

CASE REPORTS

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Rate-adaptive Cardiac Pacing: Implications of Environmental Noise during Craniotomy

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IT has recently been estimated that approximately 1 million Americans have permanent implantable cardiac pacemakers. Of these, approximately 50-70% use rate-adaptive technology.^{1,2} We report a case in which a patient undergoing a suboccipital craniotomy experienced vibration-mediated malfunction of a rate-adaptive cardiac pacemaker.

This Case Report is accompanied by a commentary from the manufacturer. See Correspondence, page 1261.

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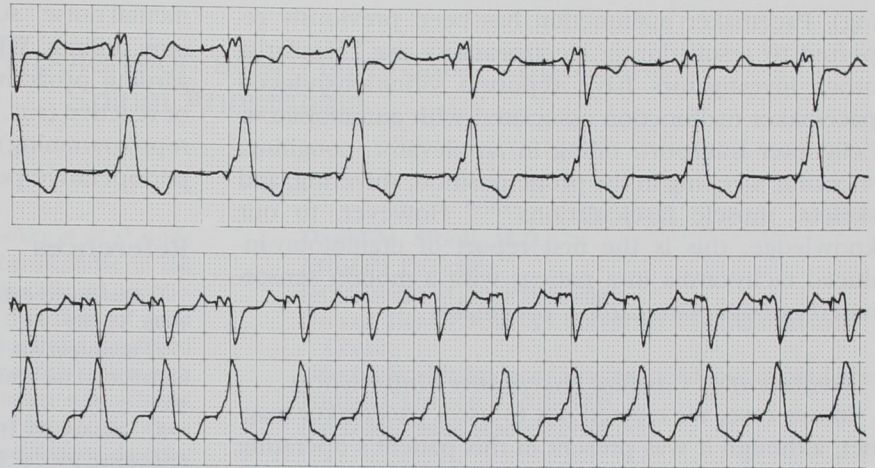
Case Report

A 63-kg, 70-yr-old man with glossopharyngeal neuralgia presented for left suboccipital craniotomy with section of the left glossopharyngeal nerve and superior fibers of the vagus nerve. His medical history was remarkable for a third-degree atrioventricular (AV) heart block, which was treated with a permanent implantable dual-chamber rate-adaptive (DDDR) cardiac pacemaker (Trilogy[®], Pacesetter, Sylmar, CA, model 2350). Eight months before surgery, the pacemaker was functioning normally with lower and upper rate limits of 60 and 120 beat/min, respectively. He denied having other cardiac diseases, cardiac symptoms with exercise, or problems related to his pacemaker. Preoperative medications included carbamazepine and baclofen (drugs being used for symptomatic therapy of his glossopharyngeal neuralgia) and atenolol. Pertinent preoperative laboratory values were within normal limits. Preoperative electrocardiogram (ECG) documented AV sequential or dual-chamber pacing at a rate of 77 beat/min. A chest radiograph demonstrated appropriate placement of pacemaker leads in the right atrium and ventricle, and the pulse generator was located in the left prepectoral region. A cardiology specialist was consulted and recommended placing the electrocautery grounding pad on the right thigh during surgery.

General anesthesia was induced with intravenous thiopental, fentanyl, and vecuronium. The trachea was intubated, and anesthesia was maintained with isoflurane, nitrous oxide, fentanyl, and vecuronium. A right radial arterial catheter and 18-gauge lumbar malleable needle (for cerebrospinal fluid drainage) were placed. Anesthesia proceeded uneventfully, the patient remained in the supine position throughout surgery, and an electrocautery grounding pad was placed

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Fig. 1. Electrocardiogram leads II and V₅ before (above) and during (below) craniotomy drilling of the left retromastoid region. Pacemaker spikes were noted to proceed each QRS complex. ST segment changes were not noted during episodes of pacemaker-induced tachycardia.



on the right thigh. A pacemaker magnet was available in the operating room if needed to convert the pacemaker to a fixed-rate, asynchronous pacing mode.

Shortly after incision, the heart rate periodically increased to 120 beat/min during unipolar electrocautery (Valleylab, Boulder, CO, model E2516H) use, but rapidly returned to approximately 60–70 beat/min with the cessation of electrocautery. The patient's blood pressure remained stable, and there were no ST segment changes during these episodes. Because the patient remained hemodynamically stable, we elected not to convert to asynchronous pacing.

Approximately 30 min later, the heart rate again increased to 120 beat/min and then spontaneously returned to baseline. Pacemaker artifacts were noted to proceed each QRS complex (fig. 1). Electrocautery was not in use at this time. To ensure an adequate depth of anesthesia, inhaled isoflurane was increased from 0.6% to 1.0%. After several similar episodes, it became apparent that the tachycardia was temporally related to craniotomy drilling in the retromastoid region. We consulted the pacemaker service to document if pacemaker function was normal and how best to manage the unexpected rate variations. Within 10 min, the pacemaker was reprogrammed to a DDD mode (*i.e.*, the rate-adaptive function was turned "off") with rate limits of 70 and 100 beat/min. The remainder of the case proceeded uneventfully.

After surgery, the patient was awakened and extubated in the operating room. After transport to the postanesthesia care unit, the pacemaker service reprogrammed his pacemaker to its preoperative parameters. The postoperative course was uncomplicated, and the patient was discharged to home on the third postoperative day.

Discussion

Rate-adaptive Cardiac Pacing

In patients with chronotropic incompetence (*i.e.*, patients who are unable to increase heart rate in response to increased metabolic demand), research has focused on modes of cardiac pacing that would closely mimic normal cardiac physiology.^{1,3–6} In the 1980s, rate-adap-

tive cardiac pacemakers were introduced into clinical practice.^{5,6} Rate-adaptive technology uses various biosensors that continually monitor atrial rate, respiratory rate, respiratory minute ventilation, central venous temperature, endocardial-evoked potential, preinjection interval, pH, oxygen saturation, QT interval length, right ventricular pressure, or patient movement.^{1,3–6} However, the majority of rate-adaptive pacemakers used today use piezoelectric- or accelerometer-based motion sensors.¹ Motion sensors are simple, responsive, compatible with any standard lead system, and compact.^{1,4} The sensors increase heart rate in response to perceived increases in metabolic demand.^{1,3–6} When used in conjunction with dual-chamber pacing, rate adaptive pacing significantly improves cardiac output, exercise tolerance, general sense of well being, and quality-of-life.^{3,7,8}

Comparison of Rate-adaptive Pacing to Normal Physiology

In patients with rate-adaptive pacing, no single sensor is ideal for all clinical scenarios.^{5,6} Thus, it is not surprising that attempts to artificially replicate normal chronotropic physiology will likely require more than one type of biosensor.^{5,6} The ideal, or "smart," sensor should (1) be sensitive (*i.e.*, respond to physiologic demand), (2) be specific (*i.e.*, nonresponsive to environmental or nonmetabolic noise), (3) have a rapid onset, and (4) initiate and maintain a rate that is proportional to the metabolic demand.^{1,3–6}

In our case, the patient's sensor was sensitive and rapid but lacked specificity (*i.e.*, the pulse generator inappropriately responded to "environmental noise" associated with electrocautery use or craniotomy drill-

ing). Pacemaker malfunction has been previously reported to result during electrocautery use.⁹ Similarly, other investigators have reported vibration-induced pacemaker malfunction associated with automobile or helicopter transport, riding in an elevator, coughing, sneezing, sleeping in the prone position, shivering, and skeletal muscle fasciculations.^{1,4,10} However, to our knowledge, this is the first report of craniotomy-induced tachycardia in a patient with a motion sensor-based rate-adaptive cardiac pacemaker.

Treatment of Cardiac Pacemaker Malfunction

In our case, we elected not to use a pacemaker magnet, although it was present in this patient's operating room, for three reasons: (1) the patient remained hemodynamically stable, (2) previous reports of unpredictable or "surprise" programs when pulse generators were indiscriminately exposed to magnetic fields,¹⁰ and (3) a cardiac pacemaker service that is typically less than 100 yards away from the neurosurgical corridor. In retrospect, it would have been prudent to prophylactically reprogram the patient's pacemaker to a DDD mode before surgery.

Conclusion

Dual-chamber rate-adaptive cardiac pacing is state-of-the-art technology that is commonly used to treat chronotropically challenged patients. In addition to electromagnetic-mediated pacemaker malfunction, rate-adaptive sensors may respond inappropriately to other "environ-

mental noise" such as vibration associated with craniotomy drilling. When in doubt, consult a cardiologist regarding proactive (e.g., prophylactic reprogramming) or reactive (e.g., magnet application or pulse generator reprogramming) management of pacemakers in the perioperative period.

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