British Heart Journal, 1971, 33, 326–328.

Inhibition of demand pacemaker by leakage current from electrocardiographic recorder

J. Meibom and J. Damgaard Andersen

From the Department of Medicine B, University Hospital (Rigshospitalet), Copenhagen, Denmark

A 76-year-old man had his implanted demand pacemaker inhibited by an electrical leakage current caused by defective grounding in an electrocardiographic recorder power cable. Various measures can be undertaken in order to minimize this hazard, and these are discussed.

The implanted demand pacemaker offers considerable advantages compared to the fixed-rate types in decreasing the risk of competition between the heart's own electrical activity and the pacemaker if the patient should return to sinus rhythm (Sowton, 1967). Competition may lead to an irregular ventricular rate, palpitations, variations in systemic pressure, and the possibility of dangerous arrhythmias provoked by pacemaker stimuli falling in the vulnerable period of the cardiac cycle (Sowton, 1965). However, unlike the fixed-rate unit, the demand pacemaker is sensitive to interference from external electrical fields because it cannot discriminate between the heart's natural electrical activity and similar potentials generated near the sensing electrodes by electrical fields outside the body. This means that some electrical installations and equipment may present a hazard to the patient even if the risk of interference is very low in normal environments (Greatbatch, Chardack, and Gage, 1967).

The purpose of this paper is to detail a case of pacemaker malfunction caused by leakage current from a faulty electrocardiographic recorder, and to outline the measures which can be taken in order to prevent similar situations.

Case report

The patient, a 76-year-old man with a known history of progressive dyspnoea on exertion and frequent episodes with a feeling of dizziness and weakness during 6 years, was admitted to the Copenhagen University Hospital on 22 September 1968, because of more frequent attacks during some days. As he had prolonged periods of atrioventricular block with a heart rate of less than 20 beats a minute during an observation period in the intensive care unit, temporary demand pacing was performed. On 3 October a permanent pacemaker (Medtronic) was implanted and complete effective pacing was achieved. The pacemaker was connected via a catheter in the right jugular vein to a bipolar electrode placed in the apex of the right ventricle. After the implantation the patient was under observation in the coronary care unit; he was connected to the central patient monitoring system by a praecordial bipolar lead (2 exploring electrodes and a reference electrode connected to the pre-amplifier ground).

Two days after implanting the permanent pacemaker the patient fainted when he was connected to an electrocardiographic recorder for the purpose of recording a 12-lead diagnostic electrocardiogram. He was immediately disconnected and recovered in a few minutes. Since the period of asystole (as observed on a copy of the continuously recording tape, Fig. 1) seemed to be associated with the wiring up of the patient to the recorder, a careful examination of the electrical set-up and of the sensitivity of the pacemaker to external electrical influences was carried out. The patient has been followed for a year after discharge and he has not reported similar episodes during this period.

Discussion

The wiring up of the patient to the electrocardiographic recorder (with power turned on) established the following current path: from the power supply outlet via the recorder through the patient and back to the power supply system ground via the central monitoring system (Fig. 2). Under normal conditions this path will carry a current less than 10 microamperes (peak-to-peak), but in this case the current was about 130 microamperes (measured with an oscilloscope connected between the monitoring system and the recorder, with the 6 praecordial and R, N, F, and L leads connected together as a common terminal). This was sufficient to arrest the im-

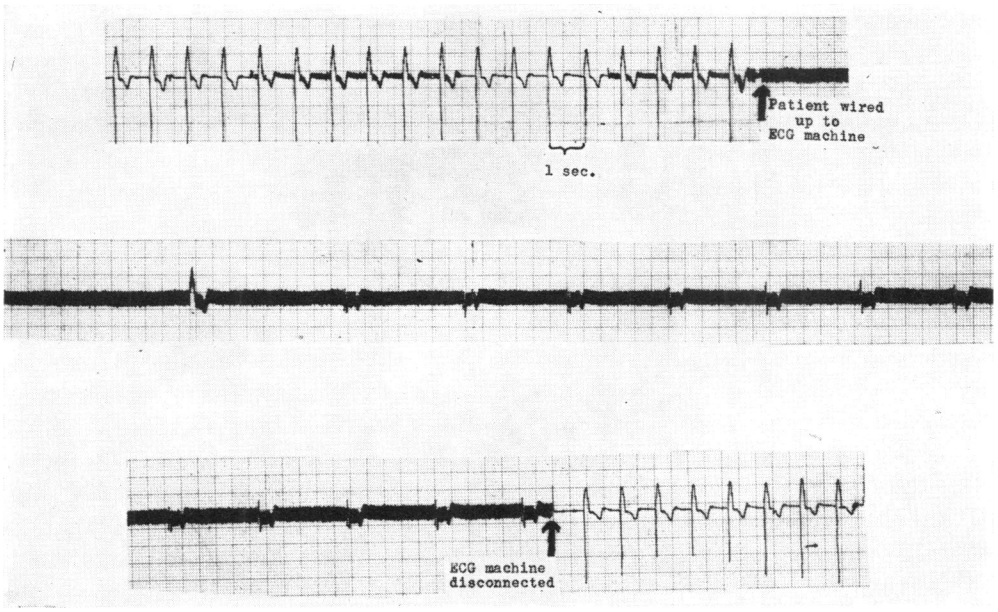


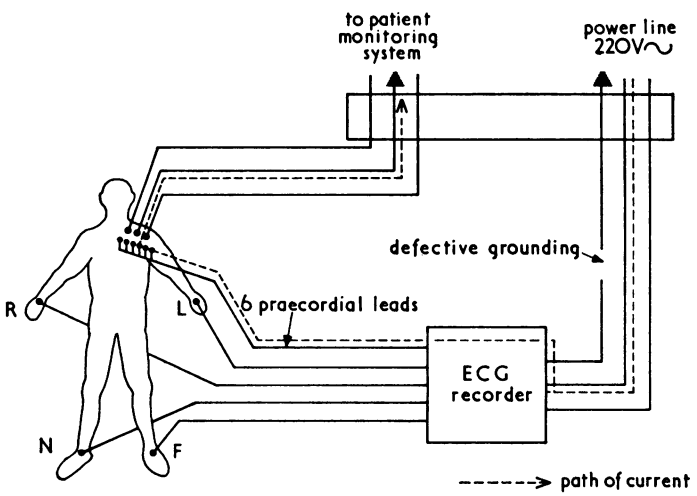
FIG. 1 *Inhibition of demand pacemaker by 50 Hertz alternating current interference from electrocardiographic recorder. Relayed from continuously monitoring tape-recorder.*

planted pacemaker, the threshold of inhibition later being measured to about 80 microamperes (same measuring set-up as above).

The high current passing from the recorder to the patient monitoring system was due to insufficient grounding of the electrocardiographic recorder because the ground cable in the power plug was defective. This caused the leakage current of the power cable and the recorder to flow through the patient and the monitoring system, instead of returning via the ground cable. Normally the capacitance between the windings of the power transformer in the recorder is low because a grounded shield is interposed between the windings. When grounding failed, capacitance between primary and secondary windings increased, and capacitance between power wire and ground wire in the power cable was added to this, so that the recorder acted as a current source of several megohms internal impedance. In this way, current is 'forced' through the patient, even in the presence of relatively high electrode impedances.

As other authors have stated (Whalen and Starmer, 1967; Weinberg, 1967), several measures can be taken in order to minimize electrical hazards, and these measures apply equally well to the care of patients with an implanted demand pacemaker. In this case we have found it important to take the following measures. (1) A technician should check the electrical equipment and installation in the intensive care unit regularly according to a fixed schedule (visual inspection of plugs, cables, cases, etc., measurement of resistances, test of function). (2) Physicians and nurses should be educated in medical electronics, emphasizing the practical aspects: how to avoid electrical hazards and simple ways to check equipment and installation. (3) Regular checks of pacemaker function in patients suspected of carrying a demand pacemaker with

FIG. 2 *Path of inhibiting current.*



a low threshold of inhibition should be carried out.

We wish to acknowledge our thanks to Dr. E. Sandøe, who invited us to investigate and report this case.

References

Greatbatch, W., Chardack, W. M., and Gage, A. A. (1967). Design considerations relating to power supplies and physiologic controls for implantable pacemakers. *Biomedical Sciences Instrumentation*, **3**, 281.

Sowton, E. (1965). Artificial pacemaking and sinus rhythm. *British Heart Journal*, **27**, 311.

—— (1967). Clinical application of demand pacemakers. *British Medical Journal*, **3**, 576.

Weinberg, D. I. (1967). Electrical safety in the operating room and at the bedside. In *Engineering in the Practice of Medicine*, p. 63. Ed. by B. L. Segal and D. G. Kilpatrick. Williams and Wilkins, Baltimore.

Whalen, R. E., and Starmer, C. F. (1967). Electric shock hazards in clinical cardiology. *Modern Concepts of Cardiovascular Disease*, **36**, 7.

Notices

European Society for Ballistocardiography and Cardiovascular Dynamics

The Eighth European Congress on Ballistocardiography and Cardiovascular Dynamics is to be held on 5, 6, 7, and 8 April 1971 in Ljubljana, Yugoslavia. This Society holds its Congresses in alternate years. Every fourth year the European and American branches hold a combined World Congress on Ballistocardiography and Cardiovascular Dynamics. The last such Congress was held in Oporto (Second World Congress on Ballistocardiography and Cardiovascular Dynamics, Oporto, Portugal, on 31 March and 1–2 April 1969).

Ninth International Conference on Medical and Biological Engineering

The ninth International Congress on Medical and Biological Engineering will be held in Melbourne from 23–27 August 1971. The meeting is sponsored by the Australian Federation of Medical and Biological Engineering, with Sir Robert Menzies as chairman, and Professor R. Douglas Wright as President. Application forms and further details can be obtained from the Secretary-General of the Congress: Dr. David Dewhurst, Department of Physiology, University of Melbourne, Parkville, Victoria, Australia 3052.