

Rapid Ventricular Pacing due to Electrocautery:

A Case Report and Review

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Abstract

It is well known that the use of electrocautery during surgery can interfere with the functioning of pacemakers. The most common problem is that the electrocautery is interpreted by the pacemaker as cardiac electrical activity, which inhibits the pacemaker from firing, leading to bradycardia. The use of electrocautery in a site remote from the pacemaker generator normally does not cause interference. It is also very unusual to develop a tachycardic response to the electrocautery. We report a case of electrocautery causing rapid pacing during transurethral resection of bladder polyps. The possible causes of inappropriate rapid pacing are reviewed.

Key Words: Pacemakers, tachycardia, electrocautery, electromagnetic interference.

Introduction

ALMOST ALL ELECTRONIC DEVICES can be affected by external electromagnetic interference (EMI). Attempts to lessen the effects of EMI upon pacemakers have included metallic shielding to protect against high frequency EMI; noise sampling periods, which convert pacemakers to a fixed rate if continuing EMI is sensed; and bipolar leads, which have improved the rejection of noise over the original unipolar lead (1). Yet these improvements in pacemaker design, helpful as they may be, must be continuously reevaluated (2). This is evidenced by reports of mobile phones and cardiac monitors interfering with pacemaker functioning (3–5). This paper reports an inappropriate intraoperative rate response of a ventricular sensed and paced minute ventilation rate adaptive (VVIR) pacemaker to electrocauterization remote from the chest wall.

Case

An 83-year-old, 63 kg male presented for cystoscopic transurethral removal of bladder polyps. The pertinent medical history and preoperative testing included amyloid cardiomyopathy, chronic congestive heart failure, coronary artery bypass atrial fibrillation necessitating pacemaker placement, benign prostate hypertrophy, normal electrolytes, and a normal preoperative roentogram showing intact pacemaker leads. Preoperative evaluation indicated that the patient had a bipolar VVIR minute ventilation rate responsive Tempo™ VR, model 1102 pacemaker (Telectronic Pacing Systems, Englewood, CO) with a fixed rate of 60 beats per minute (bpm), a maximum rate of 100 bpm, a magnet rate of 100 bpm, complete and normal capture of the pacemaker with and without a magnet, and satisfactory sensing. The EKG showed a ventricular paced rhythm, at a rate of 60 bpm.

Intraoperatively, the patient was monitored with continuous electrocardiography, non-invasive blood pressure measurements, pulse oximetry, and capnography via nasal cannula. The capnogram was used to determine the respiratory rate. The patient's resting vital signs were stable at a paced heart rate of 60 bpm, blood pressure of 120/85 mm

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Hg with a mean of 98 mm Hg, and oxygen saturation >99% with a fractional concentration of inspired oxygen (FiO₂) of 0.26. Anesthesia consisted of a spinal anesthetic at the 10th thoracic vertebra.

Throughout surgery there were ECG changes ranging from a paced rate of 60 bpm when the electrocautery was not in use to a paced rate of 100 bpm when it was in use (Figs. 1 and 2). The patient's vital signs remained stable at both paced rates, with a mean arterial pressure of 70–80 mm Hg and an unchanged respiratory rate. The patient did not complain of angina or dyspnea during the surgery. In an attempt to attenuate the EMI from the electrocautery, the dispersion pad was placed on the right lower extremity and bipolar electrocautery was used in short bursts. Despite these recommended maneuvers, the electrocautery continued to cause inappropriate pacemaker rate response. Nonetheless, the surgery was completed without complication and the postoperative course was uneventful.

Discussion

To the best of our knowledge, this is only the second case reported in which a pacemaker responded to electrocautery with tachycardia, during transurethral resection surgery. Given that postoperative evaluation of the pacemaker by a compatible programmer did not detect a malfunction, interpretation of intraoperative events focused upon inappropriate rate response to EMI by a normal functioning pacemaker. Normally, titanium casing, filter circuitry, and programming shield pacemakers from the effects of EMI. But these shields are not infallible (6–9). Inappropriate pacing has been reported when the pacemaker has been placed in the active-programmable mode by a magnet, when an R wave is sensed in the noise response period, and when there is an incorrectly sensed increase in metabolic demand. Each of these reported causes of inappropriate pacing will be explored as possible explanations of the presented case.



Fig. 1. Rhythm strip of ECG, when electrocautery was not in use.



Fig. 2. Rhythm strip of ECG, while electrocautery was in use.

Manual programming is a normal function of modern pacemakers. It allows individualization of the pacemaker to the patient's metabolic needs. A programming wand, equipped with a magnet for pacemaker models that require it, places the pacemaker receiver into the active-programmable position. In this position, the pacemaker is programmable. The magnet, commonly used to place pacemakers in the fixed rate when EMI causes inappropriate inhibition of the pacemaker, paradoxically facilitates random reprogramming by EMI in pacemakers, which require it for programming. This is one way in which an inappropriate rate response may occur in a well-functioning pacemaker. An extensive list of pacemakers susceptible to random reprogramming in the presence of a magnet can be found in Domino and Smith. (6). The Telectronic 1102 model is not such a pacemaker.

Another possible explanation for the described intraoperative events in this case is the sensing of an R wave during the noise sampling period (NSP). The noise sampling period is best understood as it relates to the other components of the pacemaker timing-cycle. The timing-cycle is the time interval between a sensed beat and a paced beat or two paced beats. The timing-cycle is composed of three periods: the ventricular resettable refractory period (VRRP), the NSP, and the alert period. An R wave sensed in the VRRP will have no effect upon the timing-cycle because it is in the refractory period. An R wave sensed in the NSP will extend the NSP by a preset refractory period (RF). If an R wave is sensed in the alert period, the current timing-cycle will end, and a new one will be initiated. This design has been included in most modern pacemakers. Its purpose is to prevent EMI from causing prolonged pacemaker inhibition. The Telectronic 1102 timing-cycle is one of the simpler designs, in that the NSP is equal to the VRRP.

A report by Falkoff et al. described a predictable tachycardia in a paced patient with underlying atrial fibrillation (7). In this report, reproducible intermittent reversion to fixed-rate pacing during atrial fibrillation was recorded. During episodes of atrial fibrillation, an initial sensed beat established the VRRP; a second beat occurred in the NSP, causing reversion to the fixed rate; a third beat occurred in the alert period but was unsensed, because the pacemaker was in the fixed rate mode; and finally, a paced beat occurred in concordance with the fixed rate timing cycle. Although the patient in our case had an underlying atrial fibrillation, there were no observed conducted beats. If EMI generated by the electrocautery had mimicked an R wave or entire QRS complex, pacemaker inhibition rather than upper rate pacing at 100 bpm

would have resulted; some observable conformational difference between the paced and EMI-generated QRS complexes would be expected; and the pulse-oximeter would have been interrupted by episodic pulseless electrical activity during electrocautery use. None of these occurred, suggesting a different mechanism.

The most likely explanation of the inappropriate rate response observed in our case involves the mechanism by which rate adaptive pacemakers link changes in metabolic demand to changes in pacing rate. Rate adaptive pacemakers attempt to match cardiac output to oxygen demand. This is accomplished by directly changing the pacing rate with the metabolic rate. In minute ventilation-sensing pacemakers, pacemaker leads detect changes in thoracic impedance. If the change is of a certain amplitude, the respiratory sensor of the pacemaker is triggered. The number of times that the respiratory sensor is triggered in a set time interval becomes the respiratory rate. Each change in respiratory rate results in a preset change in paced rate. The direct relationship between a change in respiratory rate and paced rate is the respiratory factor. In this case, the electrocautery probably caused a change in thoracic impedance, which led to a paced rate. The interpretation by a pacemaker of a change in thoracic impedance of respiration has been reported to cause inappropriate rate response. Reports have pointed to cardiothoracic surgery or vigorous upper limb movement (8, 9). Van Hemel et al. reported a serious complication in which an electrocautery was used to open the chest (9). Tachycardia of 150 bpm was observed during each use of the electrocautery. External heart massage was required until normal pacemaker function resumed. Upon opening the pericardium and using the electrocautery again, the surgeon noted a recurrence of the tachycardia. The tachycardia was refractory to internal defibrillation. Fortunately, the surgical and anesthesia teams were prepared for extracorporeal circulation. The observed wide complex tachycardia may not have been ventricular fibrillation, but rather pacemaker-generated QRS complexes. If so, the upper rate pacing would have been a normally response to the change in thoracic impedance generated by the electrocautery. Subsequent pacemaker evaluation revealed a normally functioning pacemaker.

In one previous report, electrocautery during transurethral resection of prostate surgery resulted in a paced rate of 130 bpm (10). This case report also involved a Telectronic (Telectronic Pacing Systems, Englewood, CO) VVIR pacemaker. The authors proposed that the electrocautery caused a change in thoracic impedance, which resulted in an increase in the

pacemaker rate. We had a similar experience, and agree with their conclusion and their recommendations that preoperatively either these pacemakers should be reprogrammed out of the rate-responsive mode or else that the maximum pacing rate should be set to a rate that can be tolerated by the patient.

There are several maneuvers that can be done when intraoperative EMI interferes with pacemaker function: increasing the distance between the pacemaker generator and patient return electrode, using bipolar electrocautery in short random bursts, and resetting the pacemaker to ventricular paced and sensed mode with inhibition (VVI) are a few. The best approach is to first understand pacemaker function. Atlee and Bernstein have presented a protocol for management of the paced patient presenting for non-cardiac surgery (11). Briefly, the protocol suggests that the patient be seen by the pacemaker clinic prior to surgery, with a plan to reprogram the pacemaker, depending on the site of surgery and the equipment to be used, such as electrocautery. The response to a magnet should be determined. If the patient is pacemaker dependent, the pacemaker should be placed in the triggered or asynchronous mode. In the event of hemodynamic instability, the anesthesiologist should be ready to place a magnet over the pacemaker generator, if appropriate, or establish external pacing. The location of the generator should be known, so that defibrillation pads are positioned at least 10 cm away from the generator to avoid pacemaker damage. And finally, if the pacemaker is to be interrogated in the postoperative care unit, arrangements should be made pre- or intra-operatively.

In our case, placing a magnet over the generator would have switched the pacemaker to a fixed rate, and eliminated the rate responsive feature. Since the use of electrocautery was limited to brief applications, and the patient tolerated the faster rate, this was not done. Conversion to a fixed rate has the potential for R or T phenomenon, causing arrhythmias, competition of the pacemaker with the patient's native heartbeat, and phantom reprogramming. In retrospect, the best approach would have been to reprogram the pacemaker preoperatively, to disable the rate responsive feature. However, it was not anticipated that there would be electromagnetic interference.

A practice advisory for the perioperative management of patients with cardiac rhythm management devices was recently authored by an American Society of Anesthesiologists (ASA) Task Force (12). The guidelines include keeping the electrical field of the cautery away from the pacemaker generator, using short bursts of electrocautery, and using bipolar electrocautery if possible.

If electromagnetic interference is anticipated, the task force recommended that it be determined preoperatively whether the pacemaker should be reprogrammed to an asynchronous mode, or the rate adaptive functions should be suspended. According to the report, the ASA members were equivocal on both of these possible courses of action.

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