Heart Rhythm New Zealand consensus statement on the practical management of Cardiac Implanted Electronic Devices in the perioperative environment

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Abstract

- Electrosurgery is commonly used during a range of operations in order to maintain effective haemostasis. This can cause electromagnetic interference (EMI) with cardiac implanted electronic devices (CIEDs) that prevent normal device function. Cardiac Implanted Electronic Devices (CIEDs) include Pacemakers (PPM), Implantable Cardiac Defibrillators (ICD), Cardiac resynchronisation therapy devices both pacemakers and defibrillators (CRT-P/CRT-D) and Implantable loop recorders (ILRs). Damage to the generator, inhibition of pacing, activation of asynchronous pacing, and ventricular fibrillation can all be induced by electrocautery. An active management plan for CIEDs during electrosurgery is critical to minimise these adverse effects of EMI.

Purpose

- To facilitate the safe and effective perioperative management of CIED patients during electrosurgery.

Background

Heart Rhythm New Zealand (HRNZ) is an integral part of the Cardiac Society of Australia and New Zealand (CSANZ). It is composed of members of CSANZ who have expertise in the field of electrophysiology and cardiac rhythm devices. The consensus statement was generated using a combination of current international guidelines and publications, adapted to be relevant to the New Zealand medical system. The writing committee comprised of stakeholders from the specialities who frequently manage CIED patients during electrosurgical procedures. Consultation within each specialty was sought, and feedback was discussed as a group and adopted where appropriate.

CIEDs can be prone to electromagnetic interference (EMI) during surgical/medical procedures using electrocautery. The factors determining the potential for EMI to affect normal device function are: the distance between source and site of CIED (less risk if >15cm from device), the intensity and duration of field or source, the frequency and waveform of signal, and the path of current and its relation to the orientation of CIED leads. EMI usually only disrupts normal device function transiently, and when the interference ceases, the device typically returns to normal function.

Common adverse effects due to the CIED sensing EMI can include: inhibition of pacing – leading to haemodynamically significant bradycardia or asystole in the pacemaker dependent patient, inappropriate tachyarrhythmia therapy with anti-tachycardia pacing and/or shocks in ICDs, inappropriate tracking of electrical noise causing pacing at upper rate and/or mode switching, due to over-sensing on atrial lead, activation of asynchronous noise reversion mode, and changes in pacing behaviour such as the activation of rate response algorithms. Rare adverse effects can include: Thermal injury at the lead / myocardial interface, increased pacing thresholds, electrical reset of the device causing change in settings, permanent damage to device (legacy devices are more prone to this).

Recommendations for perioperative management of CIED patients has significantly altered in recent years, with advancements in device technology establishing a higher degree of tolerance to routine electrosurgical procedures. However, concurrently, newer electrosurgical technologies and CIED technologies are also occurring, this represents a challenge to the manufacturers of the CIEDs and CIED professionals.

Manufacturer specific information should be used for magnet placement. Implantable defibrillators are generally implanted at the left prepectoral position, but some may be right prepectoral, abdominal implants or subcutaneously implanted in the left axilla. Pacemaker generators are generally implanted left or right prepectoral, but some are implanted in the abdomen, particularly in children. Leadless devices are implanted directly in the heart.

General principles

Centres performing electrosurgery on patients with CIEDs are recommended to have an institutional protocol. Protocols may vary between centres depending on the availability of specialist device physiologists in each centre. The patients' CIED service should be contacted for specialist device physiologist advice. For elective procedures advice should be requested well in advance of surgery. [1-4] The perioperative management of CIEDs must be individualised to the patient, the type of CIED, and the type of procedure being performed. [1-4] A single recommendation for all CIED patients is not appropriate. [1]

The decision to reprogram a device vs magnet use will depend on staff availability, urgency of surgery and surgical site. The most effective advice for the perioperative care of a patient with a CIED will be obtained from the team that monitors that patient and device, combined

with an understanding of the procedure to be performed and risk for electromagnetic interference (EMI). [1-4]

All patients with pacemakers undergoing elective surgery should have had a device interrogation as part of routine care within the past 12 months. All patients with ICDs or any CRT device (Cardiac Resynchronization Therapy Defibrillator (CRT-D), Cardiac Resynchronization Therapy (CRT-P) undergoing elective surgery should have had a device interrogation as a part of routine care within the past 6 months, this may be in person or via remote monitoring. [1-4] ILRs should be interrogated prior to surgery if the surgery is near the device as EMI from electrosurgery may overwrite data. Interrogation can be done via remote monitoring or in person. [2]

Electrosurgery and CIEDs

Electrosurgery may be either monopolar or bipolar. Bipolar electrosurgery or the use of an ultrasonic scalpel is preferred to monopolar electrosurgery as these result in less EMI, however these technologies are not appropriate for all electrosurgery operations. [2] Bipolar electrosurgery does not use a return pad and is unlikely to cause EMI unless applied directly to the device but precautions need to be taken for some legacy devices. [5] Monopolar electrosurgery has current flow through the patient's body to a patient return electrode, casting a wider electrical field. Device interference is unlikely if surgery is below the iliac crest and the return pad is on the thigh ipsilateral to the surgical site. [2] Newer capacitive return electrode (mattress type) may disperse current throughout the body depending on mattress placement regardless of anatomical site of surgery so devices are at higher risk of EMI especially if the mattress is under patient's chest. [6, 7] Pacemakers implanted in the abdomen will be more exposed to EMI during abdominal or pelvic surgery. Monopolar electrosurgery above the iliac crest and/or <15cm from device has a higher risk of EMI. [1-4]

Recommendations for use of electrosurgery to avoid EMI interference with CIEDs:

- Follow electrosurgery unit manufacturer's guidelines for patient return electrode orientation.
- Use a harmonic (ultrasonic) scalpel or bipolar electrosurgery where possible.
- Place the patient return electrode on clean, dry hair free skin over a large, well-perfused muscle mass as close as possible to the surgical site, but >15cms from CIED.

- Ensure the heart and CIED is not between the site of surgery and the return electrode e.g. patients undergoing head–neck surgery should have the grounding pad placed on the shoulder contralateral to the device (not the thigh) whereas those undergoing breast and axillary surgery should have the pad placed on the upper arm. [8-10]
- Capacitive full body return electrode (mattress type) are designed to remove the risk of pad site burns associated with the adhesive return electrodes. The return current is distributed over the whole area of the mattress which may cause inhibition of pacing or ICD therapy even if surgical site is below the iliac crest. [6, 11]
- In pacemaker dependent patients the use of an adhesive return electrode pad is preferred to a mattress type electrode as there is potential for pacemaker inhibition due to EMI regardless of surgery site, unless the device is appropriately programmed prior to the procedure. [2, 6, 11, 12]
- Use monopolar electrosurgery in short bursts (<5 secs), intersected by pauses. Pure unblended cut is less likely to cause interference than the blended or coagulation settings of the electrosurgery unit. Use the lowest feasible energy. [1-4, 10]
- Monitor patients with ECG and pulse oximetry (and/or arterial line). Interference may saturate the ECG signal during electrosurgery making it impossible to see inhibition of pacing.
- Ensure an external defibrillator capable of transcutaneous pacing is readily available for pacemaker dependent patients or operations with high risk of EMI identified by the specialist device physiologist. Place transcutaneous pacing/defibrillator pads including ECG, prior to draping, if there are any concerns or barriers to placement during case.
- If a Specialist Physiologist has recommended the use of a magnet, the magnet should only be applied for the duration of the electrosurgery.

Preoperative device reprogramming and/or magnet use

All patients undergoing electrosurgery who have a CIED should be discussed with a specialist device physiologist prior and have a peri-operative CIED management plan established. This may include a recommendation for device reprogramming and/or magnet use.

Magnet use, placement and CIED response must be fully understood before use. [1-4, 13, 14] Magnet use may be recommended to inhibit ICD therapy or force asynchronous pacing. The

use of a magnet and the response of the device to a magnet should be guided by a specialist device physiologist as this varies depending on device type and manufacturer. [1, 2, 4, 13, 14] When a magnet has been recommended, the magnet response should be verified as expected prior to being required in pacemaker dependent patients (Table 1 and 2).

If device reprogramming is recommended it should be performed by a specialist device physiologist. Programming should be performed as close as possible to the time of surgery in case of delay or cancellation of surgery. ICDs should be reprogrammed to therapy off/or a magnet used to inhibit therapy only once the patient is in a monitored environment with ECG/pulse oximetry monitoring, defibrillator pads should be placed prior to programming the ICD off. [1-4] Pacemakers that are programmed asynchronous (DOO/VOO/AOO) for the duration of surgery should also be monitored as above. [1, 2] Rate response functions may increase heart rate during surgery in response to external stimulus or intraoperative events and may cause pacemaker driven tachycardia. Minute ventilation sensors may emit a current to measure changes in thoracic impedance that can be detected by monitoring equipment and appear to be rapid pacing without capture. The rate response sensor may need to be programmed off prior to surgery if recommended by a specialist device physiologist. [1-4, 15] Any changes to the CIED settings should be documented in the patient record (Figure 1).

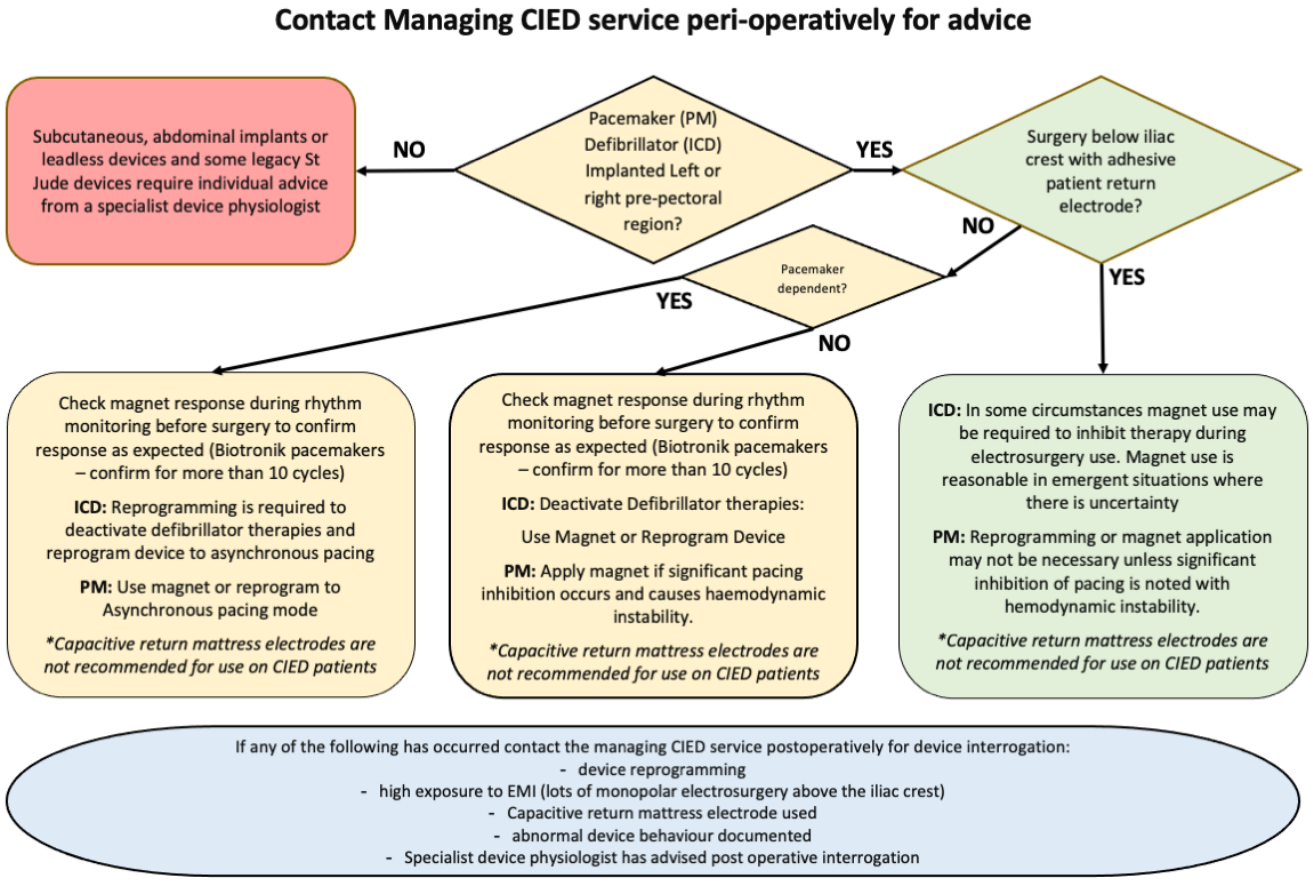
When to consider CIED reprogramming for surgery rather than magnet application

- Where the device is not easily accessible to allow placement of the magnet during surgery, due to site of surgery or patient positioning. [1-4]
- Unipolar leads or where a CIED is programmed to unipolar sensing, due to a greater risk of oversensing EMI. [1-4]
- Biotronik pacemakers where asynchronous mode is likely to be required i.e. pacing dependent patient – magnet mode should be reprogrammed from “Auto” to “Async” or device programmed to asynchronous. [13]
- Pacing dependent ICD patients as magnet use will not provide asynchronous pacing. [1-4]

- For ICD patients where correct magnet placement is difficult to assess (no tones) and monopolar electrosurgery is being used above the iliac crest or a capacitive return mattress is used. [8]
- If surgery is less than 15cm from the CIED generator for pacemaker dependent patients and all ICD patients.
- Where a higher or lower base rate is desirable due to patient haemodynamics as requested by the medical team, surgeon, or anaesthetist.
- Leadless pacemakers which are implanted directly into the ventricle (Micra/Nanostim/Aveir) and subcutaneous ICDs (S-ICD Emblem/EV-ICD) need specific advice from a device physiologist as the advice, response to magnets and magnet placement may differ. [1-4]

Figure 1: Decision Matrix for Peri-operative Cardiac Device Management.

For use when the Device has not been programmed specifically for the operation/procedure.



Intraoperative CIED management

Patients should be monitored with ECG & Pulse Oximetry/ or arterial line during the procedure as the ECG tracing will be obscured during electrosurgery. [1-4] An external defibrillator with pacing capabilities should be readily available for all CIED patients, along with staff trained in its use. [1-4]

A magnet should be immediately available for all CIED patients who are undergoing a procedure that may involve EMI even if reprogrammed, along with staff familiar with the use of magnets. [1-4] Caution should be exercised when using magnetic drapes to hold surgical equipment, placement of these on the thorax should be avoided. The use of bottom isolated magnetic drapes may reduce the risk of interaction. [16]

Postoperative indications for CIED interrogation

- Patients with CIEDs reprogrammed prior to the procedure. [1-4] If ICD therapies are deactivated for surgery/procedure or a PPM is programmed to asynchronous mode, the team requesting reprogramming are responsible to ensure the device is returned to normal operation as soon as practicable and should have a clear plan for this. [3, 4]
- Patients with CIEDs who underwent hemodynamically challenging surgeries such as cardiac surgery or significant vascular surgery (e.g., abdominal aortic aneurysmal repair) which likely have higher probability of significant EMI. [1-4]
- Patients with CIEDs who experienced significant intraoperative events including cardiac arrest requiring temporary pacing or cardiopulmonary resuscitation and those who required external electrical cardioversion. [1-4]
- Patients with CIEDs who underwent monopolar electrosurgery with a capacitive return mattress and there is a greater probability of EMI affecting device function, as determined by a specialist device physiologist. [2, 6]
- Patients with CIEDs who underwent monopolar electrosurgery above the iliac crest and there is a greater probability of EMI affecting device function, as determined by a specialist device physiologist. [1-4]
- Patients with signs of device dysfunction observed intraoperatively e.g. heart rates below or above programmed or expected rates, pectoral or diaphragmatic twitching, erroneous

pacing spikes (such as pacing spikes that vary considerably in size), beeping, alarming or vibrating from device. [1-4]

- Post magnet use where the specialist device physiologist has identified the CIED is nearing elective replacement. In this situation magnet movement, EMI and battery status may cause unintended device programming due to tripping elective replacement. Changes in programming may not always be noticeable e.g. increase in pacing rate, change in pacing mode, deactivation of rate response sensors for Pacemakers, device alarming, beeping or vibration for ICDs due to battery status alert. [3]
- Where a specialist cardiac device physiologist has recommended post-operative interrogation.
- Where a specialist cardiac device physiologist has identified the CIED is a legacy Abbott/St Jude Medical device subject to safety alert (Affinity, Entity, Integrity, Identity, Verity, Frontier, Victory, Zephyr) see Special Considerations. [5]

When emergency surgery is required

In situations where CIED patients present for urgent surgery, contact the patient's CIED centre or nearest tertiary hospital for advice. The availability of staff at local follow-up centres will vary during work hours and after hours. All tertiary Cardiology centres in New Zealand have staff on call after hours.

Prior to making contact, it is helpful to the on call team if the type of device/model can be identified – access hospital notes, question patient / attending support people, enquire if patient has a device ID card. Review the chest x-ray and 12-Lead ECG. [1-4] If pacemaker spikes are present it should be presumed the patient is potentially pacemaker dependent. Newer devices will have bipolar pacing spikes, which are very small (1mm) and may be difficult to see on the ECG. Unipolar pacing spikes are large spikes and obvious on the ECG, the presence of these may indicate older device/leads that may be more susceptible to interference. [1-4] A remote monitoring transmission can be considered as a substitute for in person interrogation if no available specialist device physiology staff on site. [1-3]

Defibrillator/pacing pads should be readily available in the event defibrillation or transcutaneous pacing is required. A defibrillator capable of transcutaneous pacing and a magnet with instructions for use (Table 1 and 2) should be readily available along with staff

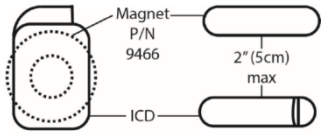
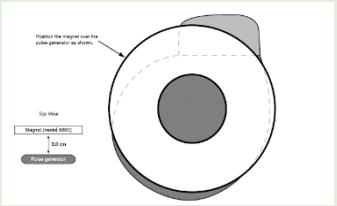
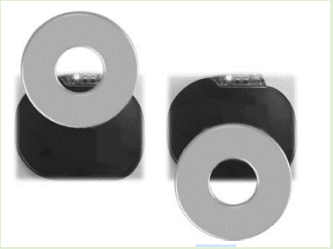
trained in its use. [1-4] In individual circumstances pads may need to be placed prophylactically, this would be advised by a specialist device physiologist. If magnet use is likely to be required, identify the expected magnet response prior to surgery (Table 2). [1-4]

If surgery is above the iliac crest or a capacitive return electrode mattress is used, have a magnet available for pacemaker patients to provide asynchronous pacing should significant periods of inhibition occur during electrosurgery resulting in asystole or haemodynamically compromising bradycardia. Transient inhibition of pacing should be expected during the delivery of electrosurgery, but normal pacing is expected to return immediately upon termination of this. Asynchronous pacing will only occur whilst magnet is in situ. [1-3, 6] Please note the magnet response for Biotronik devices is only asynchronous for 10 beats unless specifically programmed magnet response to "Async". [1-4]

For ICD patients there is the potential for inappropriate ICD shock therapy during electrosurgery due to sensing of EMI (Table 1). ICD tachyarrhythmia therapy can be temporarily disabled by placing a magnet over the device during electrosurgery, therapies will resume on removal of magnet. When access to the device for magnet placement is not possible (e.g. due to patient position) programming by a specialist device physiologist may be required prior to surgery to disable tachyarrhythmia therapies. The correct positioning of a magnet is manufacturer specific; advice should be sought from a specialist device physiologist where possible (Table 1). In pacing dependent ICD patients, electrosurgery should be in short bursts <5 secs to prevent long periods of inhibition – a magnet will only inhibit tachyarrhythmia therapy and will not provide asynchronous pacing. [1-4] In pacing dependent ICD patients the CIED may need to be reprogrammed to provide asynchronous pacing if the operative field is above the iliac crest and EMI is likely to cause significant periods of inhibition, or if a capacitive return mattress is being used. [1, 2] Where the positioning of the patient limits access to the device for magnet placement a specialist physiologist may be required prior to surgery to disable tachyarrhythmia therapies.

The post-operative device follow-up after surgery should be guided by specialist device physiologist and should generally only be required for patients where CIED malfunction is suspected, significant exposure to EMI has occurred, or device was reprogrammed prior to surgery. [1-4]

Table 1: Magnet response – Defibrillators

Summary of Magnet application to ICDs - modified from Jacobs et al, HRS ASA expert consensus statement on Perioperative Management of patients with CIEDs and EHRA consensus on prevention and management of interference due to medical procedures in patients with cardiac implantable electronic devices [1, 2, 14, 17]						
Company	**Magnet placement**	**Tachy/Shock therapy**	**Tone emitted with magnet**	**Effect on Pacer component of ICD**	**Can ICD be programmed to ignore magnet**	**Notes**
Medtronic	Directly over device [18]  	Suspended - whilst magnet in situ	Yes Loud continuous for 30secs if normal function. Alternating tone indicates an alert warranting a device interrogation.	None	No	
Boston Scientific	Directly over device - Transvenous and 101 SQ-RX [19]  Emblem subcutaneous ICD. Off centre over header or lower [19] 	Suspended * whilst magnet in situ *unless programmed to change therapy	Yes R-wave synchronous tones (very faint, not loud) use stethoscope to hear if required. NB: If patient has had an MRI the beeper function may be permanently disabled. Verify beeper function before surgery.	None	YES (but very rare)* *Can be programmed off or to trigger EGM in some legacy models	

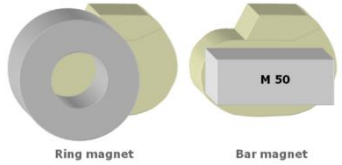
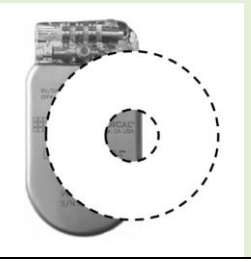
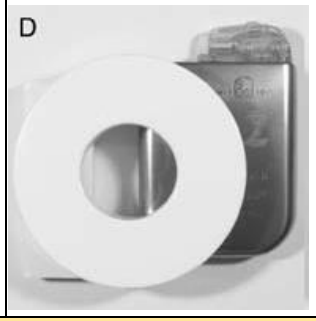
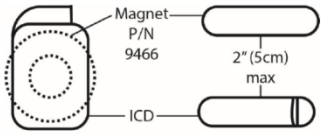
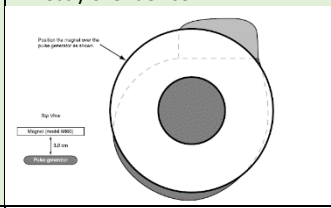
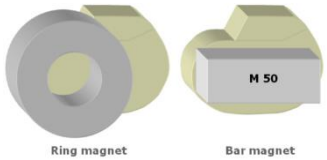
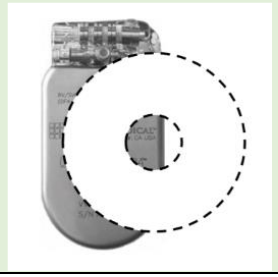
Biotronik	Directly over device Ring magnets should be offset slightly so that the opening of the magnet rests above the edge of the ICD housing. 	Suspended whilst magnet in situ limit of 8hrs	None	None	No	Will revert to normal function after 8hrs unless magnet is removed and replaced
St Jude (Abbott)	Curve of donut over left or right side of device 	Suspended* whilst magnet in situ *unless programmed to ignore	None may vibrate* *If vibrates device interrogation is warranted	None	Yes (very rare)* Can be programmed to Ignore magnet	
Liva Nova (previously ELA/Sorin)	Magnet should be positioned off centre avoiding the header at the top of the device 	Suspended whilst magnet in situ	None	Converts pacer rate to 96ppm-85ppm depending on battery life. Pacing mode unchanged.		No option to convert to asynchronous pacing mode
NB: Magnet removal will restore shock and anti-tachycardia therapies						

Table 2: Magnet response – Pacemakers

Summary of Magnet application to Pacemakers - modified from Jacobs et al, HRS ASA expert consensus statement on Perioperative Management of patients with CIEDs and EHRA consensus on prevention and management of interference due to medical procedures in patients with cardiac implantable electronic devices [1, 2, 14]					
Company	**Magnet placement**	**Default response**	**Tone emitted with magnet**	**Can pacemaker be programmed to ignore magnet**	**Notes**
Medtronic	Directly over device* 	DOO/VOO/AOO whilst magnet in situ 85ppm if device conditions are normal 65ppm if device is at RRT or device reset has occurred – a full device interrogation is warranted Normal function resumes 2 secs after removal of magnet *Micra leadless pacemaker has no magnet response	No	Magnet operation does not occur if telemetry between device and programmer is established or if MRI Surescan is programmed on.	AV delay 100ms in DOO Azure 100ppm for 5 beats then default response. Adapta™/Versa™/Sensia™ TMT 100 bpm with the amplitude reduced by 20% on the third pulse, then default response. For certain legacy models (Kappa, Enpulse, Adapta, Versa or Sensia) the magnet response is suspended for 1 hr following a device interrogation unless manual "clear data" command is chosen prior to ending the programmer session
Boston Scientific	Directly over device 	DOO/VOO/AOO whilst magnet in situ 100ppm if device conditions are normal 90ppm if device is at 1 year or less battery life 85ppm RRT	No	Yes – can be programmed to store EGM. Current devices restore magnet function after 1 stored EGM or 60 days elapse. Legacy device require magnet function to be programmed back on.	AV delay 100ms in DOO The 3rd pulse during async magnet response is issued at 50% of the programmed pulse width – consider reassessing safety margin if loss of capture is observed
Biotronik	Directly over device 	Magnet response: Auto* DOO/VOO/AOO 90ppm for 10 beats (80ppm @ERI) then programmed mode and rate (PR -11% @ERI) Async* DOO/VOO/AOO 90ppm (80ppm @ ERI) whilst magnet in situ Sync* Programmed mode/rate - stores 10 sec EGM (PR -11% @ ERI) rate response disabled	No	*Yes – 3 modes available Async/Sync/Auto	

St Jude (Abbott)	Curve of donut over left or right side of device* except leadless devices *Leadless pacemakers - a magnet applied over the apex of the heart. 	DOO/VOO/AOO @ 100ppm whilst magnet in situ Magnet rate gradually decreases over time 85ppm ERI *Aveir VOO 100ppm whilst magnet in situ *Nanostim VOO 90ppm (65ppm at ERI) whilst magnet in situ	No	Yes – Off, EGM store Vario (legacy devices)	Legacy devices that are subject to a safety alert make them more susceptible to transient anomalous device function during electrosurgery, this refers to a specific subset of legacy generation SJM pacemakers. (SJM Affinity, Entity, Integrity, Identity, Verity, Frontier, Victory, Zephyr). [5] *Leadless pacemakers: The effectiveness of magnets varies. If one magnet does not cause magnet response, place a second magnet on top of the first or try a different magnet. Pressing firmly on the magnet to decrease the distance between the magnet and the pulse generator can also help.
Liva Nova (previously ELA/Sorin)	Magnet should be positioned off centre avoiding the header at the top of the device 	DOO/VOO/AOO 96ppm whilst magnet in situ Gradual decrease to 80ppm ERI	No	Yes – Off	
NB: Magnet rate lower than default values indicates battery depletion. Some devices require more eccentric application of magnet in regard to generator casing to optimise magnetic field alignment.					

Special Considerations

Cardioversion, defibrillation, and transcutaneous pacing of adult CIED patients

High voltage cardiac defibrillation can introduce a large amount of current to CIEDs. Adverse events during cardioversion, defibrillation, and transcutaneous pacing are rare though can include: Elevated pacing thresholds/failure to capture, damage to the device, and reversion to backup safety mode. Ideally, patients who have the potential requirement for defibrillation or transcutaneous pacing during a procedure will have pads placed in advance.

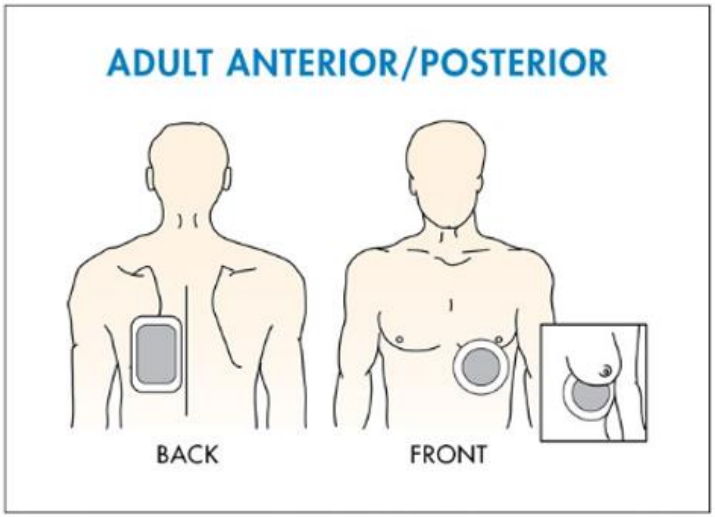
In pacing dependent patients undergoing cardioversion, consider reprogramming the device to fixed outputs. This is to ensure 2x threshold safety margins, which may not always be the case when automatic threshold testing is enabled. The need to have a physiologist present during cardioversion is at the discretion of the Specialist Device Physiologist.

In patients with an ICD or a permanent pacemaker, the placement of paddles/pads should not delay defibrillation. [20] A defibrillator capable of transcutaneous pacing should be utilised. The recommended positioning of the defibrillation pads for should be in an anterior-posterior configuration (Figure 2) where possible, with the anterior pad placed at least 15cm from the generator. [1-4, 21] For patients with large breasts the anterior pad should be placed under the breast. [22] Alternative positioning with anterior-anterolateral (Figure 3) pad placement can be used if anterior-posterior placement is within the surgical field, or preferred for cardioversion of AF. [1-4, 23] Alternative anterior-anterolateral pad placement may also be required in an emergency where it is not possible to attach a posterior pad easily.

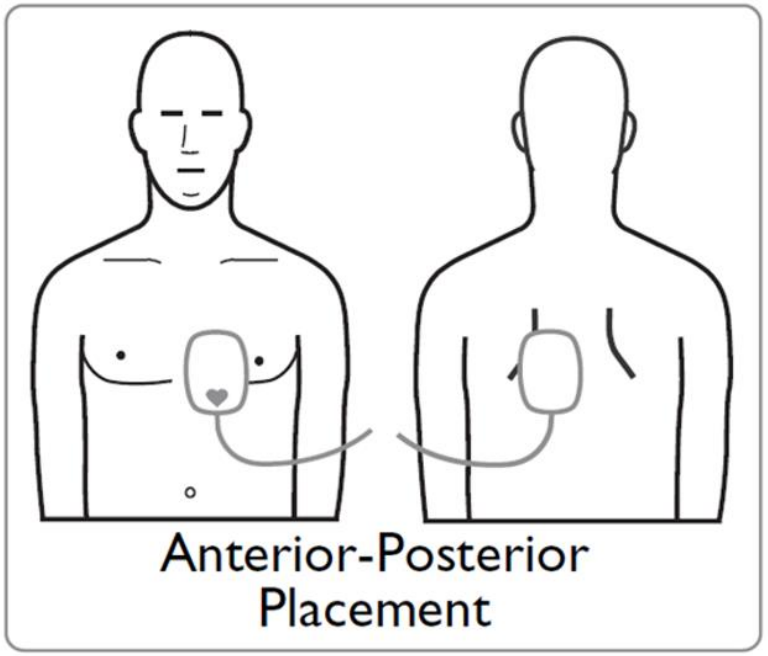
Following the procedure the device should be interrogated and fully evaluated by a specialist device physiologist, to ensure normal function. [1-4] When operating the defibrillator in AED mode, be aware pacemaker pulses may prevent advisement of an appropriate shock, regardless of the patient's underlying rhythm. [20, 24]

Figure 2: Defibrillator pad placement for Cardioversion – Adults Anterior/Posterior

NB: Pads should always be placed >15cm away from CIED



Reproduced with permission from Zoll Medical – [Defibrillator Pad Placement - ZOLL Medical][25]

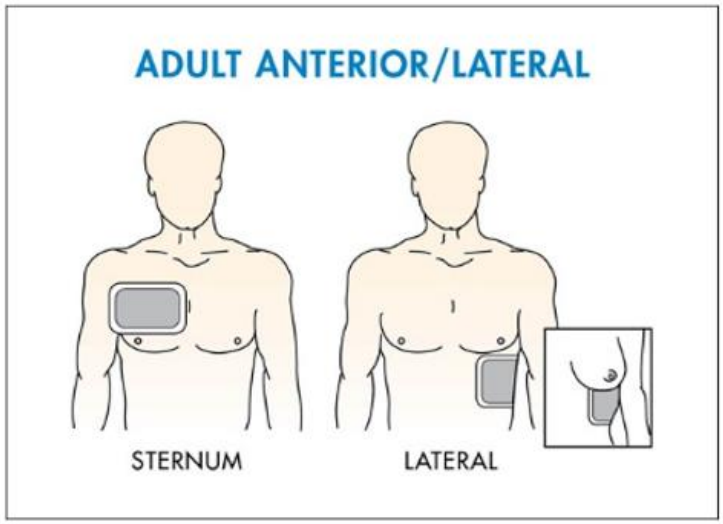


Reproduced with permission from Philips HeartStart HS1/FRx AED User Guide[26]

Figure 3: Defibrillator pad placement for Cardioversion – Adults Anterior/Anterior Lateral

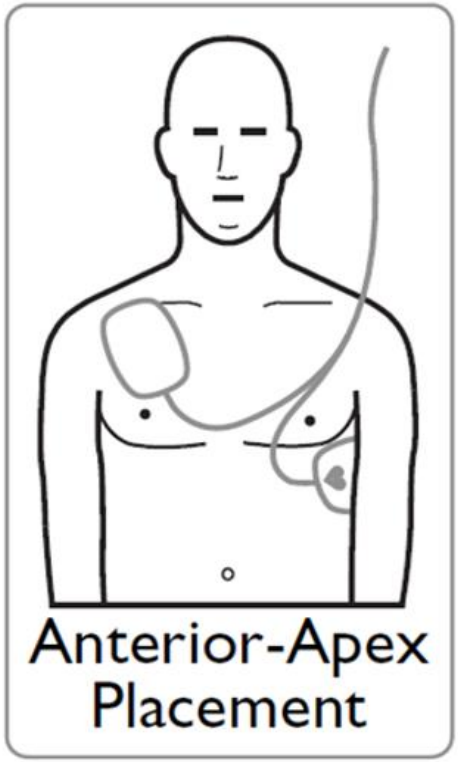
Some studies have indicated Anterior-lateral electrode positioning is more effective for biphasic cardioversion of AF [23]

NB: Pads should always be placed >15cm away from CIED



One electrode is placed on the upper right torso above the right nipple, just below the clavicle, and the other (lateral) pad should align with the bottom portion of the left pectoral muscle on a male patient or under the left breast on a female patient with the centre of the electrode in the mid axillary line.

Reproduced with permission from Zoll Medical – [Defibrillator Pad Placement - ZOLL Medical](#)[25]



Reproduced with permission from Philips HeartStart HS1/FRx AED User Guide [26]

St Jude Legacy Devices

Abbott Medical (formerly St Jude Medical) Legacy devices that are subject to a safety alert are more susceptible to transient anomalous device function during electrosurgery. This refers to a specific subset of legacy generation pacemakers, specifically: SJM Affinity, Entity, Integrity, Identity, Verity, Frontier, Victory, and Zephyr. These devices may exhibit a temporary change in function that can persist for 30 secs or longer, the most clinically significant observation being transient loss of capture due to reduction in pacing output voltage, this may occur regardless of program mode or magnet use. [5]

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Competing interests

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