing threshold of the ICD and therefore may be misconstrued by the ICD as being ventricular tachycardia or ventricular fibrillation if the impulse is in proximity to the sensing electrode.11 Although devices have algorithms to prevent inappropriate sensing, poten-
tial adverse effects of electrocautery in this setting include pacing inhibition, mode switching, incorrect detection of tachyarrhythmias, device inactivation, myocardial burns, ventricular fibrillation, and death.11 There are limited data pertaining to EMI from electrosurgery resulting in any adverse events. In 1 series, Fiek et al12 found no device-related adverse events in 48 patients with ICDs in whom electrocautery was used. In another study, Cheng et al13 enrolled 92 individuals being referred for evaluation of an implanted pacemaker or defibrillator before noncardi-
cardiac surgery/endoscopy. The devices were programmed to allow for detection of EMI and were fully interrogated again after surgery. Cheng et al found that all devices with-
stood periprocedural EMI exposure without malfunction or changes in programming and ultimately concluded that EMI during noncardiac surgical/endoscopic procedures poses little threat to current device systems. Of note, Cheng et al found 3 devices that demonstrated brief atrial mode-switching episodes and 2 pacemaker devices that demonstrated inappropriate sensing of ventricular noise, when the application of electrosurgery was in close proximity to the generator (<8 cm).

Nonetheless, because there is potential for adverse events as a result of EMI from electrosurgery, current rec-
ommendations are to reprogram an ICD to inactivate tachyarrhythmia detection before procedures in which electrosurgery is to be used. If unable to do so, a magnet placed over the pulse generator may inactivate tachyar-
rhythmia therapy. Some devices may be programmed to disable this magnet function, thus eliminating the poten-
tial benefit from magnet placement.9 Most guidelines for managing ICDs in the setting of electrosurgical
procedures recommend consulting a cardiologist or a team specifically trained in cardiovascular implantable device management in the preoperative period to do the reprogramming.

CARDIAC RESYNCHRONIZATION THERAPY

Cardiac resynchronization therapy (CRT) differs from pacemakers and ICDs in that its left ventricular lead is placed on the outer wall of the left ventricle as opposed to pacemakers and ICDs in which the lead placement is intraventricular (Fig. 3). CRT has been shown to significantly improve symptoms and survival in patients with heart failure and left bundle branch block and may be useful in some patients with wide QRS complexes not caused by left bundle branch block.

The underlying pathology in these patients is mechanical and electrical dyssynchrony leading to wall motion abnormalities and ultimately a decline in stroke volume. CRT devices correct this dyssynchrony by stimulating the right and left ventricles simultaneously. As these devices generally sense only the right atrium and ventricle, they should behave like dual-chamber devices.

There are limited studies evaluating the effect of EMI with regard to CRT and electrosurgery. There are currently no specific recommendations for management of patients with CRT being exposed to EMI, and current recommendations are mainly based on studies that have been done on pacemakers and ICDs, summarized in the following (Tables 1 and 2).

DISCUSSION

Limited data have resulted in variations among societal recommendations of how to properly manage implantable cardiac rhythm control devices that are potentially susceptible to EMI during electrosurgery. It is imperative that further studies be done to produce a general consensus on evidence-based guidelines. This holds especially true with regard to CRT. Despite certain differences among societal recommendations, there are recommendations that are uniformly emphasized. The first is to ascertain the type and exact location of the implanted cardiac device, its programmed settings, the patient’s underlying disease process requiring its placement, and whether the patient is device dependent. The second is that the patient’s
### TABLE 1. Pacemakers: recommendations for managing pacemakers in the setting of electrosurgical procedures

<table>
<thead>
<tr>
<th>Pre-procedure</th>
<th>During procedure</th>
<th>Post-procedure</th>
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<tbody>
<tr>
<td><strong>Universal recommendations</strong></td>
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<tr>
<td>1. Assess the type of implanted cardiac device, its location, the reason for the patient’s need for the device and dependence on the device.</td>
<td>Closely monitor vital signs and heart rhythms with electrocardiography during the procedure. The patient should be monitored continuously via hard-wired monitoring.</td>
<td>If the pacemaker or ICD was reprogrammed, restore baseline function of the device.</td>
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<td>2. Determine whether the patient is pacemaker dependent and attempt to predict whether prolonged electromagnetic current will be needed.</td>
<td>2. Cardioverter-defibrillation equipment should readily available.</td>
<td>2. There is no need for further follow-up if the device is interrogated after the procedure.</td>
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<td>a. If patient is not pacemaker dependent, then no reprogramming is necessary.</td>
<td>3. Use alternative methods to electrocautery whenever possible.</td>
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<tr>
<td>b. If pacemaker dependent and prolonged electrocautery may be required, see specific recommendations below.</td>
<td>4. Apply bipolar or multipolar currents rather than unipolar currents whenever possible.</td>
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<td></td>
<td>5. Whenever unipolar cautery is required, place the grounding pad on the patient in a location such that the applied current does not pass close to or through the leads of the cardiac device.</td>
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<td></td>
<td>6. Minimize the strength of the electrosurgical current applied.</td>
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<td></td>
<td>7. Apply the electrosurgical current intermittently and for the shortest amount of time possible.</td>
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<td></td>
<td>8. External pacing can be effective. It can be set to the asynchronous mode and will be unaffected by cautery.</td>
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<tr>
<td><strong>AACF/AHA</strong></td>
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<tr>
<td>1. Procedure team should be responsible for determining type of implanted cardiac device, its location, the reason for the patient’s need for the device and dependence on the device.</td>
<td>1. Restore baseline settings and closely monitor the patient in the immediate postprocedural period, but no need for specific consultation or follow-up.</td>
<td></td>
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<tr>
<td>2. If pacemaker dependent and prolonged electrocautery may be required, the pacemaker should be reprogrammed to the asynchronous mode for the duration of the procedure.</td>
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<tr>
<td><strong>ASGE</strong></td>
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<tr>
<td>1. Procedure team should be responsible for determining type of implanted cardiac device, its location, the reason for the patient’s need for the device and dependence on the device.</td>
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<td>2. If pacemaker dependent and prolonged electrocautery may be required, the pacemaker should be reprogrammed to the asynchronous mode for the duration of the procedure.</td>
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<td><strong>HRS/ASA</strong></td>
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<tr>
<td>1. A team specifically trained in cardiovascular implantable devices should be consulted to determine type of implanted cardiac device, its location, the reason for the patient’s need for the device and dependence on the device.</td>
<td>1. Consult cardiology or pacemaker/ICD service for restoring baseline device settings.</td>
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<tr>
<td>2. If pacemaker dependent and prolonged electrocautery may be required, reprogram the pacemaker to the asynchronous mode only when electrosurgical procedures are used above the level of the umbilicus.</td>
<td>2. An additional evaluation of the device should be performed within 1 month after the procedure.</td>
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ACCF/AHA, American College of Cardiology Foundation/American Heart Association; ASGE, American Society for Gastrointestinal Endoscopy; HRS/ASA, Heart Rhythm Society and the American Society of Anesthesiologists; ICD, implantable cardioverter-defibrillator.
vital signs and electrocardiographic rhythms should be continuously monitored during the procedure. 

Third, exposure to electrosurgical current should be minimized and, when required, should be delivered in irregular intermittent bursts rather than sustained applications, ideally for no more than 5 seconds at a time. 

Next, when possible, bipolar or multipolar modes are preferred over unipolar modes because they are less prone to induce EMI. When unipolar cautery is required, the grounding pad should be placed on the patient in a location distant to the cardiac device such that the current induced by the electrosurgery does not pass close to or through the leads of the cardiac device. Finally, electrosurgical procedures should be performed at the farthest distance possible from the cardiac device to minimize the potential EMI.

Advances in endoscopic techniques, particularly an increased use of video capsule endoscopy, have raised concern regarding its potential to induce EMI in patients with implanted cardiac devices. These devices do produce an electromagnetic field, and therefore the U.S. Food and Drug Administration requires manufacturers of these pill cameras to include package inserts stating whether its use is contraindicated in patients with implanted cardiac devices. 

Cuschieri et al recently conducted a chart review of 20 patients with implanted pacemakers or ICDs who underwent small-bowel capsule endoscopies with continuous electrocardiographic monitoring. They found no adverse events or hemodynamically significant arrhythmias, and a majority of the abnormalities found on electrocardiography were also present before and after the capsule endoscopy. They concluded that capsule-induced EMI is increased but unlikely of any clinical relevance. Similarly, in 2011 Bandorski et al retrieved data from 62 patients in a retrospective study to determine the safety of capsule endoscopy in patients with different types of pacemakers or ICDs. They found none of the pacemakers or ICDs to be impaired, and there was no clinically significant event observed in any of these patients after capsule endoscopy. As a result, Bandorski et al concluded that capsule endoscopy is safe in patients with cardiac pacemakers and ICDs.

**SUMMARY**

To date, the major guidelines for the management of implanted cardiac devices during electrosurgical procedures have come from 1 of several major medical societies. These most recent guidelines are from the ACCF/AHA in 2009, a combined consensus statement from the Heart Rhythm Society and the American Society of Anesthesiologists in 2011, as well as an update from the ASGE in 2007. Tables 1 and 2 summarize the most recent recommendations by society. Further studies are needed so that data can be available for the specialty societies to unify consensus on guidelines on the proper management of patients with implanted cardiac devices.
REFERENCES

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1. When doing procedures in patients with implanted devices
   a. Use bipolar or multipolar devices instead of monopolar if possible
   b. Place grounding pad near the device to divert the current
   c. No special action is needed if patient is not pacemaker dependent
   d. Program the pacemaker to asynchronous mode if the patient is pacemaker dependent and bipolar coagulation of an ulcer edge is planned.

2. True or False
   2. Current recommendations regarding ICD’s are to re-program it to inactivate tachyarrhythmia detection or to place a magnet over the generator.
   3. A patient who is not pacemaker dependent should have the pacemaker inactivated prior to endoscopy
   4. A grounding pad is needed for bipolar electrocoagulation
   5. Interrogation and reprogramming of the pacemaker must be done immediately before and after endoscopic procedures in patients who are pacemaker dependent
   6. Consideration should be given to changing the pacemaker to asynchronous mode (no sensing capability) in patients who will undergo extensive electrocautery
   7. The grounding pad should be draped over the pacemaker for maximum protection
   8. Most studies have shown that endoscopic cautery does not appear to cause electromagnetic interference with ICD’s
   9. Some ICD’s are programmed to disable the magnet function, in which case placing a magnet over the device is useless.
   10. Available data suggests that capsule endoscopy is safe in patients with pacemakers or implanted defibrillators