Practice Advisory for the Perioperative Management of Patients with Cardiac Implantable Electronic Devices: Pacemakers and Implantable Cardioverter-Defibrillators

An Updated Report by the American Society of Anesthesiologists Task Force on Perioperative Management of Patients with Cardiac Implantable Electronic Devices*

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Address correspondence to the American Society of Anesthesiologists: 520 N. Northwest Highway, Park Ridge, Illinois 60068-2573. This Practice Advisory, as well as all ASA Practice Parameters, may be obtained at no cost through the Journal Web site, www.anesthesiology.org.
This document updates the "Practice Advisory for the Perioperative Management of Patients with Cardiac Rhythm Management Devices: Pacemakers and Implantable Cardioverter-Defibrillators, adopted by the ASA in 2004 and published in 2005.†

Methodology

A. Definition of Cardiac Implantable Electronic Devices

For this Advisory, a cardiac implantable electronic device (CIED) refers to any permanently implanted cardiac pacemaker or any implantable cardioverter-defibrillator (ICD). The term CIED also refers to any cardiac resynchronization device.‡

B. Purposes of the Advisory

The purposes of this Advisory update are to: (1) facilitate safe and effective perioperative management of the patient with a CIED, and (2) reduce the incidence of adverse outcomes. Perioperative management refers to the preoperative, intraoperative, postoperative or recovery period in any setting where an anesthesia provider will be delivering anesthesia care. Adverse outcomes associated with a CIED include, but are not limited to, damage to the device, inability of the device to deliver pacing or shocks, lead-tissue interface damage, changes in pacing behavior, electrical reset to the backup pacing mode, or inappropriate ICD therapies.§ Adverse clinical outcomes include, but are not limited to, hypotension, tachyarrhythmia or bradyarrhythmia, myocardial tissue damage, and myocardial ischemia or infarction. Other related outcomes may

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† American Society of Anesthesiologists: Practice Advisory for the Perioperative Management of Patients with Cardiac Rhythm Management Devices: Pacemakers and Implantable Cardioverter-Defibrillators. ANESTHESIOLOGY 2005; 103:186-198

‡ Generic pacemaker and defibrillator codes are provided in appendix 1. Note that every ICD includes both pacing and shock therapies for the management of bradyarrhythmias and tachyarrhythmias.

§ Inappropriate ICD therapy refers to the delivery of antitachycardia therapy (paced or shock) in the absence of a clinically indicated tachyarrhythmia. Inappropriate ICD therapy can harm a patient by inducing ischemia, worsening the arrhythmia, or causing the patient to move during a delicate procedure.
include extended hospital stay, delay or cancellation of surgery, readmission to manage device
malfunction, or additional hospital resource utilization and cost.

C. Focus

This updated Advisory focuses on the perioperative management of the patient who has a
preexisting, permanently implanted CIED for treatment of bradyarrhythmia, tachyarrhythmia or heart
failure. Both inpatient and outpatient procedures are addressed by this update. This update does not
address the perioperative management of any patient undergoing CIED implantation or revision. It is
not applicable to any patient: (1) without a permanently implanted pacemaker or ICD, (2) with a
temporary CIED, (3) with a noncardiac implantable device (e.g., neurological or spinal cord
stimulator), or (4) with an implantable mechanical cardiac assist device (e.g., ventricular assist
device). This updated Advisory does not address procedures where there are no known perioperative
CIED concerns, such as plain radiography, fluoroscopy, mammograms, or ultrasound.

D. Application

This updated Advisory is intended for use by anesthesiologists and all other individuals who
deliver or who are responsible for anesthesia care. The update may also serve as a resource for
other physicians and health care professionals who manage patients with CIEDs.

E. Task Force Members and Consultants

The original Advisory was developed by an ASA appointed task force of 12 members, consisting
of anesthesiologists and cardiologists in private and academic practices from various geographic
areas of the United States, and two methodologists from the ASA Committee on Standards and
Practice Parameters.

The Task Force developed the original Advisory by means of a six-step process. First, they
reached consensus on the criteria for evidence. Second, original published articles from peer-
reviewed journals relevant to the perioperative management of cardiac rhythm management devices were evaluated. Third, consultants who had expertise or interest in CIEDs, and who practiced or worked in various settings (e.g., private and academic practice) were asked to: (1) participate in opinion surveys on the effectiveness of various perioperative management strategies, and (2) review and comment on a draft of the Advisory developed by the Task Force. Fourth, additional opinions were solicited from random samples of active members of both the ASA and the Heart Rhythm Society (HRS).** Fifth, the Task Force held an open forum at a national anesthesia meeting and at a major cardiology meeting to solicit input on the key concepts of this Advisory.†† Sixth, all available information was used to build consensus within the Task Force to finalize the Advisory.

In 2009, the ASA Committee on Standards and Practice Parameters requested that scientific evidence for this Advisory be updated. The update consists of an evaluation of literature that includes new studies obtained after publication of the original Advisory.

** F. Availability and Strength of Evidence

Preparation of this update used the same methodological process as was used in the original Advisory to obtain new scientific evidence. Opinion-based evidence obtained from the original Advisory is reported in this update. The protocol for reporting each source of evidence is described below:

Scientific Evidence:

Study findings from published scientific literature were aggregated and are reported in summary form by evidence category, as described below. All literature (e.g., randomized controlled trials, observational studies, case reports) relevant to each topic was considered when evaluating the

** Formerly North American Society of Pacing and Electrophysiology (NASPE).
findings. However, for reporting purposes in this document, only the highest level of evidence (i.e., level 1, 2, or 3 identified below) within each category (i.e., A, B, or C) is included in the summary.

**Category A: Supportive Literature.** Randomized controlled trials report statistically significant (p < 0.01) differences between clinical interventions for a specified clinical outcome.

- **Level 1:** The literature contains multiple randomized controlled trials, and the aggregated findings are supported by meta-analysis.‡‡
- **Level 2:** The literature contains multiple randomized controlled trials, but the number of studies is insufficient to conduct a viable meta-analysis.
- **Level 3:** The literature contains a single randomized controlled trial.

**Category B: Suggestive Literature.** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes.

- **Level 1:** The literature contains observational comparisons (e.g., cohort, case-control research designs) of clinical interventions or conditions and indicates statistically significant differences between clinical interventions for a specified clinical outcome.
- **Level 2:** The literature contains non-comparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics.
- **Level 3:** The literature contains case reports.

**Category C: Equivocal Literature.** The literature cannot determine whether there are beneficial or harmful relationships among clinical interventions and clinical outcomes.

- **Level 1:** Meta-analysis did not find significant differences among groups or conditions.
- **Level 2:** The number of studies is insufficient to conduct meta-analysis, and (1) randomized controlled trials have not found significant differences among groups or conditions or (2) randomized controlled trials report inconsistent findings.

‡‡ Practice advisories lack the support of a sufficient number of adequately controlled studies required to conduct an appropriate meta-analysis. Therefore, category A1 evidence is not reported in this document.
Level 3: Observational studies report inconsistent findings or do not permit inference of beneficial or harmful relationships.

*Category D: Insufficient Evidence from Literature.* The lack of scientific evidence in the literature is described by the following terms.

Silent: No identified studies address the specified relationships among interventions and outcomes.

Inadequate: The available literature cannot be used to assess relationships among clinical interventions and clinical outcomes. The literature either does not meet the criteria for content as defined in the “Focus” of the Advisory or does not permit a clear interpretation of findings due to methodological concerns (e.g., confounding in study design or implementation).

**Opinion-Based Evidence:**

The original Advisory contained formal survey information collected from expert consultants, a random sample of members of the ASA, and a random sample of members of the HRS. Additional information was obtained from open forum presentations and other invited and public sources. All opinion-based evidence relevant to each topic (e.g., survey data, open-forum testimony, Internet-based comments, letters, editorials) was considered in the development of the original Advisory.

Survey responses from Task Force-appointed expert consultants are reported in summary form in the text, with a listing of consultant survey responses reported in an appendix. In addition, survey responses from active ASA and HRS members are reported in summary form in the text, with a listing of survey responses reported in an appendix.

**Advisories:**

*I. Preoperative Evaluation*

A focused preoperative evaluation of CIED patients consists of: (1) establishing whether a patient has a CIED, (2) defining the type of device, (3) determining whether a patient is CIED dependent for
antibradycardia pacing function, and (4) determining device function.

Although no controlled trials of the clinical impact of performing a focused preoperative
evaluation for CIED patients were found, case reports suggest that incomplete preoperative
examination of patients with CIEDs may lead to adverse outcomes (e.g., inhibited CIED function,
asystole).\(^1,2\) (Category B3 evidence)

The majority of consultants, ASA members, and HRS members agree that the above four
preoperative evaluation activities should be conducted.\(^\S\S\)

**Advisory for Preoperative Evaluation:** A focused preoperative evaluation should include
establishing whether a patient has a CIED, defining the type of device, determining whether a patient
is CIED dependent for pacemaking function, and determining CIED function.

Determining whether a patient has a CIED should be based on: (1) a focused history including
but not limited to the patient interview, medical records review, review of available chest x-rays,
electrocardiogram [ECG] or any available monitor or rhythm strip information and (2) a focused
physical examination (checking for scars, palpating for device).

Defining the type of device is accomplished by: (1) obtaining the manufacturer’s ID card from the
patient or other source, (2) ordering chest x-rays if no other data are available,\(^***\) or (3) referring to
supplemental resources (e.g., manufacturer’s databases, pacemaker clinic records, consultation with a
cardiologist).

CIED dependency for pacemaking function may be determined by one or more of the following:
(1) a verbal history or an indication in the medical record that the patient has experienced a
bradyarrhythmia that has caused syncope or other symptoms requiring CIED implantation, (2) a
history of successful atrioventricular (A-V) nodal ablation that resulted in CIED placement, or (3) a

\(^\S\S\) Refer to Appendix 2 for results of the Consultant, ASA membership, and HRS membership surveys.
\(^***\) Most current CIEDs have an x-ray code that can be used to identify the manufacturer of the device.
CIED evaluation that shows no evidence of spontaneous ventricular activity when the pacemaking function of the CIED is programmed to VVI pacing mode at the lowest programmable rate.

CIED function is ideally assessed by a comprehensive evaluation of the device.\textsuperscript{3} If a comprehensive evaluation is not possible, then \textit{at a minimum}, confirm whether pacing impulses are present and create a paced beat. Consultation with a cardiologist or CIED service may be necessary.

Contacting the manufacturer for perioperative recommendations may be a consideration.

\textit{II. Preoperative Preparation}

Preparation for patient safety and proper maintenance of the device during a procedure includes:
(1) determining whether electromagnetic interference (EMI) is likely to occur during the planned procedure, (2) determining whether preoperative reprogramming the CIED pacemaking function to an asynchronous pacing mode or disabling any special algorithms, including rate adaptive functions, is needed, (3) suspending anti-tachyarrhythmia functions if present, (4) advising the individual performing the procedure to consider use of a bipolar electrocautery system or ultrasonic (harmonic) scalpel to minimize potential adverse effects of EMI on the pulse generator or leads, (5) assuring the availability of temporary pacing and defibrillation equipment, and (6) evaluating the possible effects of anesthetic techniques on CIED function and patient-CIED interactions.

Numerous descriptive studies and case reports suggest that the following procedures are likely to be associated with EMI: (1) electrocautery,\textsuperscript{4-10} (2) radio frequency ablation,\textsuperscript{11-16} and (3) magnetic resonance imaging (MRI),\textsuperscript{17-30} (\textit{Category B2-B3 evidence}) Studies with observational findings report the occurrence of EMI during radiation therapy,\textsuperscript{31-33} while other observational studies and case reports indicate no apparent EMI effects.\textsuperscript{34,35} (\textit{Category B2-B3 evidence}) Studies with observational findings report the occurrence of EMI during lithotripsy,\textsuperscript{36,37} while other observational studies and case reports indicate no apparent EMI effects.\textsuperscript{38-41} (\textit{Category B2-B3 evidence}) No studies were found that reported EMI during electroconvulsive therapy (ECT). (\textit{Category D evidence}) Case reports
indicate that inappropriately high pacing rates may occur due to EMI effects between cardiac monitoring equipment and CIEDs with active minute ventilation sensors.\(^{42-44}\)

No controlled trials of the clinical impact of programming the pacemaking function to an asynchronous mode for a procedure were found. \((\text{Category D evidence})\) Although a case report suggests that such reprogramming may be beneficial during electrocautery,\(^{45}\) other reports indicate that EMI may continue to affect reprogrammed pacemakers.\(^{46,47}\) \((\text{Category B3 evidence})\) The literature lacks sufficient guidance regarding the potential perioperative impact of anesthetic techniques on CIED function. \((\text{Category D evidence})\)

The majority of Consultants, ASA members, and HRS members agree that it should be determined whether EMI is likely to occur prior to a planned procedure. The majority of Consultants agree that a CIED’s rate-adaptive therapy should be turned off prior to a procedure, while the ASA and HRS members are equivocal. The majority of Consultants and HRS members disagree that all patients’ CIEDs should be programmed to an asynchronous mode prior to surgery, while the ASA members are equivocal. In addition, the majority of Consultants and HRS members agree that pacemaker-dependent patients’ CIEDs should be programmed to an asynchronous mode prior to surgery, while the ASA members are again equivocal. The majority of Consultants, ASA and HRS members agree that: (1) suspending anti-tachyarrhythmia functions if present, (2) advising the individual performing the procedure to consider use of a bipolar electrocautery system to minimize potential adverse effects of EMI on the pulse generator or leads, (3) assuring the availability of temporary pacing and defibrillation equipment, and (4) evaluating the possible effects of anesthetic techniques on CIED function and patient-CIED interactions are important steps in promoting patient safety and successfully managing patients with CIEDs. The Consultants and ASA members agree, and HRS members are equivocal regarding the consideration of using an ultrasonic scalpel.
**Advisory for Preoperative Preparation:** Planned procedures should include a determination as to whether EMI is likely to occur for either conventional pacemakers or ICDs. If EMI is likely to occur, the conventional pacing function of a CIED should be altered by changing to an asynchronous pacing mode††† in pacemaker dependent patients and suspending special algorithms, including rate-adaptive functions.‡‡‡ These alterations may be accomplished by programming or applying a magnet when applicable.§§§ However, the Task Force cautions against the routine use of the magnet over an ICD.**** In addition, an ICD’s anti-tachyarrhythmia functions should be suspended, if present. For the ICD patient who depends on pacing function for control of bradyarrhythmia, these functions should be altered by programming as noted above. Consultation with a cardiologist or pacemaker-ICD service may be necessary.

For all CIEDs, consider advising the individual performing the procedure to use a bipolar electrocautery system or an ultrasonic scalpel when applicable. Temporary pacing and defibrillation equipment should be immediately available before, during, and after a procedure.

Finally, the Task Force believes that anesthetic techniques do not influence CIED function. However, anesthetic-induced physiologic changes (i.e., cardiac rate, rhythm or ischemia) in the patient may induce unexpected CIED responses or adversely affect the CIED-patient interaction.

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††† The VVT mode (with attention to the upper rate limit) might also be considered for a patient with ventricular ectopy where concern exists regarding R-on-T pacing during an asynchronous pacing mode. However, the upper pacing rate during VVT mode is manufacturer and possibly generator specific and can approach 200 beats per minute for many devices. Generally, VVT mode pacing would not be a consideration except in very rare circumstances. Before using the VVT mode, a cardiologist and the generator manufacturer should be consulted to determine the suitability of the upper pacing rate for any patient.

‡‡‡ Disabling of ICDs may not be needed in low risk situations (e.g., appropriate preoperative CIED check, no EMI, no ICD or lead issues likely to lead to inappropriate discharge, no patient issues likely to lead to any discharge, such as an ICD placed for "primary prevention"

§§§ A magnet correctly applied to a pacemaker often results in asynchronous pacemaker function at a predetermined rate without rate responsiveness. The magnet rate and response varies by manufacturer. Magnet response can be affected by programming and remaining battery life. The magnet rate may be excessive for some patients. Some pacemakers may have no magnet response.

**** Magnet application to an ICD rarely alters bradycardia pacing rate and function. A magnet correctly applied to an ICD often results in suspension of tachyarrhythmia therapy. For most ICDs, there is no reliable means to detect appropriate magnet placement. Some ICDs may have no magnet response. Some ICDs can be permanently disabled by magnet application.
III. Intraoperative Management

The primary activities associated with intraoperative management of a CIED include: (1) monitoring the operation of the device, (2) preventing potential CIED dysfunction, and (3) performing emergency defibrillation, cardioversion, or heart rate support.

Intraoperative Monitoring:

Intraoperative monitoring includes continuous ECG as well as monitoring of the peripheral pulse (e.g., palpation of the pulse, auscultation of heart sounds, monitoring of a tracing of intraarterial pressure, ultrasound peripheral pulse monitoring, or pulse plethysmography or oximetry). Although no controlled trials were found that examine the clinical impact of ECG or peripheral pulse monitoring for CIED patients, case reports note the importance of intraoperative ECG monitoring in the detection of pacemaker or cardiac dysfunction for these patients.2,49-53 (Category B3 evidence)

The majority of Consultants, ASA and HRS members agree that: (1) continuous ECG monitoring should be done for all CIED patients, and (2) continuous peripheral pulse monitoring should be conducted.

Advisory for Intraoperative Monitoring: ECG and peripheral pulse monitoring are important components of perioperative management of the patient with a CIED. A patient’s ECG should be continuously displayed, as required by ASA standards, from the beginning of anesthesia until the patient is transferred out of the anesthetizing location, with additional ECG monitoring in the postoperative period as indicated by the patient’s medical condition.48,54 These standards should apply to all CIED patients receiving general or regional anesthesia, sedation or monitored anesthesia care. Continuous peripheral pulse monitoring should be performed for all CIED patients receiving general or regional anesthesia, sedation or monitored anesthesia care. If unanticipated device interactions are found, consider discontinuation of the procedure until the source of interference can be eliminated or managed.
Managing Potential Sources of EMI:

Procedures using electrocautery, radio frequency ablation, lithotripsy, MRI, or radiation therapy may damage CIEDs or interfere with CIED function, potentially resulting in severe adverse outcomes. Sources of EMI are often unique to specific procedures, and the management of each of these potential EMI sources is reported separately below.

**Electrocautery.** Management of potential sources of EMI associated with electrocautery includes: (1) assuring that the cautery tool and current return pad†††† are positioned so that the current pathway does not pass through or near the CIED pulse generator and leads, (2) avoiding proximity of the cautery’s electrical field to the pulse generator or leads, (3) using short, intermittent and irregular bursts at the lowest feasible energy levels, and (4) using a bipolar electrocautery system or an ultrasonic (harmonic) scalpel, if possible.

The literature is insufficient to evaluate whether positioning the current pathway away from the CIED pulse generator and leads reduces the occurrence of EMI.

Two case reports⁵²,⁵⁵ and one observational study⁵⁶ suggest that EMI may occur in spite of positioning the current return pad as far as possible away from the generator and leads. *(Category B₂-B₃ evidence)* One case report suggested that application of unipolar electrocautery on the sternum resulted in complete pacemaker inhibition.¹ *(Category B₃ evidence)*

Although no recent studies were found examining the benefit of using short intermittent bursts at the lowest feasible energy levels, earlier‡‡‡‡ literature suggests that short intermittent bursts may be useful in completing procedures without notable EMI interference.⁵⁷-⁶⁰ *(Category B₂-B₃ evidence)* One case report describes pacemaker failure when short bursts of electrocautery current were used.⁶⁰ *(Category B₃ evidence)*

†††† Although commonly referred to as the “grounding pad,” most operating room power supplies in the United States are ungrounded.

‡‡‡‡ See appendix for an explanation of the term “earlier literature”
Finally, case reports suggest that surgery for pacemaker patients may proceed uneventfully when bipolar electrocautery systems\textsuperscript{45,46,49} or harmonic scalpels\textsuperscript{61,62} are used. (\textit{Category B3 evidence}) However, a case report describes pacemaker failure occurring when bipolar electrocautery was used.\textsuperscript{63} (\textit{Category B3 evidence})

The majority of Consultants, ASA and HRS members agree that the current return pad should be positioned so that the electrosurgical current pathway does not pass through or near the CIED pulse generator or leads. The majority of Consultants, ASA and HRS members agree that direct contact between the electrocautery system and the CIED pulse generator or its leads should be avoided. The majority of Consultants, ASA and HRS members agree that short intermittent bursts should be performed. The majority of Consultants and ASA members agree that harmonic scalpels should be used when possible, and HRS members are equivocal. The majority of Consultants, ASA and HRS members agree that bipolar electrocautery systems should be used when possible.

\textbf{Advisory for Managing EMI from Electrocautery:} The Task Force believes that EMI could be minimized during certain procedures using a variety of intraoperative management techniques. The risk of intraoperative interference from electrocautery systems may be minimized by: (1) positioning the cautery tool and current return pad so that the current pathway does not pass through or near the CIED system,\textsuperscript{§§§§} (2) avoiding proximity of the cautery’s electrical field to the pulse generator and leads, including avoidance of waving the activated electrode over the generator,\textsuperscript{*****} (3) using short, intermittent and irregular bursts at the lowest feasible energy levels, and 4) using bipolar electrocautery systems or ultrasonic (harmonic) scalpels if possible. Advising or reminding the individual performing the procedure to implement these management techniques should be considered.

\textsuperscript{§§§§} For some cases, the electrosurgical receiving plate will need to be placed on a site different from the thigh. For example, in head and neck cases, the receiving plate can be placed on the posterior superior aspect of the shoulder contralateral to the generator position.

\textsuperscript{*****} An inhibitory effect could occur even when the active electrode of the electrocautery is not touching the patient.
Radio frequency (RF) Ablation. Management of potential sources of EMI associated with RF ablation primarily involves keeping the RF current path (electrode tip to current return pad) as far away from the pulse generator and lead system as possible. One observational study reports 3 of 12 cases that resulted in a significant drop in resistance on the pacemaker leads when RF ablation was used in proximity to the leads.\(^6\)\(^4\) (Category B2 evidence) One case report suggests that positioning of the RF ablation cluster electrode no closer than 5 cm from the pacer leads allowed the procedure to continue uneventfully.\(^6\)\(^5\) (Category B3 evidence)

The majority of Consultants, ASA and HRS members agree that the individual performing the procedure should avoid direct contact between the ablation catheter and the CIED and leads, and should keep the RF ablation current path as far away from the pulse generator and lead system as possible.

Advisory for Managing EMI from RF Ablation: The risk of interference from RF ablation may be reduced by avoiding direct contact between the ablation catheter and the pulse generator and leads, and keeping the RF’s current path (electrode tip to current return pad) as far away from the pulse generator and leads as possible. During all RF ablative procedures, consider discussing with the individual performing the procedure any concerns regarding the proximity of the ablation catheter to the CIED leads.

Lithotripsy. Management of potential sources of EMI associated with lithotripsy includes: (1) avoiding focus of the lithotripsy beam near the pulse generator and (2) disabling atrial pacing if the lithotripsy system triggers on the R-wave. The literature is silent regarding the benefits of focusing the lithotripsy beam away from the pulse generator as well as the benefits of disabling atrial pacing during lithotripsy. (Category D evidence)
The majority of Consultants, ASA and HRS members agree that focusing the lithotripsy beam near the pulse generator should be avoided, and all three groups are equivocal regarding whether atrial pacing should be disabled prior to a procedure if the lithotripsy system triggers on the R-wave.

**Advisory for Managing EMI from Lithotripsy:** During lithotripsy, the lithotripsy beam should not be focused near the pulse generator. If the lithotripsy system triggers on the R-wave, atrial pacing might need to be disabled prior to the procedure.

**Magnetic Resonance Imaging.** The literature is not sufficiently rigorous to examine the effects of specific management activities related to CIED patients receiving MRI. *(Category D evidence)* Observational studies and case reports suggest that MRI may be completed without notable EMI under specific circumstances and with appropriate patient qualification and monitoring. *(Category B2-B3 evidence)* However, other literature generally suggests that MRI is contraindicated. *(Category B2-B3 evidence)* The majority of Consultants, ASA and HRS members generally agree that MRI is contraindicated for all CIED patients.

**Advisory for Managing EMI from Magnetic Resonance Imaging:** MRI is generally contraindicated for CIED patients. If MRI must be performed, consult with the ordering physician, the patient’s pacemaker specialist or cardiologist, the diagnostic radiologist, and the CIED manufacturer.

**Radiation Therapy.** The literature does not provide sufficient guidance regarding specific management activities related to CIED patients undergoing radiation therapy. *(Category D evidence)* None of the Consultants or HRS members, and only 10% of the ASA members agree that radiation therapy is contraindicated for all CIED patients. Fifty-seven percent of the Consultants, 59% of the HRS members, and 37% of the ASA members agree that radiation therapy is
contraindicated for some, but not all CIED patients; while 43% of the Consultants, 41% of the HRS members, and 53% of the ASA members agree that radiation therapy is not contraindicated for any CIED patient.

**Advisory for Managing EMI from Radiation Therapy:** The Task Force believes that radiation therapy can be safely performed for CIED patients. The device must be outside the field of radiation. Therefore, some pulse generators will require surgical relocation prior to commencing radiation. Most manufacturers recommend verification of pulse generator function during and at the completion of radiation. Problems may include pacemaker failure and runaway pacemaker.

**Electroconvulsive Therapy.** No clinical studies were found that report EMI effects or permanent CIED malfunction associated with electroconvulsive therapy (ECT). *(Category D evidence)* One study reports two cases where patients’ ICDs were turned off prior to ECT, but does not report the effect of the therapy on ICD function. *(Category B3 evidence)* However, the author indicates that treatment with ECT might be associated with significant cardiac risks. Transient electrocardiographic changes (e.g., increased P-wave amplitude, altered QRS shape, T-wave and ST-T abnormalities) may result from ECT, and additional cardiac complications (e.g., arrhythmia or ischemia) may occur in patients with preexisting cardiac disease. Finally, physiologic stresses following ECT, such as a period of bradycardia and reduced blood pressure, followed by tachycardia and a rise in blood pressure, may account for cardiac failure in the extended postoperative period (i.e., several hours or days following ECT) among patients with marginal cardiac function.

**Advisory for Managing EMI from Electroconvulsive Therapy:** Although transient or long-term myocardial and nervous system effects may be associated with ECT, the Task Force believes that

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++ Radiation shielding may not be feasible for some patients due to the size and weight of the shield. This may be compensated for by relocating the generator.

+++ Runaway pacemaker is a potentially catastrophic pulse generator malfunction characterized by the sudden onset of rapid, erratic pacing. Runaway pacemaker is the result of multiple internal component failure and it is relatively uncommon in modern devices. Circuitry in modern pacemakers (and ICDs) limits the runaway pacing rate to less than 210 beats per minute.
such therapies may be administered to CIED patients without significant damage to a disabled CIED.

If ECT must be performed, consult with the ordering physician and the patient’s cardiologist to plan for the first and subsequent ECT’s. All CIEDs should undergo a comprehensive interrogation prior to the procedure(s). ICD functions should be disabled for shock therapy during ECT; however, be prepared to treat ventricular arrhythmias that occur secondary to the hemodynamic effects of ECT.

CIED-dependent patients may require a temporary pacing system to preserve cardiac rate and rhythm during shock therapy. Also, the CIED may require programming to asynchronous activity to avoid myopotential inhibition of the device in pacemaker dependent patients.

Emergency Defibrillation or Cardioversion: During the perioperative period, emergency defibrillation or cardioversion may become necessary for the CIED patient. In this case, the primary concern is to minimize the current flowing through the pulse generator and lead system. Case reports suggest that optimal positioning of the defibrillation or cardioversion pads or paddles may be an important factor in the prevention of adverse CIED-related outcomes.\textsuperscript{71-75}

The majority of Consultants, ASA and HRS members agree that positioning the defibrillation or cardioversion pads as far as possible from the pulse generator should be done. The majority of Consultants, ASA and HRS members also agree that the anterior-posterior position should be used, and that a clinically appropriate energy output should be used regardless of the type of CIED.

Advisory for Emergency Defibrillation or Cardioversion: Before attempting emergency defibrillation or cardioversion of the patient with an ICD and magnet-disabled therapies, all sources of EMI should be terminated and the magnet should be removed to re-enable antitachycardia therapies. The patient should then be observed for appropriate CIED therapy. For the patient with an ICD and antiarrhythmic therapies that have been disabled by programming, consider re-enabling therapies through programming. If the above activities fail to restore ICD function, proceed with
emergency external defibrillation or cardioversion.

Overriding the above discussion is the need to follow existing ACLS and emergency guidelines\textsuperscript{76} to provide rapid cardioversion or defibrillation, and attention should be turned to providing this therapy as quickly as possible.

If a life-threatening arrhythmia occurs, follow ACLS guidelines for energy level and for paddle placement. If possible, attempt to minimize the current flowing through the pulse generator and lead system by (1) positioning the defibrillation or cardioversion pads or paddles as far as possible from the pulse generator, and (2) positioning defibrillation or cardioversion pads or paddles perpendicular to the major axis of the CIED pulse generator and leads to the extent possible by placing them in an anterior-posterior location. A clinically appropriate energy output should always be used regardless of the presence of a CIED, and the paddles should be positioned as best as can be done in an emergency.

\textit{IV. Postoperative Management}

Postoperative management of CIED patients primarily consists of interrogating and restoring CIED function. One observational study and a case report indicate that postoperative pacemaker checks revealed the need to alter pacing mode or other parameters, which included increasing ventricular pacing output due to pacing threshold increase.\textsuperscript{77,78} (\textit{Category B2-B3 evidence}) The case report also indicated that a postoperative check of a pacemaker identified a safety mode reset, which they attributed to EMI from monopolar electrosurgery. A second observational study indicates that a postoperative ICD check identified the appearance of the elective replacement indicator, likely from EMI during surgery.\textsuperscript{79} (\textit{Category B2 evidence}) In addition, this report identified EMI detections on the atrial lead in both pacemakers and defibrillators, and on the ventricular lead in patients with pacemakers, but without significant consequence to the patients.

The majority of Consultants, ASA and HRS members agree that postoperative patient
management should include interrogating and restoring CIED function in the postanesthesia care unit or the intensive care unit.

**Advisory for Postoperative Management:** Cardiac rate and rhythm should be continuously monitored throughout the immediate postoperative period. Back-up pacing capability and cardioversion-defibrillation equipment should be immediately available at all times.

Postoperative interrogation and restoration of CIED function are basic elements of postoperative management. The CIED first should be interrogated to assess postoperative device functions. If interrogation determines that CIED settings are inappropriate, then the device should be reprogrammed to appropriate settings. For an ICD, all anti-tachyarrhythmic therapies should be restored. Consultation with a cardiologist or pacemaker-ICD service may be necessary.

---

Postoperative checks of CIEDs may not be needed in low risk situations (e.g., appropriate preoperative CIED check, no EMI-generating devices used during case, no blood transfused, no perioperative reprogramming took place, and no problems identified during case).
References: ******

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Appendix 1: Generic Pacemaker and Defibrillator Codes

The generic pacemaker and defibrillator codes were developed as joint projects by the North American Society of Pacing and Electrophysiology (NASPE)†††††† and the British Pacing and Electrophysiology Group (BPEG). The five positions refer to the order of the programmed settings on the CIED (Tables 1 and 2).

Table 1. Generic Pacemaker Code (NBG‡‡‡‡‡‡): NASPE / BPEG Revised (2002)

<table>
<thead>
<tr>
<th>Position I</th>
<th>Position II</th>
<th>Position III</th>
<th>Position IV</th>
<th>Position V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacing Chamber(s)</td>
<td>Sensing Chamber(s)</td>
<td>Response(s) to Sensing</td>
<td>Programmability</td>
<td>Multisite Pacing</td>
</tr>
<tr>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
</tr>
<tr>
<td>A = Atrium</td>
<td>A = Atrium</td>
<td>I = Inhibited</td>
<td>R = Rate Modulation</td>
<td>A = Atrium</td>
</tr>
<tr>
<td>V = Ventricle</td>
<td>V = Ventricle</td>
<td>T = Triggered</td>
<td></td>
<td>V = Ventricle</td>
</tr>
<tr>
<td>D = Dual (A+V)</td>
<td>D = Dual (A+V)</td>
<td>D = Dual (T+I)</td>
<td></td>
<td>D = Dual (A+V))</td>
</tr>
</tbody>
</table>

Examples:

AAI = Atrial-only antibradycardia pacing. In the AAI mode, any failure of the atrium to produce an intrinsic event within the appropriate time window (determined by the Lower Rate Limit) will result in an atrial pacing pulse emission. There is no ventricular sensing; thus a premature ventricular event will not likely reset the pacing timer.

AOO = Asynchronous atrial-only pacing. In this mode, the pacing device emits a pacing pulse regardless of the underlying cardiac rhythm.

DDD = Dual chamber antibradycardia pacing function in which every atrial event, within programmed limits, will be followed by a ventricular event. The DDD mode implies dual chamber pacing with atrial tracking. In the absence of intrinsic activity in the atrium, it will be paced, and, after any sensed or paced atrial event, an intrinsic ventricular event must appear before the expiration of the A-V timer or the ventricle will be paced.

†††††† Now called the Heart Rhythm Society (HRS)
‡‡‡‡‡‡ NBG: N refers to NASPE, B refers to BPEG, and G refers to generic.
DDI = Dual chamber behavior in which the atrial activity is tracked into the ventricle only when the atrial event is created by the antibradycardia pacing function of the generator. In the DDI mode, the ventricle is paced only when no intrinsic ventricular activity is present.

DOO = Asynchronous A-V sequential pacing without regard to underlying cardiac rhythm.

VOO = Asynchronous ventricular-only pacing without regard to the underlying cardiac rhythm.

VVI = Ventricular-only antibradycardia pacing. In VVI mode, any failure of the ventricle to produce an intrinsic event within the appropriate time window (determined by the Lower Rate Limit) will result in a ventricular pacing pulse emission. There is no atrial sensing; thus there can be no A-V synchrony in a patient with a VVI pacemaker and any intrinsic atrial activity.

**Table 2. Generic Defibrillator Code (NBD): NASPE / BPEG**

<table>
<thead>
<tr>
<th>Position I</th>
<th>Position II</th>
<th>Position III</th>
<th>Position IV *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock Chambers(s)</td>
<td>Antitachycardia Pacing Chamber(s)</td>
<td>Tachycardia Detection</td>
<td>Antibradycardia Pacing Chamber(s)</td>
</tr>
<tr>
<td>O = None</td>
<td>O = None</td>
<td>E = Electrogram</td>
<td>O = None</td>
</tr>
<tr>
<td>A = Atrium</td>
<td>A = Atrium</td>
<td>H = Hemodynamic</td>
<td>A = Atrium</td>
</tr>
<tr>
<td>V = Ventricle</td>
<td>V = Ventricle</td>
<td></td>
<td>V = Ventricle</td>
</tr>
<tr>
<td>D = Dual (A+V)</td>
<td>D = Dual (A+V)</td>
<td></td>
<td>D = Dual (A+V)</td>
</tr>
</tbody>
</table>

* For robust identification, Position IV is expanded into its complete NBG code. For example, a biventricular pacing-defibrillator with ventricular shock and antitachycardia pacing functionality would be identified as VVE-DDDRV, assuming that the pacing section was programmed DDDRV. Currently, no hemodynamic sensors have been approved for tachycardia detection (Position III).
Table 3. Example of a Stepwise Approach to the Perioperative Management of the Patient with a Cardiac Rhythm Management Device

<table>
<thead>
<tr>
<th>PERIOPERATIVE PERIOD</th>
<th>PATIENT/CIED CONDITION</th>
<th>INTERVENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PREOPERATIVE</strong></td>
<td><strong>Patient has CIED</strong></td>
<td><strong>Focused history</strong></td>
</tr>
<tr>
<td><strong>EVALUATION</strong></td>
<td><strong>Determine CIED type (PM, ICD, CRT)</strong></td>
<td><strong>Focused physical examination</strong></td>
</tr>
<tr>
<td><strong>EVALUATION</strong></td>
<td><strong>Determine if patient is CIED-dependent for pacing function</strong></td>
<td><strong>Manufacturer’s CIED identification card</strong></td>
</tr>
<tr>
<td><strong>EVALUATION</strong></td>
<td><strong>Determine CIED function</strong></td>
<td><strong>Chest x-ray (no data available)</strong></td>
</tr>
<tr>
<td><strong>PREOPERATIVE</strong></td>
<td><strong>EMI unlikely during procedure</strong></td>
<td><strong>Supplemental resources§§§§§§</strong></td>
</tr>
<tr>
<td><strong>PREPARATION</strong></td>
<td><strong>EMI likely; CIED is PM</strong></td>
<td><strong>Verbal history</strong></td>
</tr>
<tr>
<td><strong>PREPARATION</strong></td>
<td><strong>EMI likely; CIED is ICD</strong></td>
<td><strong>Bradyarrhythmia symptoms</strong></td>
</tr>
<tr>
<td><strong>PREPARATION</strong></td>
<td><strong>EMI likely; All CIED</strong></td>
<td><strong>AV node ablation</strong></td>
</tr>
<tr>
<td><strong>PREPARATION</strong></td>
<td><strong>Intraoperative physiologic changes likely (e.g. bradycardia, ischemia)</strong></td>
<td><strong>No spontaneous ventricular activity</strong>****</td>
</tr>
<tr>
<td><strong>INTRAOPERATIVE</strong></td>
<td><strong>Monitoring</strong></td>
<td><strong>Comprehensive CIED evaluation†††††††</strong></td>
</tr>
</tbody>
</table>

§§§§§§Manufacturer’s databases, pacemaker clinic records, cardiology consultation;  
******With CIED programmed VVI at lowest programmable rate  
††††††Ideally CIED function assessed by interrogation, with function altered by reprogramming if required  
†††††††Most times this will be necessary; when in doubt, assume so
| INTRAOPERATIVE MANAGEMENT (continued) | Electrocautery interference | CT/CRP—no current through PG/leads  
• Avoid proximity of CT to PG/leads  
• Short bursts at lowest possible energy  
• Use bipolar cautery; ultrasonic scalpel  

RF catheter ablation | RF current path far away from PG/leads  
• Discuss these concerns with operator  

Lithotripsy | Do not focus lithotripsy beam near PG  
• R-wave triggers lithotripsy? Disable atrial pacing§§§§§§  

MRI | Generally contraindicated  
• If required, consult ordering physician, cardiologist, radiologist and manufacturer  

Radiation therapy | PG/leads must be outside of RT field  
• Possible surgical relocation of PG  
• Verify PG function during/after RT course  

ECT | Consult with ordering physician, patient’s cardiologist, a CIED service, or CIED manufacturer  

| EMERGENCY DEFIBRILLATION-CARDIOVERSION | ICD: magnet-disabled | Terminate all EMI sources  
• Remove magnet to re-enable therapies  
• Observe for appropriate therapies  

ICD: programming disabled | Programming to re-enable therapies,  
• Or proceed directly with external cardioversion/defibrillation  

ICD: either of above | Minimize current flow through PG/leads  
• PP as far as possible from PG  
• PP perpendicular to major axis PG/leads  
• To extent possible, PP in anterior-posterior location  

Regardless of CIED type | Use clinically appropriate cardioversion/defibrillation energy  

| POSTOPERATIVE MANAGEMENT | Immediate postoperative period | Monitor cardiac R&R continuously  
• Back-up pacing and  

§§§§§§§Atrial pacing spikes may be interpreted by device as R waves, possible inciting the lithotripter to deliver a shock during a vulnerable period in the heart.
<table>
<thead>
<tr>
<th>Postoperative interrogation and restoration of CIED function</th>
<th>cardioversion/defibrillation capability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Interrogation to assess function</td>
</tr>
<tr>
<td></td>
<td>• Settings Appropriate?********</td>
</tr>
<tr>
<td></td>
<td>• Is CIED an ICD?††††††††</td>
</tr>
<tr>
<td></td>
<td>• Use cardiology/pacemaker-ICD service if needed</td>
</tr>
</tbody>
</table>

CRP = current return pad; CRT = cardiac resynchronization therapy; CT = cautery tool; ECT = electroconvulsive therapy; EMI = electromagnetic interference; ICD = internal cardioverter-defibrillator; MRI = magnetic resonance imaging; PG = pulse generator; PP = cardioversion-defibrillation pads or paddles; R&R = rhythm and rate; CIED = cardiac rhythm management device; RT = radiation therapy.

********If necessary, reprogram appropriate settings
††††††††Restore all antitachycardia therapies
Appendix 2: Summary of Advisory Statements

Preoperative Evaluation

- Establish whether a patient has a cardiac rhythm management device (CIED).
  - Conduct a focused history (patient interview, medical records review, review of available chest x-rays, electrocardiogram [ECG] or any available monitor or rhythm strip information).
  - Conduct a focused physical examination (check for scars, palpate for device).
- Define the Type of CIED.
  - Obtain manufacturer’s ID card from patient or other source.
  - Order chest x-ray if no other data are available.
  - Refer to supplemental resources (e.g., manufacturer’s databases).
- Determine Dependency on Pacing Function of the CIED.
  - History of symptomatic bradyarrhythmia resulting in CIED implantation.
  - History of successful A-V nodal ablation.
  - Inadequate escape rhythm at lowest programmable pacing rate.
- Determine CIED Function.
  - Interrogate device (consultation with a cardiologist or pacemaker-ICD service may be necessary).
  - Determine whether the device will capture when it paces (i.e., produce a mechanical systole with a pacemaker impulse).
  - Consider contacting the manufacturer for perioperative recommendations.

Preoperative Preparation

- Determine if EMI is likely to occur during the planned procedure.
- Determine whether reprogramming pacing function to asynchronous mode or disabling rate responsive function is advantageous.
- Suspend anti-tachyarrhythmia functions if present.
- Advise individual performing the procedure to consider use of a bipolar electrocautery system or ultrasonic (harmonic) scalpel.
- Temporary pacing and defibrillation equipment should be immediately available.
- Evaluate the possible effects of anesthetic techniques and of the procedure on CIED function and patient CIED interactions.

Intraoperative Management

- Monitor operation of the CIED.
  - Conduct ECG monitoring per ASA standard.
  - Monitor peripheral pulse (e.g., manual pulse palpation, pulse oximeter plethysmogram, arterial line).
- Manage potential CIED dysfunction due to EMI.
  - Electrocautery.
    - Assure that the electrosurgical receiving plate is positioned so that the current pathway does not pass through or near the CIED system. For some cases, the receiving plate might need to be placed on a site different from the thigh (e.g., the superior posterior aspect of the shoulder contralateral to the generator position for a head and neck case).
Advise individual performing the procedure to avoid proximity of the cautery’s electrical field to the pulse generator or leads.

Advise individual performing the procedure to use short, intermittent and irregular bursts at the lowest feasible energy levels.

Advise individual performing the procedure to reconsider the use of a bipolar electrocautery system or ultrasonic (harmonic) scalpel in place of a monopolar electrocautery system, if possible.

- Radio-frequency (RF) ablation.
  - Advise individual performing the procedure to avoid direct contact between the ablation catheter and the pulse generator and leads.
  - Advise individual performing the procedure to keep the RF’s current path as far away from the pulse generator and lead system as possible.

- Lithotripsy.
  - Advise individual performing the procedure to avoid focusing the lithotripsy beam near the pulse generator.
  - If the lithotripsy system triggers on the R-wave, consider preoperative disabling of atrial pacing.

- Magnetic Resonance Imaging.
  - MRI is generally contraindicated in patients with CIEDs.
  - If MRI must be performed, consult with the ordering physician, the patient’s cardiologist, the diagnostic radiologist, and the CIED manufacturer.

- Radiation Therapy.
  - Radiation therapy can be safely performed in patients who have CIEDs.
  - Surgically relocate the CIED if the device will be in the field of radiation.

- Electroconvulsive Therapy.
  - Consult with the ordering physician, the patient’s cardiologist, a CIED service, or the CIED manufacturer.

- Emergency defibrillation or cardioversion.
  - For the patient with an ICD and magnet-disabled therapies:
    - Advise individual performing the procedure to terminate all sources of EMI while magnet is removed.
    - Remove the magnet to re-enable antitachycardia therapies.
    - Observe the patient and the monitors for appropriate CIED therapy.
    - If the above activities fail to restore ICD function, proceed with emergency external defibrillation or cardioversion.
  - For the patient with an ICD and programming-disabled therapies:
    - Advise individual performing the procedure to terminate all sources of EMI while magnet is removed.
    - Re-enable therapies through programming if the programmer is immediately available and ready to be used.
    - Observe the patient and the monitors for appropriate CIED therapy
    - If the above activities fail to restore ICD function, proceed with emergency external defibrillation or cardioversion.
  - For external defibrillation:
    - Position defibrillation/cardioversion pads or paddles as far as possible from the pulse generator.
    - Position defibrillation/cardioversion pads or paddles perpendicular to the major axis of the CIED to the extent possible by placing them in an anterior-posterior location.
If it is technically impossible to place the pads or paddles in locations that help to protect the CIED, then defibrillate/cardiovert the patient in the quickest possible way and be prepared to provide pacing through other routes.

Use a clinically appropriate energy output

Postoperative Management

- Continuously monitor cardiac rate and rhythm and have back-up pacing and defibrillation equipment immediately available throughout the immediate postoperative period
- Interrogate and restore CIED function in the immediate postoperative period
  - Interrogate CIED; consultation with a cardiologist or pacemaker-ICD service may be necessary
  - Restore all anti-tachyarrhythmic therapies in ICDs
  - Assure that all other settings of the CIED are appropriate
Appendix 3: Methods and Analyses

A. State of the Literature.

For this updated Advisory, a review of studies used in the development of the original Advisory and published after 1990 were combined with studies published subsequent to approval of the original Advisory. The updated literature review was based on evidence linkages, consisting of directional statements about relationships between specific perioperative management activities and CIED function or clinical outcomes.

For the literature review, potentially relevant studies were identified via electronic and manual searches of the literature. The updated electronic search covered a 7-year period from 2004 through 2010. The manual search covered a 21-year period of time from 1990 through 2010. Since CIEDs represent a rapidly changing technology, earlier literature (i.e., literature published before 1990) was rarely included in the evaluation of evidence for this Practice Advisory. Over 300 citations that addressed topics related to the evidence linkages were initially identified. These articles were reviewed and combined with pre-2004 articles used in the original Advisory, resulting in a total of 134 articles that contained direct linkage-related evidence. No evidence linkage contained sufficient literature with well-defined experimental designs and statistical information to conduct an analysis of aggregated studies (i.e., meta-analysis). A complete bibliography used to develop this updated Advisory, organized by section, is available as Supplemental Digital Content 2, http://links.lww.com.

For the original Advisory, interobserver agreement among Task Force members and two methodologists was established by interrater reliability testing. Agreement levels using a kappa (κ) statistic for two-rater agreement pairs were as follows: (1) type of study design, κ = 0.72 to 0.90; (2) type of analysis, κ = 0.80 to 0.90; (3) evidence linkage assignment, κ = 0.84 to 1.00; and (4) literature inclusion for database, κ = 0.70 to 1.00. Three-rater chance-corrected agreement values were: (1)
study design, Sav = 0.81, Var (Sav) = 0.010; (2) type of analysis, Sav = 0.86, Var (Sav) = 0.009; (3) linkage assignment, Sav = 0.82 Var (Sav) = 0.005; (4) literature database inclusion, Sav = 0.78 Var (Sav) = 0.031. These values represent moderate-to-high levels of agreement.

B. Consensus-Based Evidence.

For the original Advisory, consensus was obtained from multiple sources, including: (1) survey opinion from consultants who were selected based on their knowledge or expertise in perioperative management of CIEDs, (2) survey opinions from randomly selected samples of active members of the American Society of Anesthesiologists and active members of the Heart Rhythm Society, (3) testimony from attendees of two publicly-held open forums at a national anesthesia meeting and at a major cardiology meeting, (4) internet commentary, and (5) Task Force opinion and interpretation. The survey rate of return was 56% (N = 23/41) for Consultants, and 15% (N=89/600) for the ASA membership, and 15% (N=44/300) for the HRS membership (Table 4)

For the original Advisory, an additional survey was sent to the consultants asking them to indicate which, if any, of the evidence linkages would change their clinical practices if the Advisory was instituted. The rate of return was 39% (N = 16/41). The percent of responding Consultants expecting no change associated with each linkage were as follows: preoperative evaluation - 67%; preoperative patient preparation- 67%; intraoperative monitoring of CIEDs - 67%; emergency defibrillation or cardioversion - 87%; postoperative monitoring of CIEDs - 73%; postoperative interrogation and restoration of CIED function - 60%; intraoperative management of EMI during: electrocautery - 73%; radio-frequency ablation - 73%, lithotripsy - 80%, MRI - 80%, radiation therapy - 80%, and electroconvulsive therapy - 73%. Forty percent of the respondents indicated that the Advisory would have no effect on the amount of time spent on a typical case. Nine respondents (60%) indicated that there would be an increase in the amount of time they would spend on a typical case with the implementation of this Advisory. The amount of increased time anticipated by these respondents
ranged from 5-30 minutes.
### Table 4. Consultant and Membership Survey Responses: Percent Agreement/Disagreement

<table>
<thead>
<tr>
<th>Survey Item:</th>
<th>Consultants</th>
<th>ASA§§§§§§§§ Members</th>
<th>HRS******* Members</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent Agree/Disagree</td>
<td>Percent Agree/Disagree</td>
<td>Percent Agree/Disagree</td>
</tr>
<tr>
<td>1. To perform a preoperative evaluation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establish whether a patient has a CIED</td>
<td>23 100/0</td>
<td>89 100/0</td>
<td>44 100/0</td>
</tr>
<tr>
<td>Define the type of device</td>
<td>23 100/0</td>
<td>87 95/0</td>
<td>44 100/0</td>
</tr>
<tr>
<td>Determine whether a patient is CIED dependent for pacemaking function</td>
<td>23 96/0</td>
<td>89 96/0</td>
<td>44 96/4</td>
</tr>
<tr>
<td>Determine CIED function</td>
<td>23 96/0</td>
<td>89 88/3</td>
<td>44 71/11</td>
</tr>
<tr>
<td>2. To prepare a CIED patient for a procedure:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine if EMI is likely to occur</td>
<td>23 96/4</td>
<td>89 91/2</td>
<td>44 96/2</td>
</tr>
<tr>
<td>Turn pacemaking rate-adaptive therapy off</td>
<td>23 52/35</td>
<td>89 35/35</td>
<td>44 34/34</td>
</tr>
<tr>
<td>Program pacemaking function to asynchronous mode:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All CIED patients</td>
<td>22 0/82</td>
<td>88 21/48</td>
<td>43 9/84</td>
</tr>
<tr>
<td>- Pacemaker dependent patients only</td>
<td>22 73/23</td>
<td>83 47/27</td>
<td>43 54/28</td>
</tr>
<tr>
<td>Suspend anti-tachyarrhythmia functions</td>
<td>21 86/5</td>
<td>87 54/21</td>
<td>43 63/21</td>
</tr>
<tr>
<td>Consider using a bipolar electrocautery system (when applicable)</td>
<td>22 91/0</td>
<td>86 90/2</td>
<td>44 77/14</td>
</tr>
<tr>
<td>Consider using an ultrasonic (harmonic) scalpel (when applicable)</td>
<td>22 68/18</td>
<td>88 63/3</td>
<td>44 34/9</td>
</tr>
<tr>
<td>Assure the availability of temporary pacing and defibrillation equipment</td>
<td>22 100/0</td>
<td>87 95/1</td>
<td>44 89/7</td>
</tr>
</tbody>
</table>

‡‡‡‡‡‡‡‡ The percentage of respondents who agreed/disagreed with each item is presented. The percentages who were uncertain are not presented.

ASA§§§§§§§§ American Society of Anesthesiologists

HRS******* Heart Rhythm Society
Consider the possible effects of anesthetic agents or techniques on CIED function

3. Intraoperative monitoring should include:

<table>
<thead>
<tr>
<th>Monitor</th>
<th>22</th>
<th>64/18</th>
<th>86</th>
<th>779</th>
<th>44</th>
<th>66/21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous ECG</td>
<td>23</td>
<td>100/0</td>
<td>88</td>
<td>100/0</td>
<td>44</td>
<td>100/0</td>
</tr>
<tr>
<td>Continuous peripheral pulse</td>
<td>23</td>
<td>96/0</td>
<td>88</td>
<td>86/11</td>
<td>44</td>
<td>61/18</td>
</tr>
</tbody>
</table>

4. For procedures using Electrocautery:

<table>
<thead>
<tr>
<th>Instruction</th>
<th>23</th>
<th>100/0</th>
<th>88</th>
<th>97/0</th>
<th>44</th>
<th>96/0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position the electrosurgical receiving plate so current pathway does not pass through or near the generator or leads</td>
<td>23</td>
<td>100/0</td>
<td>88</td>
<td>100/0</td>
<td>44</td>
<td>96/0</td>
</tr>
<tr>
<td>Avoid proximity of the cautery’s electrical field to the pulse generator or leads</td>
<td>23</td>
<td>96/0</td>
<td>87</td>
<td>100/0</td>
<td>44</td>
<td>96/2</td>
</tr>
<tr>
<td>Use short, intermittent and irregular bursts at the lowest feasible energy levels</td>
<td>23</td>
<td>96/0</td>
<td>87</td>
<td>83/2</td>
<td>44</td>
<td>91/7</td>
</tr>
<tr>
<td>Use a bipolar electrocautery system (when applicable)</td>
<td>23</td>
<td>91/0</td>
<td>88</td>
<td>94/1</td>
<td>44</td>
<td>84/2</td>
</tr>
<tr>
<td>Use an ultrasonic (harmonic) scalpel (when applicable)</td>
<td>23</td>
<td>57/13</td>
<td>88</td>
<td>65/1</td>
<td>44</td>
<td>41/9</td>
</tr>
</tbody>
</table>

5. For Radio frequency Ablation:

<table>
<thead>
<tr>
<th>Instruction</th>
<th>23</th>
<th>83/0</th>
<th>87</th>
<th>76/0</th>
<th>44</th>
<th>91/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid direct contact between the ablation catheter and the CIED and leads</td>
<td>23</td>
<td>83/0</td>
<td>87</td>
<td>76/0</td>
<td>44</td>
<td>91/2</td>
</tr>
<tr>
<td>Keep the current path (electrode tip to return plate) as far away from the pulse generator and lead system as possible</td>
<td>23</td>
<td>87/0</td>
<td>87</td>
<td>78/0</td>
<td>44</td>
<td>89/5</td>
</tr>
</tbody>
</table>

6. For Lithotripsy:

<table>
<thead>
<tr>
<th>Instruction</th>
<th>23</th>
<th>91/0</th>
<th>86</th>
<th>78/1</th>
<th>44</th>
<th>86/0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid focusing the lithotripsy beam near the pulse generator</td>
<td>23</td>
<td>91/0</td>
<td>86</td>
<td>78/1</td>
<td>44</td>
<td>86/0</td>
</tr>
<tr>
<td>If the lithotripsy system triggers on the R-wave, disable atrial pacing prior to procedure</td>
<td>23</td>
<td>39/26</td>
<td>86</td>
<td>38/13</td>
<td>44</td>
<td>39/9</td>
</tr>
</tbody>
</table>
7. For MRI:*

| MRI contraindicated for all CIED patients | 21 | 81 | 79 | 80 | 44 | 55 |
| MRI contraindicated for some, but not all CIED patients | 21 | 19 | 79 | 18 | 44 | 39 |
| MRI not contraindicated for any CIED patient | 21 | 0 | 79 | 2 | 44 | 6 |

8. For RT:*

| RT contraindicated for all CIED patients | 21 | 0 | 73 | 10 | 44 | 0 |
| RT contraindicated for some, but not all CIED patients | 21 | 57 | 73 | 37 | 44 | 59 |
| RT not contraindicated for any CIED patient | 21 | 43 | 73 | 53 | 44 | 41 |

9. For Emergency Defibrillation or Cardioversion:

- Position the defibrillation or cardioversion pads as far as possible from the pulse generator | 23 | 83/0 | 87 | 69/13 | 44 | 91/7 |
- Use an anterior-posterior position | 23 | 74/9 | 84 | 61/6 | 44 | 68/25 |
- Use a clinically appropriate energy output regardless of the device | 23 | 100/0 | 87 | 87/0 | 44 | 100/0 |

10. To manage CIED patients postoperatively:

- Interrogate and restore CIED function in the PACU or ICU | 23 | 96/4 | 88 | 98/1 | 44 | 77/21 |

** Respondents were asked to select one of the three choices. Therefore the numbers represent percentage agreement only.