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Environmental Influence on Implantable Cardiac Pacemakers

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IMPLANTABLE CARDIAC PACEMAKERS are being used with increasing frequency in the management of patients with symptoms of a complete heart block. Although electromechanical control of heart rate would seem to demand a high level of both knowledge and professional concern regarding interactions between pacemakers and the environment, little information is available in scientific journals. We are, therefore, reporting preliminary observations of the behavior of two brands of pacemakers in several environments which may be encountered by patients.

Material and Methods

Three pacemakers have been used. Two were designed and made by one of us (R. W. S.) and are of the type used in 26 patients treated in this institution.[1,2] One of these had the long lead wires intact, the other had them removed to ensure that any induction currents or alterations of function which were detected had originated within the pacemaker unit itself. The third pacemaker, a popular, commercially produced brand, was purchased from ordinary stock and studied with its lead wires intact.

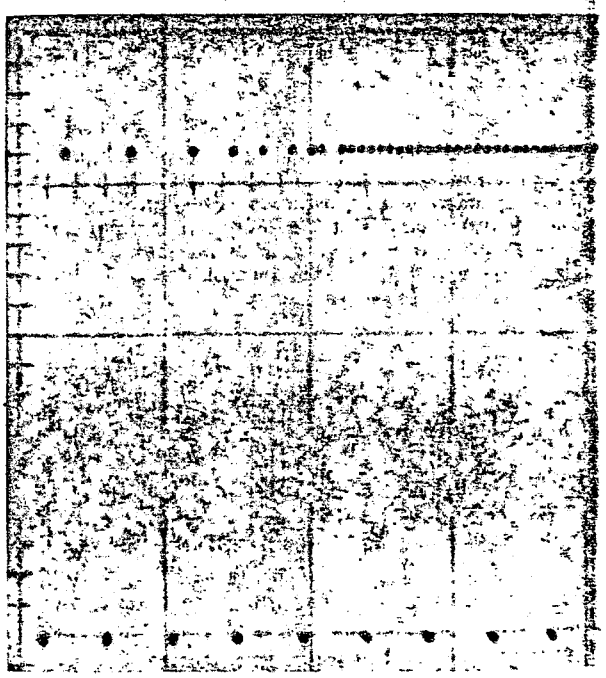
All testing in the laboratory was performed by connecting the pacemaker output to an oscilloscope with an attached camera. Tests conducted away from the laboratory were performed in two ways. Qualitative tests of impulse regularity, rate, and amplitude were made with the pacemaker lea touching the tongue of the investigator. The secor method involved the use of a 900-watt, 115-vo 60-cycle alternator, the oscilloscope and camer the pacemakers on the end of a long stick, and a observer, all positioned on the tailgate of a stati wagon. Each pacemaker was then placed into ar systematically moved through the area being teste while the pacemaker output was monitored.

Results

The distributor of a 6-volt automobile electric system produced acceleration of the pacemaker ra when the pacemaker was brought to within 6 cm the distributor. An increase in the rate up to 4 impulses per minute occurred when any of the pac makers was moved to within 1 cm of the distribut (Figure). Upon their withdrawal from the distrib tor field, however, a difference was noted betwe the two types of pacemakers; the locally made ty produced no impulse for seven to ten seconds, whi the commercially available pacemaker promptly r sumed the original rate. The distributor of a 1 volt automobile electrical system produced simil alterations in pacemaker performance.

The coils of both automobiles produced occasio al, sporadic, premature impulses without a fix acceleration of rate in either type of pacemake

The spark plugs on a gasoline-powered lawnmo er and the gasoline-powered alternator were teste The spark plug of each was shown to alter pac maker activity when the spark plug-pacemaker se aration was less than 8 cm. As demonstrated wit the distributor, a progressive acceleration of pac



Left-to-right sweep of electron beam across oscillo scope face. Lower line shows normal pacemaker activity; upper tracing shows acceleration from 66 to 450 impulses per minute produced by proximity to automobile distributor.

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maker rate occurred as the pacemaker was brought closer. All three pacemakers responded similarly.

Commercially available diathermy units operating at frequencies of 13.5 or 27 megacycles also have altered pacemaker activity. A pacemaker rate acceleration of 10 to 20 impulses per minute was detectable as far as 30 cm from the diathermy head when the diathermy was being used to treat a quadriceps muscle in a sitting subject. Each pacemaker, when held near the individual's umbilicus or near his left pectoralis muscles, was disrupted while the diathermy was operating at treatment levels.

The effects of cardiac defibrillators were tested by immersing the pacemaker leads in a bath of sodium chloride solution. The defibrillator paddles were positioned 25 cm apart in the sodium chloride solution; the pacemaker lead terminals, themselves 8 cm apart, were placed 6 cm from one paddle and 31 cm from the other. A direct-current defibrillator stopped the locally made pacemaker transiently but had no effect on the purchased type. An external, alternating-current defibrillator on the "adult" setting stopped each pacemaker transiently. With the defibrillator on the "adult-high" setting, the locally made pacemaker again stopped transiently; the purchased brand stopped permanently.

Exposure to many other environments did not influence pacemaker activity. These were (1) infrared heating, used in physiotherapy; (2) 60-cycle, alternating-current motors or generators; (3) electrical transformer substations stepping down alternating-current voltage from 132,000 to 12,000 volts; (4) ultrasound generator operating at 870 kc per second and 3.5 watts/sq cm; (5) all other portions of automobiles; (6) passenger compartments of a DC-8 jet aircraft, a DC-3 piston-driven aircraft, and a position in a passenger seat two feet from the jet pod of a 727 aircraft; (7) a commercial radio tower (at a distance of 30 feet) transmitting at 1 megacycle and 50,000 watts; (8) search radar at a Nike missile site at a distance of 50 feet; (9) a shielded cyclotron at Argonne National Laboratories at a distance of 30 feet; (10) muscle stimulator in contact with the pacemaker case and operating with a 0.5-millisecond pulse at rates of 1 to 85 pulses per second; (11) contact with all external portions of household radio and television receivers; (12) γ-radiation from Cobalt 60 at a dose rate of 80 r per minute in air to a total dose of 2,000 r; (13) x-radiation from a 200-kv unit at a dose rate of 180 r per minute in air to a total dose of 1,000 r; (14) contact with all areas of Teletype units; and (15) contact with the antennae of transmitters and receivers of 10-watt, 463.25-megacycle or 129.5-megacycle, short-distance, radio communications systems.

In most of these tests the pacemakers were covered only with three to four layers of towel wrapping. However, completely covering the pacemaker with the hands, thus interposing tissue of the approximate thickness of the usual subcutaneous pocket, did not protect against the effects of diathermy or automobile distributors.

The inherent electrical characteristics of oscillating circuits make them vulnerable to interference by electromagnetic activity in the environment. Since metals of high magnetic permeability, such as alloys with 80% nickel, have been used in other applications to provide electromagnetic shielding, a pacemaker was tested after its complete encasement in such an alloy. No protection from the effects of diathermy was observed, but the malfunction induced by automobile electrical parts was attenuated. With such shielding, the pacemaker output was stable at distances greater than 2 cm from distributors or spark plugs.

The role played by the lead wires could best be seen near diathermy. The pacemakers both with and without lead wires were equally affected by diathermy; however, moving a loop of lead wires through the diathermy radio-frequency field induced a 13.5- or 27-megacycle distortion of as much as 10 volts, upon which the basic pacemaker impulse was superimposed.

Circuit diagrams of other pacemakers with specifically identifiable components are not available. Although the basic design in most of the commercially available pacemakers is similiar to that of those used in this study, it would be unwise to extrapolate our findings quantitatively to devices other than those tested.

Comment

This study demonstrated disturbance of function of two types of pacemakers by three commonly encountered environments. In terms of frequency of exposure, an automobile electrical distributor and the spark plug of a small, one-cylinder, gasoline engine are most to be feared. An effect has been noted, in the form of transitory rate increases, as far as 8 cm from the distributor or spark plug. A change in pacemaker function of even slight degree would produce a premature beat and in the presence of myocardial hypoxia or high levels of endogenous epinephrine might produce ventricular fibrillation. Pacemaker rates greater than 300 detected near such electrical sources produce ventricular fibrillation in dogs. It seems wise to recommend that an individual with an implanted pacemaker avoid opening the hood of an automobile or approaching within three feet of even a small, running gasoline engine. Diathermy, while less frequently encountered, also poses a hazard to people whose lives depend on implanted pacemakers. It is recommended that these people avoid diathermy devices by a distance of at least five feet. Several other types of electromagnetic fields have no effect on the pacemakers.

This report is not meant to be totally inclusive, but rather to emphasize the continuing responsibility which is borne by those who substitute electromechanical control for natural control of biologic functions.

Summary

The activity of two types of implantable cardiac pacemakers studied in diverse surroundings was altered or disrupted by functioning automotive distributors, spark plugs, diathermy, and by cardiac defibrillators. Patients with pacemakers should be alerted to these and other possible hazards.

This investigation was supported in part by Public Health Service research grant HE-05579 from the National Institutes of Health and by grants from the Chicago and Illinois Heart Associations.

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Granulomatous Hypersensitivity After Use of Zirconium-Containing Poison Oak Lotions

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OF THE METALS to which man is exposed, only zirconium and beryllium are known to induce delayed granulomatous hypersensitivity. Historically, axillary granulomas following the application of zirconium-containing stick deodorants[1-4] drew attention to this metal as a cause of allergic granulomas.[5-8] More recent cases have masqueraded as sarcoidosis.[9-11] In this report we describe another instance of presumed sarcoidosis due in fact to granulomatous hypersensitivity to zirconium in a topical remedy for poison oak dermatitis.

Report of a Case

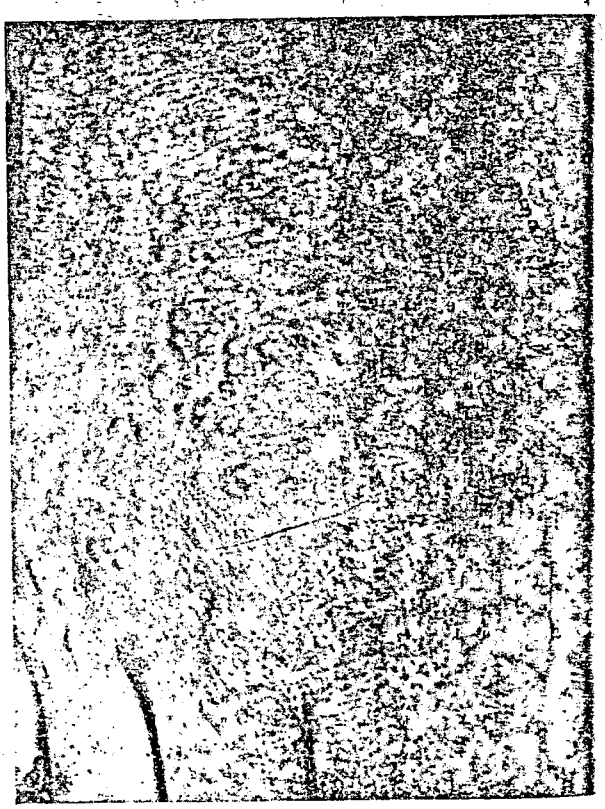
A 16-year-old Japanese girl presented with a nonpruritic papular eruption of four months' duration on the face, forearms, and the dorsum of her hands. The lesions appeared as large, reddish-brown, flat-topped papules, 3 to 6 mm in diameter (Fig 1. Note: No topical therapy was used at this point.). She showed no signs of systemic illness. A biopsy revealed a "noncaseating dermal granuloma consistent with sarcoidosis." The clinical diagnosis was sarcoidosis; laboratory evaluation including chest and hand x-rays, electrocardiogram (ECG), serum electrophoretic pattern, and serum and urine calcium did not support the diagnosis. A Kveim test with the Siltzbach antigen observed for one year gave no reaction; results of second strength purified protein derivative (PPD) skin tests were repeatedly negative. In searching for an alternative diagnosis, an intradermal injection of 0.1 ml of 1:100 zirconium lactate suspension produced a 1-cm diameter red nodule within three weeks. This enlarged to a 3-cm draining lesi by three months. Biopsy at this time revealed an organiz epithelioid cell granuloma with intense surrounding i flammation (Fig 2). The lesion persisted unchanged f six months at which time it was excised in toto.

Careful questioning revealed that the patient beca sensitive to poison oak shortly after coming to this couni seven years ago. She suffered numerous bouts of dermati treated with a number of proprietary lotions, including compound of 1% benadryl hydrochloride and 2% zirconi oxide (identified as Ziradryl Lotion); this agent was us for poison oak dermatitis six weeks before the appearan of granulomas.

Course.—The lesions on the hands and arms partia cleared in four to six months with topical application fluocinolone acetonide (Synalar) under occlusive dressin The facial lesions were resistant. They have persisted f more than 2½ years, responding only partially to 0.2 fluocinolone acetonide in propylene glycol. The erupti continues to be a distressing problem to this date.

Further Studies.—The extreme and persistent reacti to injected zirconium in this case suggested that clinicia might be unwilling to carry out the skin test in other p tients thought sensitive to zirconium. In addition, the tense inflammation distorted the pathological pictu making recognition of epithelioid cell tubercles diffic The problem could be solved by injecting serial dilutions the zirconium suspensions, but this would entail seve reaction sites. The prick method used by Williams a Skipworth,[9] on the other hand, gives erratic results. V have had one technical failure with this method in a pers known to be sensitive to zirconium. As an alternative evolved the following patch-test method.

After local injection with zylocaine hydrochloride, scraped off a 1-cm² area of epidermis with a dermal cu A pledget saturated with 1% zirconium lactate was pla on the site and occluded with surgical tape. In nonsensit persons the test sites healed rapidly and uneventfully.



1. Reddish-brown papules sharply limited to the dorsum of hands and wrists.

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