

**ASA Practice Advisory for Perioperative Management of Patients with Cardiac
Implantable Electronic Devices: Pacemakers and Implantable Cardioverter-
Defibrillators 2019 Update
Supplement 3: Bibliography by Section**

Preoperative Evaluation

Case reports or series

1. Anfinson OG, Berntsen RF, Aass H, Kongsgaard E, Amlie JP: Implantable cardioverter defibrillator dysfunction during and after magnetic resonance imaging. *Pacing Clin Electrophysiol* 2002; 25:1400-2
2. Atar I, Bal U, Ertan C, Ozin B, Muderrisoglu H: Inappropriate shock and battery switching to "End of Life" in a patient with biventricular ICD during magnetic resonance imaging. *Turk Kardiyol Dern Ars* 2016; 44:79-81
3. Baser K, Guray U, Durukan M, Demirkan B: High ventricular lead impedance of a DDD pacemaker after cranial magnetic resonance imaging. *Pacing Clin Electrophysiol* 2012; 35:e251-3
4. Fiek M, Remp T, Reithmann C, Steinbeck G: Complete loss of ICD programmability after magnetic resonance imaging. *Pacing Clin Electrophysiol* 2004; 27:1002-4
5. Schulman PM, Rozner MA: Case report: Use caution when applying magnets to pacemakers or defibrillators for surgery. *Anesth Analg* 2013; 117:422-7

Preoperative Preparation

Observational studies or non-pertinent comparison groups

1. Baeg MK, Kim S-W, Ko S-H, Lee YB, Hwang S, Lee B-W, Choi HJ, Park JM, Lee I-S, Oh Y-S, Choi M-G: Endoscopic electrosurgery in patients with cardiac implantable electronic devices. *Clin Endosc* 2016; 49:176-81
2. Gifford J, Larimer K, Thomas C, May P, Stanhope S, Gami A: Randomized controlled trial of perioperative ICD management: magnet application versus reprogramming. *Pacing Clin Electrophysiol* 2014; 37:1219-24
3. Gifford J, Larimer K, Thomas C, May P: ICD-ON registry for perioperative management of CIEDs: Most require no change. *Pacing Clin Electrophysiol* 2017; 40:128-34
4. Mahlow WJ, Craft RM, Misulia NL, Cox JW, Jr., Hirsh JB, Snider CC, Nabers JO, Dickson ZA, Muenchen RA, Wortham DC: A perioperative management algorithm for cardiac rhythm management devices: The PACED-OP protocol. *Pacing Clin Electrophysiol* 2013; 36:238-48
5. Schulman PM, Treggiari MM, Yanez ND, Henrikson CA, Jessel PM, Dewland TA, Merkel MJ, Sera V, Harukuni I, Anderson RB, Kahl E, Bingham A, Alkayed N, Stecker EC: Electromagnetic interference with protocolized electrosurgery dispersive electrode positioning in patients with implantable cardioverter defibrillators. *Anesthesiology* 2018 doi; 10.1097/ALN.0000000000002571
6. Chang AC, McAreavey D, Tripodi D, Fananapazir L: Radiofrequency catheter atrioventricular node ablation in patients with permanent cardiac pacing systems. *Pacing Clin Electrophysiol* 1994; 17:65-9
7. Ellenbogen KA, Wood MA, Stambler BS: Acute effects of radiofrequency ablation of atrial arrhythmias on implanted permanent pacing systems. *Pacing Clin Electrophysiol* 1996; 19:1287-95
8. Pfeiffer D, Tebbenjohanns J, Schumacher B, Jung W, Luderitz B: Pacemaker function during radiofrequency ablation. *Pacing Clin Electrophysiol* 1995; 18:1037-44
9. Sadoul N, Blankoff I, de Chillou C, Beurrier D, Messier M, Bizeau O, Magnin I, Dodinot B, Aliot E: Effects of radiofrequency catheter ablation on patients with permanent pacemakers. *J Interv Card Electrophysiol* 1997; 1:227-33
10. Skonieczki BD, Wells C, Wasser EJ, Dupuy DE: Radiofrequency and microwave tumor ablation in patients with implanted cardiac devices: Is it safe? *Eur J Radiol* 2011; 79:343-6

11. Trohman RG, Simmons TW, Moore SL, Firstenberg MS, Williams D, Maloney JD: Catheter ablation of the atrioventricular junction using radiofrequency energy and a bilateral cardiac approach. *Am J Cardiol* 1992; 70:1438-43
12. Awad K, Griffin J, Crawford TC, Lane Cox S, Ferrick K, Mazur A, Pena RE, Lloyd SG, Michalski J, Johnson W, Bailey WM: Clinical safety of the Lforia implantable cardioverter-defibrillator system in patients subjected to thoracic spine and cardiac 1.5-T magnetic resonance imaging scanning conditions. *Heart Rhythm* 2015; 12:2155-61
13. Bailey WM, Rosenthal L, Fananapazir L, Gleva M, Mazur A, Rinaldi CA, Kypta A, Merkely B, Woodard PK: Clinical safety of the ProMRI pacemaker system in patients subjected to head and lower lumbar 1.5-T magnetic resonance imaging scanning conditions. *Heart Rhythm* 2015; 12:1183-91
14. Bailey WM, Mazur A, McCotter C, Woodard PK, Rosenthal L, Johnson W, Mela T: Clinical safety of the ProMRI pacemaker system in patients subjected to thoracic spine and cardiac 1.5-T magnetic resonance imaging scanning conditions. *Heart Rhythm* 2016; 13:464-71
15. Camacho JC, Moreno CC, Shah AD, Mittal PK, Mengistu A, Lloyd MS, El-Chami MF, Lerakis S, Saindane AM: Safety and quality of 1.5-T MRI in patients with conventional and MRI-conditional cardiac implantable electronic devices after implementation of a standardized protocol. *Am J Roentgenol* 2016; 207:599-604
16. Gimbel JR, Kanal E, Schwartz KM, Wilkoff BL: Outcome of magnetic resonance imaging (MRI) in selected patients with implantable cardioverter defibrillators (ICDs). *Pacing Clin Electrophysiol* 2005; 28:270-3
17. Halshtok O, Goitein O, Abu Sham'a R, Granit H, Glikson M, Konen E: Pacemakers and magnetic resonance imaging: No longer an absolute contraindication when scanned correctly. *Isr Med Assoc J* 2010; 12:391-5
18. Higgins JV, Sheldon SH, Watson RE, Dalzell C, Acker N, Cha Y-M, Asirvatham SJ, Kapa S, Felmlee JP, Friedman PA: "Power-on resets" in cardiac implantable electronic devices during magnetic resonance imaging. *Heart Rhythm* 2015; 12:540-4
19. Horwood L, Attili A, Luba F, Ibrahim EH, Parmar H, Stojanovska J, Gadoth-Goodman S, Fette C, Oral H, Bogun F: Magnetic resonance imaging in patients with cardiac implanted electronic devices: Focus on contraindications to magnetic resonance imaging protocols. *Europace* 2017; 19:812-7
20. Martin ET, Coman JA, Shellock FG, Pulling CC, Fair R, Jenkins K: Magnetic resonance imaging and cardiac pacemaker safety at 1.5-Tesla. *J Am Coll Cardiol* 2004; 43:1315-24
21. Mollerus M, Albin G, Lipinski M, Lucca J: Magnetic resonance imaging of pacemakers and implantable cardioverter-defibrillators without specific absorption rate restrictions. *Europace* 2010; 12:947-51
22. Naehle CP, Strach K, Thomas D, Meyer C, Linhart M, Bitaraf S, Litt H, Schwab JO, Schild H, Sommer T: Magnetic resonance imaging at 1.5-T in patients with implantable cardioverter-defibrillators. *J Am Coll Cardiol* 2009; 54:549-55
23. Vahlhaus C, Sommer T, Lewalter T, Schimpf R, Schumacher B, Jung W, Luderitz B: Interference with cardiac pacemakers by magnetic resonance imaging: Are there irreversible changes at 0.5 Tesla? *Pacing Clin Electrophysiol* 2001; 24:489-95
24. Nazarian S, Hansford R, Rahsepar AA, Weltin V, McVeigh D, Gucuk Ipek E, Kwan A, Berger RD, Calkins H, Lardo AC, Kraut MA, Kamel IR, Zimmerman SL, Halperin HR: Safety of magnetic resonance imaging in patients with cardiac devices. *N Engl J Med* 2017; 377:2555-64
25. Brambatti M, Mathew R, Strang B, Dean J, Goyal A, Hayward JE, Long L, DeMeis P, Smoke M, Connolly SJ, Morillo CA, Amit G, Capucci A, Healey JS: Management of patients with implantable cardioverter-defibrillators and pacemakers who require radiation therapy. *Heart Rhythm* 2015; 12:2148-54
26. Elders J, Kunze-Busch M, Jan Smeenk R, Smeets JLRM: High incidence of implantable cardioverter defibrillator malfunctions during radiation therapy: neutrons as a probable cause of soft errors. *Europace* 2013; 15:60-5
27. Gelblum DY, Amols H: Implanted cardiac defibrillator care in radiation oncology patient population. *Int J Radiat Oncol Biol Phys* 2009; 73:1525-31

28. Gomez DR, Poenisch F, Pinnix CC, Sheu T, Chang JY, Memon N, Mohan R, Rozner MA, Dougherty AH: Malfunctions of implantable cardiac devices in patients receiving proton beam therapy: Incidence and predictors. *Int J Radiat Oncol Biol Phys* 2013; 87:570-5
29. Grant JD, Jensen GL, Tang C, Pollard JM, Kry SF, Krishnan S, Dougherty AH, Gomez DR, Rozner MA: Radiotherapy-induced malfunction in contemporary cardiovascular implantable electronic devices: clinical incidence and predictors. *JAMA Oncol* 2015; 1:624-32
30. Makkar A, Prisciandaro J, Agarwal S, Lusk M, Horwood L, Moran J, Fox C, Hayman JA, Ghanbari H, Roberts B, Belardi D, Latchamsetty R, Crawford T, Good E, Jongnarangsin K, Bogun F, Chugh A, Oral H, Morady F, Pelosi F: Effect of radiation therapy on permanent pacemaker and implantable cardioverter-defibrillator function. *Heart Rhythm* 2012; 9:1964-8
31. Zaremba T, Jakobsen AR, Sogaard M, Thogersen AM, Johansen MB, Madsen LB, Riahi S: Risk of device malfunction in cancer patients with implantable cardiac device undergoing radiotherapy: A population-based cohort study. *Pacing Clin Electrophysiol* 2015; 38:343-56

Case reports or series

1. Anfinson OG, Berntsen RF, Aass H, Kongsgaard E, Amlie JP: Implantable cardioverter defibrillator dysfunction during and after magnetic resonance imaging. *Pacing Clin Electrophysiol* 2002; 25:1400-2
2. Atar I, Bal U, Ertan C, Ozin B, Muderrisoglu H: Inappropriate shock and battery switching to "End of Life" in a patient with biventricular ICD during magnetic resonance imaging. *Turk Kardiyol Dern Ars* 2016; 44:79-81
3. Baser K, Guray U, Durukan M, Demirkan B: High ventricular lead impedance of a DDD pacemaker after cranial magnetic resonance imaging. *Pacing Clin Electrophysiol* 2012; 35:e251-3
4. Fiek M, Remp T, Reithmann C, Steinbeck G: Complete loss of ICD programmability after magnetic resonance imaging. *Pacing Clin Electrophysiol* 2004; 27:1002-4
5. Bailey AG, Lacey SR: Intraoperative pacemaker failure in an infant. *Can J Anaesth* 1991; 38:912-913
6. Bales JG, Colon J, Ramadhani U, LeDoux E, Bennett JT: Electrocautery-induced asystole in a scoliosis patient with a pacemaker. *J Pediatr Orthop B* 2007; 16:19-22
7. Casavant D, Haffajee C, Stevens S, Pacetti P: Aborted implantable cardioverter defibrillator shock during facial electrosurgery. *Pacing Clin Electrophysiol* 1998; 21:1325-6
8. Rozner MA: Review of electrical interference in implanted cardiac devices. *Pacing Clin Electrophysiol* 2003; 26:923-5
9. Rubin JM, Miller ED, Jr.: Intraoperative pacemaker malfunction during total hip arthroplasty. *Anesth Analg* 1995; 80:410-2
10. Wong DT, Middleton W: Electrocautery-induced tachycardia in a rate-responsive pacemaker. *Anesthesiology* 2001; 94:710-1
11. Peters RW, Gold MR: Reversible prolonged pacemaker failure due to electrocautery. *J Interv Card Electrophysiol* 1998; 2:343-4
12. Hammwöhner M, Stachowitz J, Willich T, Goette A: Induction of ventricular tachycardia during radiofrequency ablation via pulmonary vein ablation catheter in a patient with an implanted pacemaker. *Europace* 2012; 14:298-9
13. Tong NY, Ru HJ, Ling HY, Cheung YC, Meng LW, Chung PC: Extracardiac radiofrequency ablation interferes with pacemaker function but does not damage the device. *Anesthesiology* 2004; 100:1041
14. Mangar D, Atlas GM, Kane PB: Electrocautery-induced pacemaker malfunction during surgery. *Can J Anaesth* 1991; 38:616-8
15. Gimbel JR, Johnson D, Levine PA, Wilkoff BL: Safe performance of magnetic resonance imaging on five patients with permanent cardiac pacemakers. *Pacing Clin Electrophysiol* 1996; 19:913-9
16. Gimbel JR: Unexpected asystole during 3T magnetic resonance imaging of a pacemaker-dependent patient with a 'modern' pacemaker. *Europace* 2009; 11:1241-2
17. John J, Kaye GC: Shock coil failure secondary to external irradiation in a patient with implantable cardioverter defibrillator. *Pacing Clin Electrophysiol* 2004; 27:690-1
18. Nemeč J: Runaway implantable defibrillator--a rare complication of radiation therapy. *Pacing Clin Electrophysiol* 2007; 30:716-8
19. Raitt MH, Stelzer KJ, Laramore GE, Bardy GH, Dolack GL, Poole JE, Kudenchuk PJ: Runaway pacemaker during high-energy neutron radiation therapy. *Chest* 1994; 106:955-7

20. Chew EW, Trougher RH, Kuchar DL, Thorburn CW: Inappropriate rate change in minute ventilation rate responsive pacemakers due to interference by cardiac monitors. *PACE* 1997; 20:276-82
21. Lau W, Corcoran SJ, Mond HG. Pacemaker tachycardia in a minute ventilation rate-adaptive pacemaker induced by electrocardiographic monitoring. *Pacing Clin Electrophysiol* 2006; 29:438-40
22. Southorn PA, Kamath GS, Vasdev GM, Hayes DL: Monitoring equipment induced tachycardia in patients with minute ventilation rate-responsive pacemakers. *Br J Anaesth* 2000; 84:508-9
23. Hu R, Cowie DA: Pacemaker-driven tachycardia induced by electrocardiograph monitoring in the recovery room. *Anaesth Intensive Care* 2006; 34:266-8

Intraoperative Management

Case reports or series

1. Gimbel JR: Unexpected asystole during 3T magnetic resonance imaging of a pacemaker-dependent patient with a 'modern' pacemaker. *Europace* 2009; 11:1241-2
2. Kellow NH: Pacemaker failure during transurethral resection of the prostate. *Anesthesia* 1993; 48:136-8
3. Mychaskiw G, Eichhorn JH: Interaction of an implanted pacemaker with a transesophageal atrial pacemaker: Report of a case. *J Clin Anesth* 1999; 11:669-71
4. Rubin JM, Miller ED: Intraoperative pacemaker malfunction during total hip arthroplasty. *Anesth Analg* 1995; 80:410-2
5. Rodriguez-Blanco YF, Souki F, Tamayo E, Candiotti K: Magnets and implantable cardioverter defibrillators: what's the problem? *Ann Card Anaesth* 2013; 16:54-7
6. Smith CL, Frawley G, Hamar A: Diathermy and the telectronics "META" pacemaker. *Anaesth Intens Care* 1993; 21:452-4

Managing Potential Sources of EMI: Electrosurgery

Observational studies or non-pertinent comparison groups

1. Schulman PM, Treggiari MM, Yanez ND, Henrikson CA, Jessel PM, Dewland TA, Merkel MJ, Sera V, Harukuni I, Anderson RB, Kahl E, Bingham A, Alkayed N, Stecker EC: Electromagnetic interference with protocolized electrosurgery dispersive electrode positioning in patients with implantable cardioverter defibrillators. *Anesthesiology* 2018; doi: 10.1097/ALN.0000000000002571

Case reports or series

1. Bales JG, Colon J, Ramadhani U, LeDoux E, Bennett JT: Electrocautery-induced asystole in a scoliosis patient with a pacemaker. *J Pediatr Orthop B* 2007; 16:19-22
2. Mychaskiw G, Eichhorn JH: Interaction of an implanted pacemaker with a transesophageal atrial pacemaker: Report of a case. *J Clin Anesth* 1999; 11:669-71
3. Heller LI: Surgical electrocautery and the runaway pacemaker syndrome. *PACE* 1990; 13:1084-1085
4. Kleinman B, Hamilton J, Heriman R, Olshansky B, Justus D, Desai R: Apparent failure of a precordial magnet and pacemaker programmer to convert a DDD pacemaker to VOO mode during the use of the electrosurgical unit. *Anesthesiology* 1997; 86:247-50
5. Peters RW, Gold MR: Reversible prolonged pacemaker failure due to electrocautery. *J Interv Card Electrophysiol* 1998; 2:343-4
6. Rodriguez-Blanco YF, Souki F, Tamayo E, Candiotti K: Magnets and implantable cardioverter defibrillators: what's the problem? *Ann Card Anaesth* 2013; 16:54-7
7. Smith CL, Frawley G, Hamar A: Diathermy and the telectronics "META" pacemaker. *Anaesth Intens Care* 1993; 21:452-4

Managing Potential Sources of EMI: Magnetic Resonance Imaging

Observational studies or non-pertinent comparison groups

1. Camacho JC, Moreno CC, Shah AD, Mittal PK, Mengistu A, Lloyd MS, El-Chami MF, Lerakis S, Saindane AM: Safety and quality of 1.5-T MRI in patients with conventional and MRI-conditional cardiac implantable electronic devices after implementation of a standardized protocol. *AJR* 2016; 207:599-604
2. Halshok O, Goitein O, Sham'a RA, Granit H, Glikson M, Konen E: Pacemakers and magnetic resonance imaging: no longer an absolute contraindication when scanned correctly. *Isr Med Assoc J* 2010; 12:391-5
3. Higgins JV, Sheldon SH, Watson RE, Dalzell C, Acker N, Cha Y-M, Asirvatham SJ, Kapa S, Felmlee JP, Friedman PA: "Power-on resets" in cardiac implantable electronic devices during magnetic resonance imaging. *Heart Rhythm* 2015; 12:540-4
4. Horwood L, Attili A, Luba F, Ibrahim E-s H, Parmar H, Stojanovska J, Gadoth-Goodman S, Fette C, Oral H, Bogun F: Magnetic resonance imaging in patients with cardiac implanted electronic devices: focus on contraindications to magnetic resonance imaging protocols. *Europace* 2016; doi:10.1093/europace/euw122
5. Mollerus M, Albin G, Lipinski M, Lucca J: Magnetic resonance imaging of pacemakers and implantable cardioverter-defibrillators without specific absorption rate restrictions. *Europace* 2010; 12:947-51
6. Naehle CP, Strach K, Thomas D, Meyer C, Linhart M, Bitaraf S, Litt H, Schwab JO, Schild H, Sommer T: Magnetic resonance imaging at 1.5-T in patients with implantable cardioverter-defibrillators. *J Am Coll Cardiol* 2009; 54:549-5
7. Buendía F, Sánchez-Gómez JM, Sancho-Tello MJ, Olagüe J, Osca J, Cano Ó, Arnau MA, Igual B: Nuclear magnetic resonance imaging in patients with cardiac pacing devices. *Rev Esp Cardiol (English Edition)* 2010; 63:735-9
8. Gimbel JR, Bailey SM, Tchou PJ, Ruggieri PM, Wilkoff BL: Strategies for the safe magnetic resonance imaging of pacemaker-dependent patients. *Pacing Clin Electrophysiol* 2005; 28:1041-6
9. Awad K, Griffin J, Crawford TC, Cox SL, Ferrick K, Mazur A, Pena RE, Lloyd SG, Michalski J, Johnson W, Bailey WM: Clinical safety of the Lforia implantable cardioverter-defibrillator system in patients subjected to thoracic spine and cardiac 1.5-T magnetic resonance imaging scanning conditions. *Heart Rhythm* 2015; 12:2155-61
10. Bailey WM, Rosenthal L, Fananapazir L, Gleva M, Mazur A, Rinaldi CA, Kypta A, Merkely B, Woodard PK: Clinical safety of the ProMRI pacemaker system in patients subjected to head and lower lumbar 1.5-T magnetic resonance imaging scanning conditions. *Heart Rhythm* 2015; 12:1183-91
11. Bailey WM, Mazur A, McCotter C, Woodard PK, Rosenthal L, Johnson W, Mela T: Clinical safety of the ProMRI pacemaker system in patients subjected to thoracic spine and cardiac 1.5-T magnetic resonance imaging scanning conditions. *Heart Rhythm* 2016; 13:464-71

Managing Potential Sources of EMI: Radiation Therapy

Observational studies or non-pertinent comparison groups

1. Elders J, Kunze-Busch M, Smeenk RJ, Smeets J: High incidence of implantable cardioverter defibrillator malfunctions during radiation therapy: neutrons as a probable cause of soft errors. *Europace* 2013; 15:60-5
2. Gomez DR, Poenisch F, Pinnix CC, Sheu T, Chang JY, Memon N, Mohan R, Rozner MA, Dougherty AH: Malfunctions of implantable cardiac devices in patients receiving proton beam therapy: Incidence and predictors. *Int J Radiat Oncol Biol Phys* 2013; 87:570-5

Case reports or series

1. John J, Kaye GC: Shock coil failure secondary to external irradiation in a patient with implantable cardioverter defibrillator. Pacing Clin Electrophysiol 2004; 27:690-1
2. Nemeč J: Runaway implantable defibrillator--a rare complication of radiation therapy. Pacing Clin Electrophysiol 2007; 30:716-8
3. Raitt MH, Stalzer KJ, Laramore GE, Bardy GH, Dolack GL, Poole JE, Kudenchuk PJ: Runaway pacemaker during high-energy neutron radiation therapy. Chest 1994; 106:955-7

Postoperative Mangement

Observational studies or non-pertinent comparison groups

1. Zaremba T, Jakobsen AR, Sogaard M, Thogersen AM, Johansen MB, Madsen LB, Riahi S: Risk of device malfunction in cancer patients with implantable cardiac device undergoing radiotherapy: A population-based cohort study. Pacing Clin Electrophysiol 2015; 38:343-56

Case reports or series

1. Schulman PM, Rozner MA: Case report: Use caution when applying magnets to pacemakers or defibrillators for surgery. Anesth Analg 2013; 117:422-7
2. Donohoo JH, Anderson MT, Mayo-Smith WW: Pacemaker reprogramming after radiofrequency ablation of a lung neoplasm. Am J Roentgenol 2007; 189:890-2