### INTRODUCTION

- CIEDs include permanent pacemakers and implantable cardioverter-defibrillators (ICDs).
- The number of surgical patients with CIEDs are increasing.
- Confusion and equivocality exists in clinical practice regarding appropriate CIED management regarding device magnet application.
- Diverse programming capabilities.
- Manufacturer-specific functionality.
- Advancements in technology.
- Leadless pacemakers
- Subcutaneous-ICDs
- Device magnet application results in alteration to certain CIED functions
- CIED functionality can be disrupted by electromagnetic interference (EMI) during surgery.
- EMI-related device malfunction can lead to adverse clinical outcomes.
- Insufficient studies exploring EMI-related device malfunction incidence and safety and efficacy of CIED magnet application in the surgical patient.

### OBJECTIVES

To develop a clinical cardiac implantable electronic device (CIED) management reference tool by examining current literature regarding the appropriate perioperative management of device magnet application in surgical patients with CIEDs.

### DESIGN & METHODS

An integrated research review (IRR) was conducted. Relevant searches were conducted by utilizing Science Direct, CINHAL, and the Cochrane Central Register of Controlled Trials databases. The inclusion criteria involved studies that were published within the last six years (2014-2020) and were comprised of adult surgical patients requiring anesthesia with permanent pacemakers or implantable cardioverter-defibrillators (ICDs).

### RESULTS

- Randomized trials which assess best perioperative management of CIEDs do not exist.
- Routine, nonselective magnet application over the CIED is not recommended.
- The CIED type and manufacturer, surgical location, likelihood of EMI, and individual CIED settings and/or pacemaker dependence should be considered by the anesthesia provider, as well as the manufacturer-specific magnet response when determining an appropriate protocol.
- Most clinically relevant EMI occurs from monopolar electrosurgery (e.g. Bovie).
- Most studies and experts agree that most clinically meaningful EMI in non-cardiac surgery occurs above the umbilicus or iliac crest, which leads to a general consensus of either reprogramming or magnet application to alter CIED function.
- EMI-induced inappropriate ICD antitachycardia therapies may result in adverse clinical outcomes:
  - Myocardial injury, malignant ventricular arrhythmias, increased mortality.

### DISCUSSION & CONCLUSION

- Higher-level research, as well as more consistent manufacturer-specific device settings and responses, is necessary to formulate a more standardized, evidence-based protocol regarding the perioperative care of patients with CIEDs.
- A quick clinical CIED management reference tool can assist with basic clinical decision-making, which may be especially helpful in rural and emergency settings.
- The anesthesia provider should be equipped with the basic knowledge of CIED management and current resources to construct an optimal, individualized plan of care during the perioperative period.

- **References are available upon request**

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**Manufacturer-Specific Responses to Magnet Application and Recommendations**

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<thead>
<tr>
<th>CIED Manufacturer</th>
<th>Response to Magnet Application</th>
<th>Recommendations for Determination of Magnet Response</th>
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| Medtronic (Cronin, Dalia, Nguyen, et al., 2019) | Pacemaker: Asynchronous pacing at 85 bpm* and decrease to 65 bpm at elective replacement at device end of life.  
100 bpm for the first 3 beats with the exception of 2 models.  
*Threshold margin test may involve the emission of 1 or more ventricular pulses at a supra-threshold pulse voltage for the first 3 beats.  
Mitra Loudness Pacemaker: No response.  
Mitra Clip Antitachycardia therapies disabled and pacemaker settings unchanged. Some devices output a tone for 15-30 seconds in response to magnet application.  | Contact Medtronic at 1-800-633-7266  
Obtain device interrogation. |
| Abbott (formerly St. Jude Medical) (Cronin & Essakhal, 2019) | Defibrillator: Test = Asynchronous pacing at 100 bpm with rate decreasing at elective replacement indicator.  
OFF = No response.  
Data collection = Yes change.  
Data collection and battery test = Magnet application longer than 5 seconds results in asynchronous pacing at 100 bpm.  
Less than 5 seconds results in no change.  
ICDs: Antitachycardia therapies disabled and pacemaker settings unchanged. Some devices output a tone for 15-30 seconds in response to magnet application. | Contact St. Jude Medical at 1-800-PACE-ID  
1-800-722-3423  
Obtain device interrogation. |
| Boston Scientific (Cronin, Birgerstedt-Green, & Eisenholtz, 2019) | Defibrillator: Standard asynchronous pacing of 100 bpm and decrease to 65 bpm at elective replacement and less than 85 bpm at device end of life.  
OFF = No response.  
IEEE: Only antitachycardia therapies suspended. Pacemaker functionality remains unchanged. Reprogramming is necessary to elicit asynchronous pacing. EMI-induced pacemaker inhibition can cause a reduced cardiac output secondary to asynchronous contraction of the left ventricle.  
ICDs: Antitachycardia therapies and post-shock therapies disabled. Deep emission for 60 seconds with each R wave.  
*It is recommended that suspension of antitachycardia therapies be completed by reprogramming secondary to larger area sensing, increased susceptibility to EMI, and issues with appropriate magnet application.  | Contact Boston Scientific at 1-800-CARDIAC  
1-800-227-5423  
Obtain device interrogation. |
Default: Antitachycardia therapies return to original device settings at lower rate limit. As elective replacement indicator, these responses change.  
Asynchronous Response = Asynchronous pacing at 90 bpm. The AV delay is programmable or 100 ms.  
Synchronous Response = Pacing continues as originally programmed at lower rate.  
Defibrillator: Antitachycardia therapies disabled and pacemaker settings unchanged with no beep or tone emitters.  
*No emission of sound or confirmation of magnet detection.  | Contact Biotronik at 1-800-583-6334  
Obtain device interrogation or view current report.  
Sustained response to magnet application. |