Pacemaker System Malfunction Resulting from External Electrical Cardioversion: A Case Report

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In May 2005 a 68-year-old woman received a VDD pacemaker implantation in the right pectoral region at our hospital for the treatment of complete atrioventricular block. In July 2008, she was diagnosed with dilated cardiomyopathy based on histological testing. In November 2008, she developed syncope due to ventricular tachycardia while at another hospital. She underwent external electrical cardioversion with an anterior-lateral paddle position using a single shock of 100 J. This shock led to severe bradycardia resulting in a transfer to our hospital. The physician who provided the shock could not have been aware that the patient had an implanted pacemaker. The skin above the pulse generator was burned. The electrocardiogram showed no pacing spikes or ventricular escape rhythm. Investigation of the pacemaker 3 hours after cardioversion revealed reprogramming of the device and a marked rise in the lead impedance (>3,000 ohm). Removal of the generator and implantation of a biventricular cardioverter defibrillator were required. The emergency situation, the small size of the generator, the small incision made using the buried suture method, and the patient’s obesity all probably contributed to the physician’s not noticing the implanted pacemaker. It is important to increase awareness of the severe consequences that may follow if the physician administering external defibrillation does not know about the patient’s implanted pacemaker.

Key words: External cardioversion, Pacemaker malfunction, Ventricular tachycardia

Introduction

Implantable cardiac rhythm management devices have become more widely used in patients with not only bradycardia, but also life threatening tachycardia and severe heart failure. Therefore it is common to encounter a patient with implanted devices needing external electrical cardioversion to terminate life-threatening tachycardia. A recent study examined the safety and efficacy of external electrical cardioversion in patients with state-of-the-art rhythm-pacing devices. Here, we report lead failure and pacemaker malfunction following external defibrillation in a patient with an implanted single-lead VDD pacemaker, in which the sternal paddle was placed directly over the pulse generator.
Case report

In May 2005, a 68-year-old obese woman received a single-lead VDD pacemaker at our hospital for the treatment of complete atrioventricular block. The pulse generator (ELA Medical Symphony DR model 2550) was implanted in the right pectoral region using a buried suture method to close the incision. The ventricular pacing electrode configuration was bipolar. In July 2008, the patient was admitted to our hospital with congestive heart failure. Cardiac catheterization showed no coronary stenosis and markedly decreased left ventricular ejection fraction of 25.7%. The patient was diagnosed with dilated cardiomyopathy based on histology of biopsy samples from the left ventricular myocardium. Optimal medication including a beta blocker and angiotensin receptor blocker improved the heart failure. In November 2008, she developed syncope while at another hospital. The electrocardiogram revealed that this symptom was caused by ventricular tachycardia. Intravenous lidocaine could not terminate the tachycardia, but resulted in hemodynamic collapse. External electrical cardioversion was an emergency procedure with an anterior-lateral paddle position using a single shock of 100 J. The ventricular tachycardia was terminated; however, severe bradycardia followed which was associated with sustained cardiogenic shock. Therefore, the patient was transferred to our hospital.

Inspection of the patient’s chest revealed a skin burn overlying the pulse generator. A blood test revealed mild anemia but no evidence of myocardial damage or any electrolyte abnormalities.

One month before the third admission, testing of the pacemaker had shown normal sensing and pacing thresholds, and pacing impedance in the normal range. However, investigation of the pacemaker 3 hours after cardioversion revealed that the device was in standby mode, with settings of: VVI mode, basic rate of 70 beats per minute, pacing amplitude of 5.0 V with pulse width of 0.5 ms, ventricular sensitivity of 2.0 mV, and unipolar pacing configuration. After re-initialization of the pacemaker, measurement of the pacemaker output revealed a marked rise in the lead impedance, and no paced response could be evoked despite increase to the maximum pacing amplitude (Figure 1, 2a). A chest X-ray revealed cardiomegaly and mild pulmonary congestion but did not show the lead fracture (Figure 2b). Percutaneous intracardiac pacing inserted through right internal jugular vein and continuous injection of low-dose dopamine dramatically stabilized the hemodynamic state. After the patient had recovered from the serious hazard without any neurological abnormalities, the pulse generator was removed and a biventricular implantable cardioverter defibrillator was implanted successfully in the left pectoral region. (Figure 3)

Discussion

Safety of external defibrillation on implantable devices

Since the late 1960s, a protective mechanism, the Zener diode, has been incorporated into pacemakers and defibrillators to insulate the electronic circuit from damage due to electrical shocks. Nevertheless, there have been numerous case reports of pacemaker and/or lead dysfunctions caused by external electrical cardioversion. Gould et al. reported the case of an 81-year-old female with sick sinus syndrome who developed ventricular fibrillation and was successfully defibrillated. In that case, as in the case reported here, the defibrillation paddle was placed on the pulse generator, which led to a complete loss of function of the pulse generator.

To the best of our knowledge, only two studies have analyzed the safety of external electrical cardioversion in patients with implanted cardiac devices. The more recent report included 44 patients with pacemakers, implantable cardioverter-defibrillators, or cardiac resynchronization systems who underwent external electrical defibrillation for atrial fibrillation. Fifteen devices were implanted in the right pectoral region, and 8 leads were unipolar. There was no incidence of device or lead dysfunction following electrical cardioversion. In this study, however, a strict anterior-posterior paddle position was used to protect the device and lead system. Moreover, no case involved emergency electrical defibrillation. The older of the two studies included 36 patients with unipolar pacemakers implanted in the right pectoral region who received external electrical cardioversion with an anterior-lateral paddle position. This study reported an incidence of transient (up to 30 min) loss of capture in 50% of patients, sensing failure in 41% of patients, and three cases of pacemaker malfunction of which two required generator replacement. While most of the indications for cardioversion were atrial fibrillation or flutter, this study included one case of emergency direct current (DC) shock for ventricular fibrillation. In the patient with ventricular fibrillation, several 360 J shocks were required for VF recurrence, which resulted only in persistent elevation of the pacing threshold. In this study, however, the paddle had
been positioned as far as possible away from the pacemaker before shock delivery.

Pitfalls in the clinical setting

In our case, an emergency DC shock was delivered with the sternal paddle positioned directly over the pulse generator. The physician who provided the primary care, including the DC shock, could not have noticed that the patient had an implanted pacemaker. It seems difficult for emergency care providers to recognize implanted devices in patients with syncope due to ventricular tachycardia, or to obtain the patient’s entire medical history. In addition, in this case, the small pulse generator, the small incision done by the buried suture method, and the patient’s obesity (BMI of approximately 25) probably prevented the physician from noticing the implanted pacemaker.

Possible causes of the pacemaker system malfunction

Interestingly, after the external electrical cardioversion in this case, the lead impedance was elevated in such a measure as to indicate complete lead disconnection, whereas the chest radiograph did not provide evidence of lead fracture. In some reports, transient or persistent elevation in the pacing threshold has been observed, and this elevation was suggested to be caused by current-induced tissue damage at the electrode-endomyocardial interface.3,5) However, the degree of elevation in lead impedance observed in this case has never been reported, nor has there been any report of lead fracture associated with cardiopulmonary resuscitation. The manufacturer’s instructions do not specify the upper limit of defibrillation energy which the pulse generator could resist, but they do indicate that

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**Figure 1** Measurement of the pacemaker after re-initialization.
Patient’s data registered at the time of implantation could not be read, and the lead impedance was elevated to more than 3,000 ohm (box).
shock paddles should be positioned as far as possible away from the generator. The single-lead VDD pacing system and the short distance between the paddle position and the entire pacemaker system could have magnified the tissue damage. The remaining possibility was that the defibrillation energy directly damaged the Zener diode or the electrical circuit of the pulse generator.8) We did not perform lead measurement and analysis of the pulse generator. Therefore we could not identify the precise cause of the marked rise in lead impedance.

We selected a left-sided approach when we performed the CRT-D implantation. Even though the previously implanted VDD leads were intact, we favored the left side since the defibrillation threshold would be higher in right-sided implantation than in left-sided implantation,9) and there was a possibility of a need for atrial pacing when uptitrating beta blocker dose.

Figure 2
a) The 12-lead electrocardiogram on admission showed a wide QRS rhythm of 48 beats/min without any pacing spikes despite the programmed ventricular pacing rate. b) The chest radiogram after insertion of the pacing lead. Careful observation could not identify the lead fracture.

Figure 3 Chest radiogram a) and 12-lead electrocardiogram b) after biventricular implantable cardioverter defibrillator implantation. a) The active fixation coil lead was placed at the right ventricular septum. b) A regular atrioventricular sequential pacing rhythm of 50 beats/min. The QRS width was 167 ms.
**Paddle position**

The current (2006) ACC/AHA/ESC guidelines for the management of patients with atrial fibrillation recommend that the paddle for external electrical cardioversion be positioned as remotely as possible, preferably in the anterior-posterior configuration.\textsuperscript{10} Unlike atrial fibrillation, the feasibility of external cardioversion with an anterior-posterior paddle position for ventricular fibrillation/tachycardia remains unknown.\textsuperscript{11} The AHA 2005 guidelines for cardiopulmonary resuscitation do not mention the anterior-posterior paddle position, but recommend lateral (biaxillary) position and posterior-apical position in addition to conventional anterior-lateral position.\textsuperscript{12} Although the lateral (biaxillary) position and the posterior-apical position seem to be somewhat safer for the implanted devices than the anterior-lateral position, these positions have not been widely applied, and the posterior-apical position is apparently not practical without the use of an adhesive pad, since interruptions in chest compressions should be minimized.

It should be a required design consideration that the pacemaker and pacing lead be made completely resistant to defibrillation. Reducing the problem by better education of primary care providers may be necessary but impractical. Nevertheless, we must increase the awareness that severe hazards are possible when external electrical cardioversion is required in patients with implanted cardiac devices.

**References**


