Case Report

Electromagnetic interference in a cardiac pacemaker during cauterization with the coagulating, not cutting mode

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Abstract

Electromagnetic interference in pacemakers has almost always been reported in association with the cutting mode of monopolar electrocautery and rarely in association with the coagulation mode. We report a case of electrocautery-induced electromagnetic interference with a DDDR pacemaker (dual-chamber paced, dual-chamber sensed, dual response to sensing, and rate modulated) in the coagulating and not cutting mode during a spine procedure. We also discuss the factors affecting intraoperative electromagnetic interference. A 74-year-old man experienced intraoperative electromagnetic interference that resulted in asystole caused by surgical electrocautery in the coagulation mode while the electrodispersive pad was placed at different locations and distances from the operating site (This electromagnetic interference did not occur during the use of the cutting mode). However, because of careful management, the outcome was favorable. Clinicians should be aware that the coagulation mode of electrocautery can cause electromagnetic interference and hemodynamic instability. Heightened vigilance and preparedness can ensure a favorable outcome.

Key words: Asystole, electromagnetic interference, intraoperative arrhythmia, pacemaker

Introduction

More than 150,000 adults and children in the United States undergo cardiac pacemaker placement each year.[1] Pacemakers are liable to partial or total malfunction, which might be temporary or permanent.[2] Electromagnetic interference (EMI) is one cause of malfunction, which can occur with the use of surgical electrocautery. EMI can alter pacemaker function as a result of electromagnetic energy, either radiated or conducted.[3] Moreover, EMI can cause serious intraoperative hemodynamic sequelae. This type of interference has almost always been reported in association with the cutting mode of monopolar electrocautery[4-6] but rarely in association with the coagulation mode. We report a case of EMI resulting in asystole caused by monopolar surgical electrocautery in the coagulation mode, which did not occur during the use of the cutting mode.

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Case Report

A 97 kg, 160 cm, 74-year-old male presented with a T8-T9 pathological compression fracture. He was scheduled to undergo a T8-T9 decompression laminectomy and a T6-T10 posterior fusion. Surgery was considered an absolute necessity in the face of this patient's midthoracic spinal cord compression. His past medical history was significant for hypertension and coronary artery disease, which had been treated with coronary artery bypass grafting. The patient had a permanent bipolar DDDR (dual-chamber paced, dual-chamber sensed, dual response to sensing, and rate modulated) pacemaker (Medtronic model # 4568/4092; Medtronic, Shoreview, MN) implanted in the left subclavian region, two years prior to the scheduled surgery, for symptomatic sinus bradycardia. Preoperative interrogation of the pacemaker revealed that

the battery, capture, and sensing functions were functioning appropriately. Prior to surgery, the rate response was turned off, converting the pacemaker into DDD mode.

General anesthesia was induced with midazolam, fentanyl, propofol, and rocuronium followed by tracheal intubation. Hemodynamic monitoring included arterial and central venous catheters. Surgery commenced after the patient was placed in the prone position. Anesthesia was maintained with isoflurane in a mixture of nitrous oxide and oxygen and a sufentanil infusion. Settings for both cutting and coagulation modes in the electrocautery (Force FX™ Electrosurgical Generator, Valleylab, Boulder, CO) were well within the manufacturer's recommended guidelines of 30 W. Arterial line systolic blood pressures (SBP) prior to initial pacemaker malfunction were in the range of 110–120 mmHg, with mean arterial blood pressure range of 70–80 mmHg [Figure 1]. The surgical incision was initiated with a sharp scalpel, after which cautery was used to coagulate small vessels and to extend the dissection through the subcutaneous tissue to the deep fascia. Upon using the coagulation mode of electrocautery, we observed an abrupt onset of bradycardia, with a drop in mean and systolic pressures followed by a brief asystolic period and a loss of arterial line tracing [Figure 2]. However, almost immediately after cessation of electrocautery, the normal arterial line tracing and electrokardiograph reappeared. The position of the return electrode was transferred from the right arm (which was in closer proximity to the surgical site and on the opposite side of the pacemaker) to the right upper leg. Once, with reapplication of the coagulation mode of electrocautery, similar drop in SBP with a period of bradycardia were observed, and a brief asystolic period followed by immediate spontaneous recovery to normal sinus rhythm and base line blood pressure. Inasmuch as earlier use of electrocautery in the cutting mode did not induce hemodynamically significant EMI [Figure 3], we decided to proceed with the planned surgery utilizing electrocautery with short bursts in the cutting mode. The remainder of the surgery was accomplished uneventfully, without any hemodynamic disturbances. Postoperative interrogation of the pacemaker showed no malfunction as a result of the observed EMI. The patient recovered uneventfully from surgery.

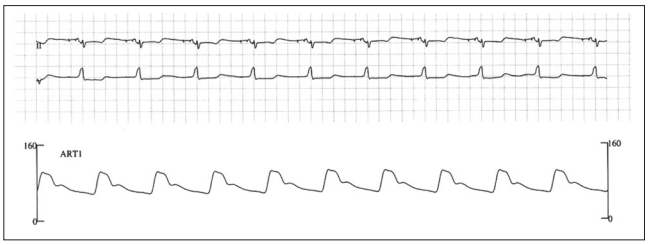

Figure 1: Patient's electrocardiogram (EKG) tracing and arterial line wave form showing normal sinus rhythm with good perfusion prior to the application of electrocautery

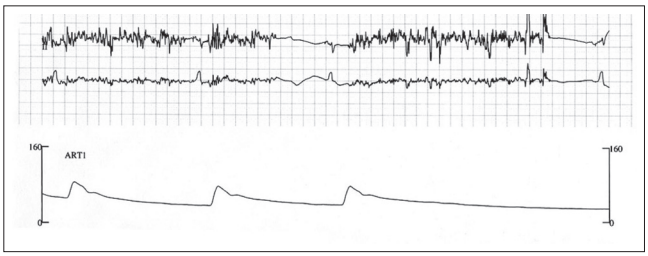

Figure 2: Patient's electrocardiogram (EKG) tracing and arterial line wave form showing bradycardia evolving to asystole as a result of EMI during electrocauterization with coagulation mode while the electrodispersive pad was on the opposite shoulder of the pacemaker. A similar response was seen when the electrodispersive pad was moved to the contralateral thigh

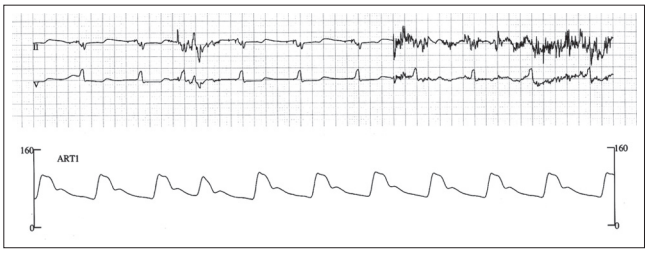

Figure 3: Patient's electrocardiogram (EKG) tracing and arterial line wave form showing minimal EMI not affecting arterial line tracing during electrocauterization with cutting mode while the electrodispersive pad was on the contralateral thigh

Discussion

Almost all the previously reported cases of EMI occurred with the cutting mode[4–6] and not with the coagulation mode of surgical electrocautery in patients with cardiac pacemakers. These reports could be explained by the fact that the cutting mode is generally utilized in settings of higher power than those in the coagulation mode; and because of its function, it is applied for a longer period of time for tissue cutting compared to a very brief burst of energy to coagulate a bleeding vessel. The findings in our case showed the opposite, being more in accord with that reported by Rozner and colleagues.[7]

The occurrence, nature, and intensity of EMI depend on various factors, many of which were operative in our case. Monopolar electrocautery exhibits a greater degree of interference because the current must dissipate through the body and return to the generator via the return electrode (electrodispersive pad [EDP] falsely known as the grounding pad). To prevent the current from intersecting the pacemaker, the EDP should be carefully placed. The closer the return electrode to the site of surgery, the less likely that EMI will occur, since electromagnetic energy will be contained in a smaller area.[8] The EDP in this case was originally placed at the right upper arm, very close to the surgical site but opposite to the pacemaker; however, EMI still occurred. Furthermore, repositioning the EDP to the right lower extremity (farther

away from the pacemaker and wires), also did not prevent EMI, most likely because the site of energy generation was too close to the pacemaker. Another explanation could be that the pacemaker wires acted as an antenna to the box of the pacemaker.

The cutting and coagulation modes are both subsets of monopolar cautery. The cutting mode generally yields a higher energy output than the coagulating mode. For example, in the electrosurgical generator that we used in this case, Force FX™ (Valleylab, Boulder, CO), the maximum power for monopolar cutting is 300 W but for monopolar coagulation is 120 W. Surgical procedures carried out in proximity to the neural elements commonly use low (30 W) bipolar electrocautery. However, during exposure of the spinal column, as in our case, surgeons typically use medium power monopolar cutting at 30–100 W or coagulation at 30–70 W. These wattages contrast with those in TURP, in which high power cutting greater than 100 W, and coagulation greater than 70 W, are used.[8] Furthermore, there is individual variation among surgeons, in that for the same surgical procedure, one surgeon might prefer coagulation over cutting. In our case, the power settings for both the cutting and coagulation modes were low (30 W). Typically, the greater the power settings, and the longer the constant application of electrocautery,[9] the more likely EMI will occur. The power settings for both modes for our patient were well within recommendations of 30 W; however, this did not prevent EMI during the use of the coagulation mode. It is recommended that the cautery current should be applied for no longer than 1 second at a time, with approximately 10 second between applications; for this will allow the pacemaker enough time to maintain cardiac output.[3] Nonetheless, electrocautery during spine surgery cases is sometimes more prolonged than a single second blast in order to coagulate larger caliber vessels. In this case, the time in between uses was greater than the 10 seconds guideline, as we were attempting to use electrocautery only when bleeding could not be managed with pressure and packing.

Dual-chamber pacemakers, such as the one our patient possessed, are known to be more susceptible to EMI than are single-chamber pacemakers.[3] It is commonly understood that EMI is avoidable if the electrocautery current pathway lies perpendicular to the pacemaker's wires. Ideally, this should take place through positioning the EDP; however, this might pose a challenge in a patient with dual lead systems as in dual-chamber pacemakers.[3] Pacemakers with bipolar leads are more resistant to EMI than those with unipolar leads. However, our patient had EMI despite the fact that his pacemaker was bipolar.

Despite following all safety precautions, we experienced EMI along with hemodynamic consequences with the coagulation mode, not the cutting mode. A likely explanation is that the pulsing mode of interference (coagulation mode) might have had a greater effect on the pulse generator than did the continuous source (cutting mode). Also, the noise spectrum of the coagulation mode (high current amplitude near 10,000 V) is broader than that of the cutting mode (less than 2,000 V) and thus it could fall within the frequencies detected by the pulse generator and cause interference.[7] It should be noted that even though pulses may occur when electrosurgical equipment is repeatedly turned on and off, and may also occur when the active electrode is removed and reapplied while the electrocautery is turned on, these occurrences did not have sequential effects in our case. Thus, the noise spectrum theory seems more compelling than the pulsing mode of interference theory.

We considered reprogramming the pacemaker to DOO (DOO = asynchronous AV sequential pacing); however, that was unnecessary since we were able to achieve hemodynamic stability while utilizing the cutting mode. In addition, a DOO mode exposes the patient to the risk of developing ventricular fibrillation if the paced R wave interrupts the T wave of the previous sinus beat.[5] On the other hand, we have considered coagulation alternatives including sharp dissection with frequent gauze packing and natural coagulation, but this often results in excessive hemorrhage in the highly vascular bed of the paraspinous muscles and can greatly extend the length of surgery. Other instruments, applicable in other kinds of surgery, might be suggested as alternatives to unipolar cautery, but none are useful in this kind of case. Laser coagulation is not feasible as a cutting tool or for coagulation of large intramuscular vessels in such an extensive incision. Likewise, the harmonic scalpel often applied in intraabdominal procedures is intended to clamp and cut thin bands of tissue and is not suitable for cutting heavy muscle or coagulating tissues adjacent to bone.

Conclusion

Clinicians should be aware that the coagulation mode of electrocautery can cause EMI as well as hemodynamic instability. Regrettably merely following the guidelines for intraoperative handling of implanted cardiac pacemakers does not necessarily eliminate the risk of EMI. Rather, a high degree of vigilance and preparedness are the most important factors for ensuring a favorable outcome.

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