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Selective interference with pacemaker activity by electrical dental devices

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Objective. We sought to determine whether electromagnetic interference with cardiac pacemakers occurs during the operation of contemporary electrical dental equipment.

Study Design. Fourteen electrical dental devices were tested in vitro for their ability to interfere with the function of two Medtronics cardiac pacemakers (one a dual-chamber, bipolar Thera 7942 pacemaker, the other a single-chamber, unipolar Minix 8340 pacemaker). Atrial and ventricular pacemaker output and electrocardiographic activity were monitored by means of telemetry with the use of a Medtronics 9760/90 programmer.

Results. Atrial and ventricular pacing were inhibited by electromagnetic interference produced by the electrosurgical unit up to a distance of 10 cm, by the ultrasonic bath cleaner up to 30 cm, and by the magnetorestrictive ultrasonic scalers up to 37.5 cm. In contrast, operation of the amalgamator, electric pulp tester, composite curing light, dental handpieces, electric toothbrush, microwave oven, dental chair and light, ENAC ultrasonic instrument, radiography unit, and sonic scaler did not alter pacing rate or rhythm.

Conclusions. These results suggest that certain electrosurgical and ultrasonic instruments may produce deleterious effects in medically fragile patients with cardiac pacemakers.

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Soon after implantation of the first permanent cardiac pacemaker in 1958,[1] patients with pacemakers were advised to avoid certain environments associated with electromagnetic fields that might interfere with pacemaker function.[2-5] The dental office, in the 1970s, was identified as a potentially hazardous environment for pacemaker patients because of devices used that propagate electromagnetic fields.[6-11] In particular, dental ultrasonic scalers and cleaners, electrosurgical instruments, dental induction-casting machines, electric pulp testers, and microwave ovens have been reported to cause interference.[6,7,11,12] Although these interactions have not been studied since 1989, improvements in pacemaker circuitry and shielding and the introduction of new dental devices have occurred. Thus it is unclear which dental devices are harmful to patients who have been fitted with pacemakers. The purpose of this study was to determine whether electromagnetic interference with cardiac pacemakers occurs during the operation of contemporary electrical dental equipment.

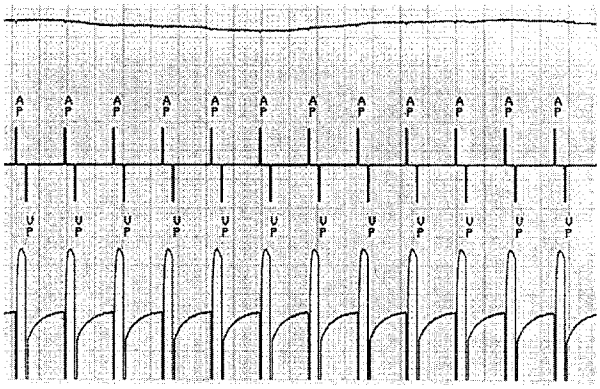

Fig. 1. Normal bipolar pacing. ECG recording *(top)*, marker channel for atrial and ventricular pacing *(middle)*, and pacing output channel *(bottom)*.

MATERIAL AND METHODS

Fourteen electrical dental devices were tested in vitro for their ability to interfere with cardiac pacemaker

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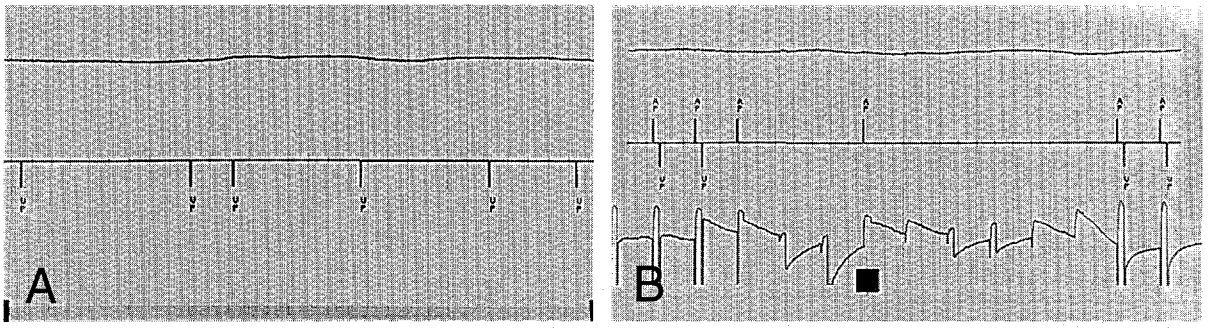

Fig. 2. **A,** Interference of unipolar pacemaker activity during operation of ultrasonic scaler. Several pauses appear in ventricular pacing during operation of scaler. **B,** Interference of bipolar pacemaker activity during operation of ultrasonic scaler. Several pauses in ventricular and atrial pacing and erratic output are discernible.

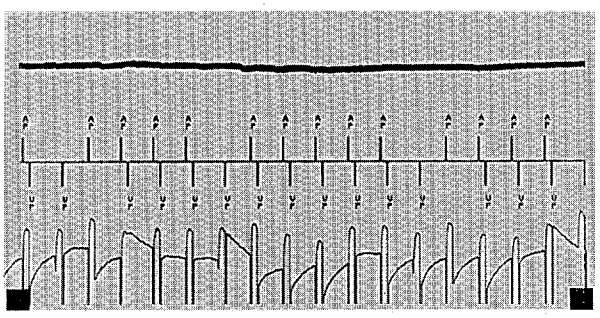

Fig. 3. Interference of bipolar pacemaker activity during operation of ultrasonic bath cleaner. Irregular atrial and ventricular pacing and erratic output are noted.

function. Two commonly used cardiac pacemakers (one a dual-chamber, bipolar Thera 7942 pacemaker, the other a single-chamber, unipolar Minix pacemaker), both manufactured by Medtronics, were evaluated.

Pacemakers were programmed to maximum sensitivity (unipolar: VVI [mode], 0.5 mV [amplitude], 3.5 mA [current], 0.5 msec [pulse width]; bipolar: DDD [mode], 1.0 mV [amplitude], 3.9 mA [current], 0.5 msec [pulse width]), set to 60 pulses/minute, and placed directly under the wand of a Medtronics 9760/90 programmer to produce a telemetric connection. Pacemaker leads (unipolar: Medtronic model 5024; bipolar: CPI 4269 [atrial], CPI 4261 [ventricular]) and electrocardiographic (ECG) leads were immersed in a 1.5-L saline-solution bath that was adjusted to 400 to 800 ohms to simulate the electrical resistance of the human body and to produce ECG signals.[13] Atrial and ventricular pacemaker output and ECG activity were continuously monitored with the programmer beginning 1 minute before each trial (Fig. 1).

Dental devices were turned on and off, operated at all power levels directly against the pacemaker, and moved from the pacemaker until no interference was recorded. Trials with each dental device were performed in triplicate. If interference was detected, the maximum distance from the pacing system that registered interference was recorded.

RESULTS

Telemetric recordings were consistent for the three trials. Atrial and ventricular pacing were inhibited by electromagnetic interference produced by the electrosurgical unit, both magnetorestrictive ultrasonic scalers, and the ultrasonic bath cleaner. Inhibition of pacing with both pacemakers was detected to a distance of 10 cm for the Sensimatic 300 SE electrosurgical unit (Parkell Electronics), 15 cm with the Cavitron magnetorestrictive ultrasonic scaler (Dentsply) (Fig. 2, *A*), and 37.5 cm with the LeClean machine ultrasonic scaler (Parkell Electronics) (Fig. 2, *B*). Interference with bipolar pacemaker activity occurred on operation of the Jelenko ultrasonic bath cleaner (Jelrus Technical) up to a distance of 22.5 cm (Fig. 3), whereas the unipolar pacemaker experienced interference to a distance of 30 cm. Pacing rate and rhythm remained normal for both pacemakers (Fig. 4) during operation of the amalgamator, electric pulp tester, composite curing light, dental handpieces, electric toothbrush, microwave oven, dental chair and light, ENAC endodontic ultrasonic instrument, radiography unit, and sonic scaler. Data were not statistically analyzed because the proportion of interference was the same for the unipolar- and bipolar-pacemaker groups.

DISCUSSION

More than a million patients in the United States are being kept alive by pacemakers, and the number is growing each year.[14] As people live longer and the number of pacemaker patients grows, chances increase

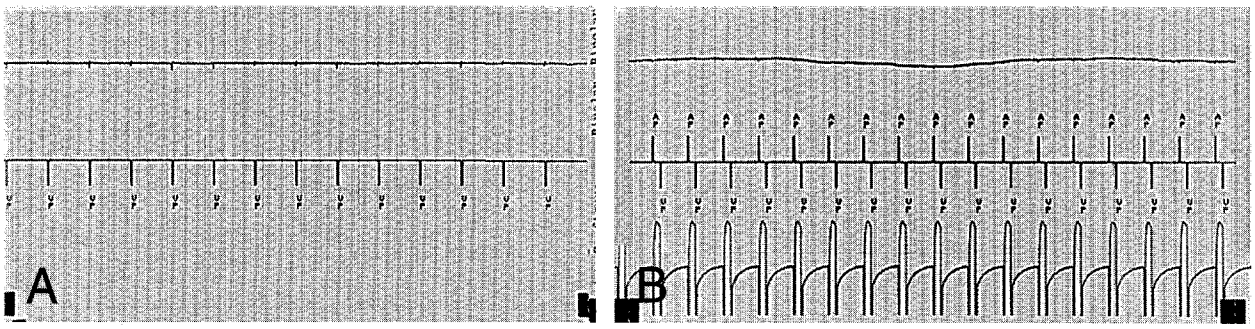

Fig. 4. **A,** No interference of unipolar pacemaker activity during operation of portable radiography unit. **B,** No interference of bipolar pacemaker activity during operation of sonic scaler.

that the dentist may treat such a patient. Safe dental treatment requires elimination of electrical interferences that could affect the cardiac health of patients fitted with pacemakers. However, guidelines for use of electrical dental equipment around pacemakers have not been updated for more than 20 years.[7] For this reason, we studied the potential interference of electrical dental equipment with cardiac pacemakers.

In this study, we evaluated the Medtronics Thera 7942 and the Minix 8340 pacemaker with the use of telemetry, which permitted continuous monitoring of pacemaker behavior in vitro. Medtronic pacemakers have been shown to be more resistant to electrical interference than other models[15,16] and are commonly used by cardiologists. Selection of these two pacemakers allowed us to evaluate a dual-chamber, bipolar pacemaker and a single-chamber, unipolar pacemaker. As expected, our results showed that the unipolar pacemaker was more sensitive to interference than the bipolar model.[17]

The results of this study correlate with the in-vivo results of Griffiths[11] and the in-vitro results of Adams et al.[12] and Rahn et al.,[18] who found that ultrasonic scalers cause interference, but are in contrast to the in-vivo results of Simon et al.[9] and the in-vitro results of Luker,[16] who reported no interference with ultrasonic scalers. A likely explanation for the discrepancy is that the pacemakers in the study by Simon et al.[9] were shielded by human tissue or that they were in demand mode and spontaneous pacing of the heart was sufficient to prevent the pacemaker from switching on during testing. Both scenarios would have resulted in no visible effect on ECG recordings of pacemaker activity. Less likely explanations for the discrepancy are that the patients in the Simon study[9] were not brought within interference range of the dental device, that the Cavitron model 1010 tested in 1975 may have produced less electromagnetic field intensity than more current models (i.e., the model 700 tested by Adams et al.[12] and the model 3000 we tested), and that the pacemakers had more shielding than current pacemakers. In the Luker study[17], the scalers differed from the models we tested (one was a piezoelectric model, the other a ferromagnetic ultrasonic scaler), the pacing system was immersed in the saline-solution bath, and the bath was only crudely adjusted to simulate electrical resistance of the human body. Measures of electrical interference can be altered by submerging the pacemaker in the bath and changing the configuration of the leads, according to Gerald L. Becker of Medtronic, Inc. (personal communication, May 1997).[19]

Interference with pacemaker activity during operation of the electrosurgical unit and ultrasonic bath cleaner also occurred in this study. Interference by electrosurgical units has been consistently reported,[8,18-21] suggesting that these units produce deleterious effects on pacemaker function. However, our detection of interference with the ultrasonic bath is a new finding. It contrasts with the findings of Adams et al.,[12] who reported no interference when a different set of pacemakers was tested. However, comparisons are difficult to make because the type of ultrasonic bath(s) tested and the distance tested was not reported in the Adams study. Until future studies reveal the importance of our finding, we advise precaution in using ultrasonic bath cleaners around pacemaker patients. This may be more of concern to dental healthcare workers who have pacemakers than to patients who have pacemakers, because ultrasonic baths are generally located more than 1 m from patient-care areas.

Our findings that the electric pulp tester, dental handpieces, radiography unit, and sonic scaler did not interfere with pacemaker function were similar to the findings of Simon et al.[9] and suggest that these devices are probably safe to use in the dental office during the treatment of pacemaker patients. However, our discovery that the microwave oven, electric pulp tester, dental chair, and electric toothbrush do not cause interference

is in contrast to the findings of King et al.,[3] who found interference with use of a microwave oven; Woolley et al.,[8] who found that electric pulp testers interfered with implanted pacemakers in dogs; Rahn et al.,[18] who found interference with Activitrax and Sensolog pacemaker activity during operation of an electric pulp tester and microwave oven; Simon et al.,[9] who found interference with the General Electric A2075 pacemaker (now discontinued) during operation of the dental and panoramic chair; and Escher et al.,[5] who reported two cases of pacemaker interference leading to dizziness during the use of an electric toothbrush. These discrepancies can most likely be explained by the improved titanium shielding and increased filtering circuits of pacemakers since 1977 that have caused pacemaker manufacturers to discontinue their warnings of interference caused by these devices. Our results are consistent with current manufacturer advice in that no interference with pacemaker function was noted during operation of the microwave oven, electric pulp tester, dental handpieces, radiography unit, or sonic scaler. Also, the absence of interference during operation of the amalgamator, ENAC, radiography unit, composite curing light, or dental light suggests that these devices can be operated safely in the dental environment with patients who have pacemakers.

In summary, until the results obtained from this in-vitro study are confirmed by in-vivo testing, it is probably in the best interest of patients to avoid the use of electrosurgery units, ultrasonic baths, and magnetorestrictive ultrasonic scalers in patients with cardiac pacemakers. Use of wireless handheld cellular telephones by these patients in the dental office should also be avoided.[22] However, the amalgamator, dental drills, dental chair and light, electric pulp tester, composite curing light, portable radiography unit, electric toothbrush, microwave, ENAC, and sonic scalers appear to be safe for use around cardiac pacemakers. This advice is for dental patients and dental healthcare workers with pacemakers.

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