Perioperative Considerations of Cardiac Implantable Electronic Devices: An Integrated Research Review of Anesthetic Management and Device Magnet Application

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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.

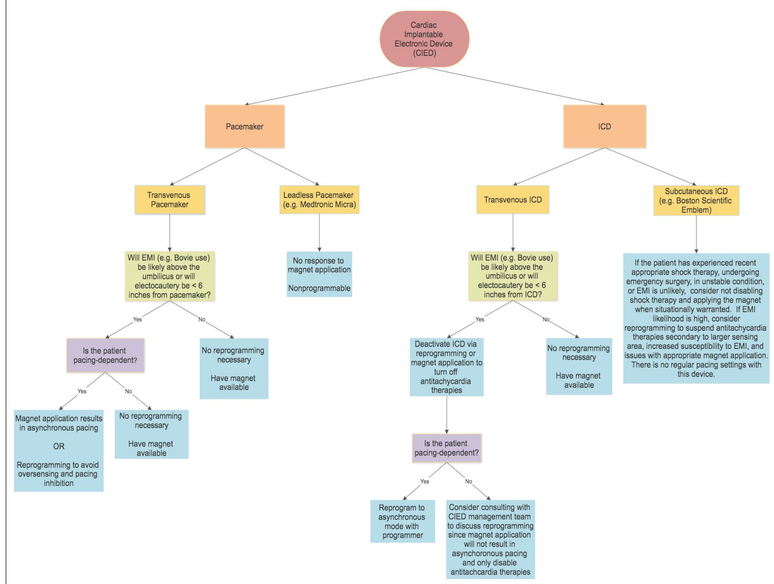
DESIGN & METHODS

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 plan regarding CIED management
- Most clinically relevant EMI occurs from monopolar electrocautery (e.g. Bovie)
- Most studies and experts agree that most clinically meaningful EMI in noncardiac 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

Decision Algorithm for CIED Management & Magnet Application



Perioperative Anesthetic Implications

Preoperative:
- Determine CIED type, manufacturer, and indication for placement
- Determine if patient is pacer-dependent
- Obtain most recent CIED interrogation report and determine CIED settings, battery status, and magnet response
- Determine if EMI is likely to occur during the intraoperative period (e.g. if monopolar electocautery [Bovie] is used above the umbilicus or within 6 inches of the CIED)
- Avoid nonselective use of magnet application
- Guarantee availability of emergency temporary pacing and/or defibrillation equipment
- When in doubt, consult the CIED manufacturer or CIED specialist

Intraoperative:
- Standard ASA monitoring (e.g. continuous electrocardiography, pulse oximetry or intraarterial pressure monitoring)
- Minimize EMI risk by using short, intermittent bursts at low energy level and/or use bipolar electocautery or harmonic scalpel
- Direct appropriate placement of electrosurgical dispersive electrodes (e.g. current pathway does not pass through the CIED)

Postoperative:
- Monitor patient cardiovascular status until pre-surgical CIED settings are restored
- Postoperative interrogation may be warranted after the occurrence of emergency surgery, preoperative reprogramming, intraoperative discharge of antitachycardia therapy, or suspicion of CIED malfunction

Manufacturer-Specific Responses to Magnet Application and Recommendations

CIED Manufacturer * Only the most four most frequently utilized CIED manufacturers are listed. More manufacturers may be seen in clinical practice.	Response to Magnet Application	Recommendations for Determination of Magnet Response
Medtronic **(Cronin, Dalia, Nguyen, et al., 2019)**	Pacemakers: Asynchronous pacing of 85 bpm* and decrease to 65 bmp at elective replacement at device end of life *100 bmp for the first 3 beats with the exception of two models *Threshold margin test may involve the emission of 1 or more ventricular pulses at a reduced pulse or voltage for the first 7 beats Micra Leadless Pacemaker: No response ICDs: Antitachycardia therapies disabled and pacemaker settings unaltered. Some devices exhibit a tone for 15-30 seconds in response to magnet application	Contact Medtronic at 1-800-633-8766 OR Obtain device interrogation
Abbott (formerly St. Jude Medical) **(Cronin & Essandoh, 2018a)**	Pacemakers: Programmable magnet response • Default "Battery Test" = Asynchronous pacing at 100 bpm with rate decreasing at elective replacement indicator • OFF = No response • Data collection = No 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: Programmable magnet response • Default = Disablement of tachyarrhythmia therapies with unchanged pacemaker settings • Off = No change either tachyarrhythmia therapies or pacemaker settings **No emission of sound or confirmation of magnet detection	Contact St. Jude Medical at 1-800-PACE-ID (1-800-722-3423) OR Obtain device interrogation
Boston Scientific **(Cronin, Birgersdottter-Green, & Essandoh, 2019)**	Pacemakers: Default asynchronous pacing* of 100 bpm and decrease to 85 bpm at elective replacement and less than 85 bpm at device end of life ICDs: Default antitachycardia therapies disabled and pacemaker settings unaltered. Placement of magnet evokes beep or tone emission CRT-Ds: Only tachyarrhythmia therapies suspended. Pacemaker functionality remains unaltered. 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 S-ICDs: Antitachycardia therapies and post-shock therapies disabled. Beep emission for 60 seconds with each R wave. **It is recommended that suspension of antitachycardia therapies be completed by reprogramming secondary to larger sensing area, increased susceptibility to EMI, and issues with appropriate magnet application	Contact Boston Scientific at 1-800-CARDIAC (1-800-227-3422) OR Obtain device interrogation
Biotronik **(Cronin, Dalia, Sandoval, et al., 2019)**	Pacemakers: Programmable magnet response • Default "Auto" Response = 10 asynchronous beats at 90 bmp → return to original device settings at lower rate limit. At elective replacement indicator, these responses change • Asynchronous Response = Asynchronous pacing at 90 bmp. The AV delay is programmable or 100 ms • Synchronous Response = Pacing continues as originally programmed at lower rate late Defibrillators: Antitachycardia therapies disabled and pacemaker settings unaltered with no beep or tone emission **No emission of sound or confirmation of magnet detection	Contact Biotronik at 1-800-547-0394 OR Obtain device interrogation or view current report OR Sustained response to magnet application

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*