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Letter to the Editor

Pacemaker malfunction risks within the electromagnetically rich hospital environment

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Dear editor,

Pacemakers (PMs) and implantable cardioverter defibrillators (ICDs) are being implanted at an increasing rate for various indications. Current generation systems are relatively immune to electromagnetic interference (EMI) because of advanced hardware and software design features. Nonetheless, EMI still presents a potential hazard to PM/ICD operation, particularly for patients dependent on pacing. Prevention of unwanted EMI requires that the clinician taking care of a patient with a PM/ICD is aware of this potential problem. Although patients usually spend less time in the hospital than in the outside environment, the former is, ironically, where most patient encounters with potentially troublesome EMI may occur.[1,2]

Cardioversion and defibrillation can cause transient oversensing and pacing inhibition, while energy conducted through the lead may cause arrhythmias and thermal damage to the myocardium at the electrode/tissue interface, leading to increase in acute and chronic pacing threshold including loss of capture. Prolonged external shocks may cause mode reversion and resetting of the device to a back-up mode. Defibrillation and cardioversion, when performed at high energies directly over the PM, can cause irreversible destruction of the circuitry.[3] Defibrillation energy should be kept as low as possible by using biphasic defibrillators, and the PM should be programmed to its maximal output prior to the shocks to reduce the risk of capture failure, particularly in pacing-dependent patients. Defibrillator paddles should be placed at a distance >15 cm from the PM and oriented such that the axis of the defibrillation circuit is perpendicular to the axis of the pacing lead, minimizing the current flow between the stimulating electrode and the PM. Sufficient time of a few minutes should be allowed between successive shocks to allow recovery of the protective Zener diodes. After defibrillation, the PM should be interrogated and the programming confirmed. Equipment for temporary pacing should be close to hand, especially if the patient is PM dependent.[4]

Electrocautery is the most common source of significant EMI in the hospital and may have variable effects on PM function. Monopolar cautery with a grounding electrode placed <15 cm from the PM can cause irreversible damage to the device. Electrocautery can cause thermal myocardial damage through current induction at the electrode-tissue interface with subsequent elevation of pacing threshold. Manufacturers of implantable PMs and ICDs either contraindicate the use of surgical diathermy/electrocautery or give strong warnings against its use, especially when in monopolar mode. Bipolar electrocautery in contrast involves delivery of energy between two electrodes at the tip of the device and does not usually cause any significant interaction. The least-required power should be used, and the frequency of electrocautery should be limited to 1- or 2-s bursts every 10 s, especially if the patient is PM dependent or has an ICD.[5] For surgery above the umbilicus, reprogramming of the PM may be needed before surgery. Provision of alternative temporary pacing (transvenous, transcutaneous) should be ready in the operating theatre. Careful monitoring of mechanical evidence of cardiac activity such as pulse oximetry and arterial pressure is necessary as ECG monitoring becomes unreliable during cautery operation. Magnet application over the PM may help by causing the PM to deliver asynchronous pacing, avoiding inhibition by interference, but it is vital to understand the different magnet responses prior to using this method. In any case, the PM should be interrogated after the procedure to confirm programming parameters.[6]

Magnetic resonance imaging (MRI) is an important and widely available diagnostic tool, and it has been estimated that 75% of patients with an implantable PM will have a clinical indication for an MRI during their device lifetime.[7] All components of MRI (the static magnetic field, the gradient magnetic field, and pulsed radiofrequency field) can interfere with PM function, so its use is traditionally avoided in PM patients. The alternating magnetic field and rapid RF pulses can result in oversensing of EMI, which can cause pacing inhibition, noise tracking response, programming changes, loss of function, or inappropriate ICD shocks. The RF field can cause heating at the electrode-myocardial tissue interface, resulting in thermal injury and increase in pacing thresholds or myocardial perforation. This heating is more pronounced with abandoned leads than with leads connected to the PM.[8]

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MRI scanning of PM-dependent patients should be avoided unless there are highly compelling circumstances when the benefits clearly outweigh the risks. If MRI must be done in a PM-dependent patient, the PM should be programmed to an asynchronous pacing mode (VOO or DOO) and magnet response disabled. Rate modulation should be disabled in PMs and tachycardia therapy in ICDs. In non-pacing-dependent PM/ICD patients, pacing and sensing functions can be temporarily switched off for further circuit protection. Careful monitoring of the patient including continuous verbal communication, ECG, blood pressure, and pulse oximetry monitoring is essential, so are the availability of emergency resuscitation equipment, temporary pacing, and cardiologist.

There is recent amassing data that patients with non-MRI-conditional devices may safely undergo non-thoracic MRI scanning at field strengths of up to 1.5 T if the device is appropriately programmed before the scanning.[7] The AHA and the FDA, however, do not recommend MRI in PM patients nor do any of the device manufacturers' instructions, except for new MRI-conditional devices.[9] As a consequence, there remains a multitude of clinical, ethical, legal, and overall risk/benefit considerations associated with MRI scanning of these patients.

The new-generation MRI-conditional or MRI-compatible pacing systems are considered safe for use in the MRI environment when used according to manufacturer's instructions, with a special MRI-compatible lead system. These newer PMs, carrying limited ferromagnetic material, are safer, but limitations even with these devices should be noted as clinical trials so far have been limited to a static magnetic field of strength 1.5 T and 3 T and have mostly excluded imaging of the chest.

We encourage the readers to exercise increased awareness, perform detailed risk-benefit assessments, and apply risk mitigation strategies for patients with implantable devices who may be exposed to hostile electromagnetic hospital environments.

Disclosures

The authors report no relevant disclosures.

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