PACEMAKER MALFUNCTION DUE TO MICROCURRENT INJECTION FROM A BIOIMPEDANCE NONINVASIVE CARDIAC OUTPUT MONITOR

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Aldrete JA, Brown C, Daily J, Buerke V. Pacemaker malfunction due to microcurrent injection from a bioimpedance noninvasive cardiac output monitor.

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INTRODUCTION

Noninvasive cardiac output monitors (NICOMs) may yield inaccurate measurements in patients with pacemakers. However, the information included with the pacemaker and the NICOM does not mention this possibility, nor does it describe the possibility that microcurrents injected into the thoracic wall by NICOM may accelerate the pacemaker's rate to the point of rendering it ineffective. Herein we describe a case of a sudden spike-rate acceleration of a pacemaker when a NICOM was connected to a patient's chest wall on two different occasions.

CASE HISTORY

An 82-year-old man with posttraumatic degenerative disk disease and spondylolisthesis of the cervical spine was scheduled to have a cervical epidural block. The patient had a history of arteriosclerotic heart disease and three years previously had undergone a coronary artery bypass graft (CABG) and the insertion of a multiprogrammable, minute ventilation, rate-responsive pulse generator with telemetry (Telectronic Pacing Systems, Englewood, CO). For 11 months, the pacemaker had functioned well.

In the treatment room, a monitor (Critikon, Dinamap Plus, Vital Signs), was attached to the patient, obtaining a control electrocardiograph (ECG) tracing (Fig 1), blood pressure (BP) = 134/60, heart rate (HR) = 78, Spo_2 = 96%. As part of a study on the hemodynamic effects of cervical epidural blocks, pre-gelled electrodes of a NICOM (BoMed NCOM3-R7, Irvine, CA) were connected as follows: two on the neck along the carotid artery, two on the lateral aspect of the chest at the level of the xyphoid bilaterally, and one bipolar electrode on the anterior chest wall (Fig 2) to receive the outgoing signals. The NICOM was activated at 8:24. After the completion of the data entry process, it was noted in the ECG that the heart rate suddenly increased to 120 beats/min, with blood pressure = 134/71, Spo_2 = 96% at 8:29. Monitoring was continued throughout. The patient was treated with nasal oxygen 3 L/min. At 8:40, lidocaine 50 mg intravenously was given and repeated 2 min later. The heart rate remained unchanged, even after 15 mg of esmolol HCP was given, at divided dosages, within the next 10 min. At 8:45, the vital signs were: blood pressure = 143/73,

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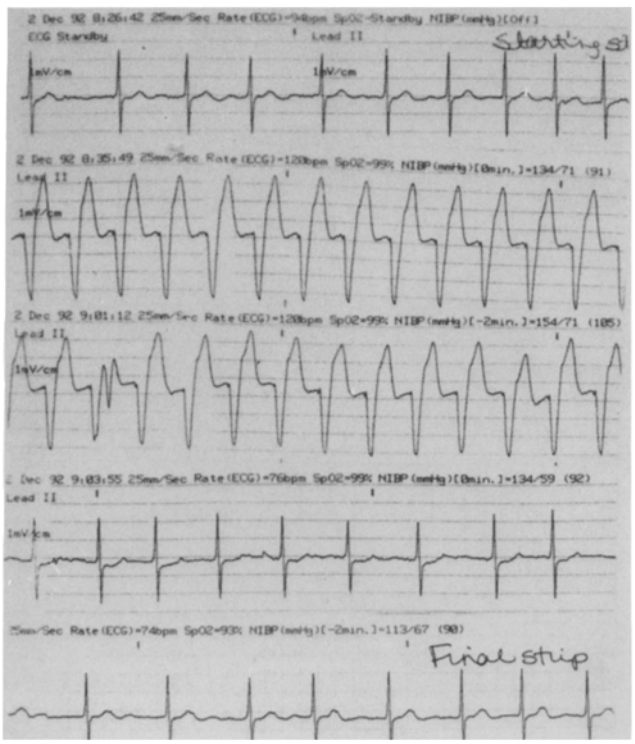

Fig 1. Patient's electrocardiograph tracing.

heart rate = 120 beats/min, Spo_2 = 98%. No significant change was noted. At 8:55, 0.25 mg of neostigmine was administered intravenously without obvious change. At 8:59 the NICOM was discontinued. By 9:03, the vital signs were: blood pressure = 154/71, heart rate = 76 beats/min, Spo_2 = 99%. *A posteriori,* a consulting cardiologist read the ECG tracings as a malfunctioning pacemaker with spikes predominating at a fixed rate of 120/min. Two hours later, the cardiologist failed to find any alteration of the pacemaker's function or any worsening of the patient's cardiovascular condition.

Two weeks later, as part of another study, the same NICOM was attached. The monitor obtained, as basic readings, blood pressure = 146/92, heart rate = 76 beats/min, Spo_2 = 92%, and a control tracing of a bipolar ECG. After placement of the electrodes, when the NICOM was turned on, the patient again exhibited a heart rate of 120 beats/min, blood pressure of 138/82, and Spo_2 94%. The ECG tracing was similar to that observed previously (consisting of pacemaker spikes). The onset of tachycardia coincided with the time when the NICOM was activated.

The predominance of spike action again suggested a pacemaker malfunction triggered by the NICOM. This time, the heart rate spontaneously returned to normal within 4 min of disconnecting the machine. Throughout this period, the patient remained alert and comfortable, with the remainder of the vital signs within normal limits.

DISCUSSION

The measurement of cardiac output by thoracic bioimpedance is based on the principle that a pulsatile change in resistance is generated as a 2.5-mA current is injected through surface gel electrodes. These electrodes are placed on the neck and lateral aspect of the thoracic wall (see Fig 2). Supposedly, the outer pairs of electrodes inject a 70-R Hz, 2.5-mA current, which is then perceived by the inner pairs of electrodes [1]. The resistance to the injected high-frequency current is dependent upon the fluid characteristics of the thoracic volume. These changes are then timed to the ventricular electrical depolarization and mechanical systole, thus establishing a quantitative correlation of blood flow changes and ultimately stroke volume, from which cardiac output and ejection fraction can be derived [2,3].

The limitations of this technology have been docu-

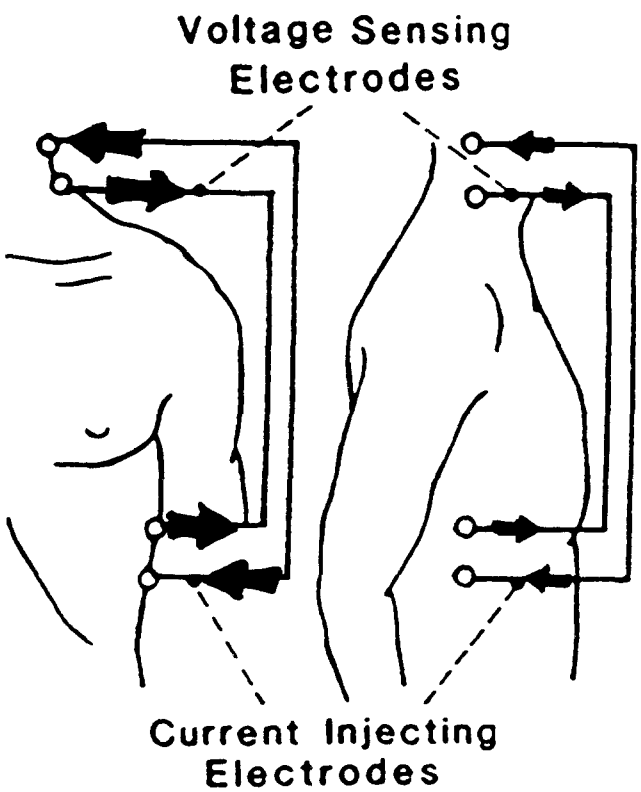

Fig 2. Pre-gelled electrodes were connected to the patient as follows: two on the neck along the carotid artery; two on the lateral aspect of the chest at the level of the xyphoid bilaterally; and one bipolar electrode on the anterior chest wall.

mented previously [1,4]. The measurements are considered less accurate in severe dysrrhythmias and tachycardia, in which pacemaker spikes result in incorrect determination of systolic time intervals, heart-rate determination, and, therefore, inaccurate cardiac output measurements [4,5]. Signal acquisition is impaired by electrode adherence defects and electrocautery [6]. The manufacturer's information included with the NICOM does not specifically warn about the possibility of its affecting pacemakers [2]. Although the alternate current delivered by bioimpedance monitors to measure thoracic resistance has been termed as "microcurrent," it appears that it is large enough to alter the performance of pacemakers. Though we failed to recognize the hazardous association of the two devices after the first incident, after the second occurrence we identified the link between them that prompted the report.

The "operator's manual" and "patient brochure" [7] of this type of pacemaker list only the following as possible dangers of interference:

1. all electrical appliances
2. microwave-operated devices
3. close proximity of electrical motors, generators, welders, and transmitters

Pacemaker manufacturers may wish to add NICOM-R7 to the list of potential hazards, while manufacturers of bioimpedance NICOMs need to list it as potentially dangerous to patients with cardiac pacemakers.

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