Influence of D-Net (EUROPEAN GSM-Standard) Cellular Telephones on Implanted Pacemakers in Children

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ELŞHERSHARI, H., ET AL.: Influence of D-Net (EUROPEAN GSM-Standard) Cellular Telephones on Implanted Pacemakers in Children. This study was designed to evaluate possible interactions between digital cellular telephones and implanted pacemakers in children. The study comprised 95 patients (53 males and 42 females) with a mean age of 11.5 ± 4.6 years (range 1–22 years). The average time from pacemaker implantation was 2.5 years (range 1 month–12 years). Fourteen (15%) devices were dual chamber and the remaining were single chamber pacemakers. The following companies manufactured the pacemakers tested: Medtronic (n = 42), Telectronics (n = 9), Vitatron (n = 16), Pacesetter (n = 19), CPI (n = 8), and Biotronik (n = 1). All the patients were tested in the supine position during continuous ECG monitoring. After completion of the routine pacemaker check, the effects of the European Global system for mobile communication (GSM) was tested using two cellular telephone models (Ericsson GA 628 and Siemens S 25, 2-W power). For this purpose, atrial and ventricular sensitivity settings were programmed to the most sensitive values, and the tests were carried out in the unipolar and bipolar sensing modes. The evaluation was performed during ringing, switching on/off, and conversation phase with the cellular telephone positioned over the pulse generator and around the pacemaker pocket. A malfunction of the pacemaker was not observed in any patient. Only 1 (1%) of 95 patients showed a brief oversensing problem during calls with the cellular telephone. In this case, an AAIR pacemaker was implanted transvenously in a subcutaneous pocket and the sensing defect occurred only with the unipolar sensing mode and was not reproducible. Once the source of interference was removed, no sensing defect was detected and the patient remained asymptomatic. No symptoms were experienced in this study. The authors believe that pacemaker dependent patients with unprotected pulse generators manufactured at the beginning of 1990s may be tested by their physicians for possible interferences before they use a digital cellular telephone. (PACE 2002; 25:1328–1330)

Pacemaker, Electromagnetic interference, children

Introduction

Electromagnetic interference (EMI) may interfere with the proper function of some medical electrical equipment including cardiac pacemakers. Electromagnetic fields generated by the new generation digital mobile telephones (European Global system for mobile communication [GSM]) represent a potential source of EMI. Today, the use of cellular telephones is widespread and they are increasingly regarded as a potential source of pacemaker interference. The signals produced by their operating functions (turning on/off, ringing, and conversation) contain components of low frequencies that may interfere with implanted pacemakers.

Interference may result in (1) inhibition of the pacemaker, (2) change of temporary or permanent pacemaker programming, and (3) switch to VO0 interference mode. This study was designed to evaluate possible interactions between digital cellular telephones and implanted pacemakers in children. Numerous investigations in the United States and Europe pertaining to EMI in implanted pacemakers in adults have been published.

Patients and Methods

To evaluate mobile telephone EMI interference on implanted pacemakers, 95 (53 males, 42 females; age 11.6 ± 4.6 years, range 1–22 years), consecutive patients were studied during routine pacemaker follow-up, the average time from pacemaker implantation was 2.5 years (range 1 month–12 years). Fourteen (15%) devices were dual chamber stimulators programmed in DDD (n = 2), DDDR (n = 2), VDD (n = 10) modes, and 81 (85%) with a sin-
gle chamber pacemaker programmed in VVI (n = 13), VVIR (n = 61), AAIR (n = 7) modes.

The pacemakers tested were manufactured by the following companies: Medtronic (Minneapolis, MN, USA) (n = 42), Teletronics (St. Paul, MN, USA) (n = 9), CPI (Cardiac Pacemakers, Inc, St. Paul, MN, USA) (n = 8), Vitatron (Dieren, the Netherlands) (n = 16), Pacesetter (Sylmar, CA, USA) (n = 19), and Biotronik (Berlin, Germany) (n = 1) (Table 1). Eighty-five transvenous pacemakers were located in the right pectoral region, subcutaneously in 45 and subpectorally in 40 patients, the remaining were epicardial within the rectus sheath. The Ericsson GA 628 and Siemens S 25 cellular telephones were used with a maximal power output of 2 W, and they were operating with digital transmission GSM system. The GSM is the standard mostly used all over Europe, which is working in the so-called D-net. The Scandinavian countries use analog systems. The GSM is pulsed and the digital information is frequency-modulated (AM) signals of 900 MHz, which is potentially more dangerous than continuous frequency-modulated (FM) signals.

All patients were tested in the pacemaker center of the Hacettepe University Children’s Hospital in the supine position during continuous ECG monitoring. The transmitting power of the cellular telephone is normally variable, and it is automatically adapted to the basic station with which the mobile telephone communicates. During the testing procedure, the output power varied from 0.2–2 W, it was maximum (2 W) during the ringing phase and declined gradually with switching on the telephone and during the talking phase to reach a minimum of 0.2 W after about 30 seconds. Prior to the study a routine pacemaker check was performed with determination of pacing and sensing thresholds. In this study, an attempt was made to determine the interference between the cellular telephone and pacemaker regarding temporary pacemaker inhibition, prolonged pacemaker inhibition, shift to asynchronous mode, and synchronization of ventricular stimulation with an electromagnetic field generated by the cellular telephone (limited to the dual chamber pacemaker programmed in DDD, DDD-R and VDD modes).

For this purpose, atrial and ventricular sensitivity settings were programmed to their most sensitive values and the tests were carried out in the unipolar and bipolar sensing modes. The evaluation was performed during ringing, switching on/off, and conversation phase with the cellular telephone positioned over the pulse generator and around the pacemaker pocket. During the whole test procedure, the electrocardiography (ECG) monitor was continuously observed by a physician to detect interference and to terminate the test if necessary. After completion of the test, the pacemaker was interrogated again and checked for changes in the programmed parameters.

Results

A change in pacemaker programming or a switch to VOO pacing due to the use of the cellular telephone was not observed in any patient. Only 1 (1%) of 95 patients showed a brief oversensing problem with the cellular telephone in the talking position and the antenna of the telephone was in close proximity to the patient’s skin over the implant site while the patient was silent. This patient had undergone an operation for atrial septal defect closure and mitral cleft repair, after which a sick sinus syndrome had developed. Therefore, an AAIR Medtronic Prodigy SR 8162 Pacemaker was implanted transvenously in the right pectoral region in a subcutaneous pocket and a Medtronic (4068–586cm) lead was inserted into the right atrium with a bipolar sensing of 0.35 mV. The sensing defect occurred only with the unipolar sensing mode and it was not reproducible. Of the parameters measured, P wave was 1.4–2.2mV, whereas lead impedance was 700 Ω. Once the source of interference was removed, no pacemaker malfunction was detected and the patient remained asymptomatic during the test. There were no symptoms experienced in this study.

Discussion

The potential for EMI of an implanted pacemaker by a cellular telephone has been recognized

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since 1994. A number of clinical and experimental studies have been conducted to evaluate interference of a pacemaker by various communication devices manufactured in Europe and the United States. EMI occurs when an electronic device is submitted to any electromagnetic field with an amplitude higher than the interference threshold. There are multiple sources of environmental EMI signals, like electronic security systems (airports, banks, etc.), which may generate dangerous electromagnetic fields. Some authors\(^7,8\) have reported no interferences with pacemaker functioning in adults, while others\(^3,12\) have found interferences.

Today, a common source of electromagnetic waves in the environment are digital mobile telephones in which different systems are used in Europe and North America with different frequency range, power, and transmission mode (continuous or pulsed). Therefore, the possibility of mobile telephone interference is different. Transmission passes through a continuous or pulsed wave that has modulation variations in frequency that ranges from about 450 MHz to around 960 MHz. These systems operate on a power of 0.6–1 W in the United States and from 20 mW to 2 W in Europe with a mean value of 0.8 W. Therefore, it is possible that a mobile telephone operating near enough to a pacemaker may cause interference in its working condition. Many studies have been carried out in vitro\(^5,11\) and in vivo\(^1,4\); they have demonstrated the possibility of interference between the cellular telephone and pacemaker, which resulted in tracking, inhibition, or conversion to the noise mode.

In this study, interference between the cellular telephone and pacemaker function, which is not clinically important, was documented in only 1 (1%) of 95 children. As this effect was not reproducible, it is probably a transmitted myosignal. However, in other studies a high rate of interferences was found in adults. In the study by Barbaro et al.,\(^1\) which was carried out in vitro, showed interferences in 55.6% if the cellular telephone was in close proximity to the pacemaker. In the same study, an influence was seen in 25.7% in vivo. In the present study, the sensing defect occurred only with the unipolar sensing mode, but other in vitro and in vivo investigations demonstrated a malfunction also in cases of bipolar sensing.

Barbaro et al.\(^1\) reported that two of four bipolar pacemakers showed interferences in vivo. Questions arise as to why the results are different in various studies. A possible explanation could be that the pacemakers used in the different studies were different in brand and model, and the transmitting power of the cellular telephone used was different in these studies. Furthermore, it is reported that implantation techniques play an important role, a telephone-generated electromagnetic field penetrates the body, but is exponentially attenuated by the conductive tissue according to its "penetration depth" (50 mm at 450 MHz, 22 mm at 2,000 MHz) and to the thickness of the tissue layer covering the lead. Inrigh\(^14\) postulated that implantation deep to the pectoralis major muscle reduces interference penetration, while a subcutaneous pocket has only a small sheet of damping and protective tissue. However, in the present study, interference had only occurred in one case between the cellular telephone and pacemaker function, which was implanted in a subcutaneous pocket. This finding cannot be attributed to the implantation place alone since other patients with a subcutaneous pacemaker did not have this kind of reaction.

Conclusion

Although no significant interference was detected, pacemaker dependent patients with unprotected pulse generators that were manufactured at the beginning of the 1990s should be tested by their physicians for possible interference before they use a digital cellular telephone. Patients with an implanted pacemaker should not carry a cellular telephone in a breast pocket close to the pacemaker and lead.

References