Third-Generation Mobile Phones (UMTS) Do Not Interfere with Permanent Implanted Pacemakers

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Aims: *Third-generation mobile phones, UMTS (Universal Mobile Telecommunication System), were recently introduced in Europe. The safety of these devices with regard to their interference with implanted pacemakers is as yet unknown and is the point of interest in this study.*

Methods and Results: *The study comprised 100 patients with permanent pacemaker implantation between November 2004 and June 2005. Two UMTS cellular phones (T-Mobile, Vodafone) were tested in the standby, dialing, and operating mode with 23 single-chamber and 77 dual-chamber pacemakers. Continuous surface electrocardiograms (ECGs), intracardiac electrograms, and marker channels were recorded when calls were made by a stationary phone to cellular phone. All pacemakers were tested under a "worst-case scenario," which includes a programming of the pacemaker to unipolar sensing and pacing modes and inducing of a maximum sensitivity setting during continuous pacing of the patient. Patients had pacemaker implantation between June 1990 and April 2005. The mean age was 68.4 ± 15.1 years. Regardless of atrial and ventricular sensitivity settings, both UMTS mobile phones (Nokia 6650 and Motorola A835) did not show any interference with all tested pacemakers. In addition, both cellular phones did not interfere with the marker channels and the intracardiac ECGs of the pacemakers.*

Conclusion: *Third-generation mobile phones are safe for patients with permanent pacemakers. This is due to the high-frequency band for this system (1,800–2,200 MHz) and the low power output between 0.01 W and 0.25 W. (PACE 2010; 33:860–864)*

cellular telephones, UMTS, pacemaker

Introduction

Investigating the interactions between electromagnetic interference caused by cellular phones and PPM requires testing under a "worst-case scenario."[1] The electromagnetic fields were found to interfere with the permanent pacemaker (PPM) function with a rate up to 41%.[2–10] Third-generation mobile phones, Universal Mobile Telecommunication System (UMTS), were recently introduced in Europe. The safety of these devices with regard to their interference with PPM is as yet unknown. In order to be able to simulate the worst-case scenario, it was essential to program the PPM to unipolar sensing and pacing modes and the induction of a maximum sensitivity setting during continuous pacing of the patient.

The aim of this study was to test the interference of two UMTS digital cellular telephones with the different models of available PPMs.

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Methods

The study was performed between November 2004 and June 2005 and included 100 patients, 23 with single-chamber and 77 with dual-chamber pacemakers. All patients had pacemaker implantation between June 1990 and April 2005. The patients wrote a formal consent before starting the study.

Two UMTS cellular phones were used: a Nokia 6650 working in the T-Mobile net and a Motorola A835 operating in the Vodafone net. Both phones use digital transmission and have a maximum power output of 0.25 W. The UMTS system is a code division multiple access technology working in a nonpulsed transmission mode. The frequency band for this system is between 1,800 and 2,200 MHz.

A routine pacemaker check-up was performed with determination of pacing and sensing thresholds where the atrial and ventricular sensitivity settings were programmed to their most sensitive values and all pacemakers were programmed to unipolar atrial and ventricular sensing. In patients with spontaneous rhythm, the pacemaker rate was programmed higher than the spontaneous rate to detect an inhibition of the pacemaker secondary to the cellular phone use. The cellular phones were positioned directly above the pacemaker pocket. Surface electrocardiograms (ECGs),

intracardiac electrograms, and marker channels were continuously recorded when calls were performed from a stationary phone to the cellular phones.

The following maneuvers were tested with both cellular phones:

- Switching the phone on and connecting to the net;
- Receiving a call and letting the phone ring for 10 seconds;
- Receiving a call without talking and hanging up.

The procedure was performed in a chamber in the hospital with the lowest signal strength of the mobile phones, indicating that the phones having the maximum output.

During this procedure, the ECG was continuously observed by a physician to detect interference with the pacemaker's function and to terminate the test if necessary. After completion of the test, the pacemakers were also checked for any change of the programmed parameters.

Results

One hundred patients were included in this study, 71 males and 29 females. The mean age was 68.4 ± 15.1 years with a range of 12–92 years. Devices were tested from the following manufacturers: Medtronic (Minneapolis, MN, USA), CPI Guidant (St. Paul, MN, USA), Biotronik (Berlin, Germany), St. Jude Medical (Sylmar, CA, USA), Vitatron (Dieren, The Netherlands), Sorin Biomedica (Saluggia, Italy), and Intermedics (St. Paul, MN, USA). Table I shows the 23 single-chamber pacemakers; one was atrial-inhibited (St. Jude Medical Microny II SR), and all other single-chamber pacemakers were ventricular-inhibited. Table II shows the 77 dual-chamber models; four were single lead (VDD) pacemakers (one Biotronik Actros SLR, one Intermedics Unity 292–07, two Vitatron Vita 2 VDD 630).

Regardless of atrial and ventricular sensitivity settings, both UMTS mobile phones (Nokia 6650 and Motorola A835) did not show any interference with all tested pacemakers. In addition, both cellular phones did not interfere with the marker channels and the intracardiac ECGs of the pacemakers. We did not see any telemetric transmission problems when the cellular phone was located near the programming head.

Table I.

Manufacturers of Single-Chamber Pacemaker Models

Companies	Models	No.
Biotronik	Actros SR	1
	Dromos SR	1
	Pikos E O1	3
	Pikos LP	1
CPI Guidant	Discovery SR 1175	3
	Insignia I Entra SR 1195	1
	Insignia I Plus SR 1194	2
	Insignia I Ultra SR 1190	4
Medtronic	Legend 8417	1
	Sigma S 303	2
	Thera SR 8960 i	1
	Kappa SR 401	1
St. Jude Medical	Microny II SR	1
Vitatron	Vita 140	1

Table II.

Manufacturers of Dual-Chamber Pacemaker Models

Companies	Models	No.
Biotronik	Actros DR	1
	Actros SLR	1
	Philos D	1
	Inos CLS	1
CPI Guidant	Vigor DR 1230	1
	Discovery DR 1274	4
	Discovery DR 1275	1
	Insignia I Entra DR 1296	1
	Insignia I Plus DR 1297	14
	Insignia I Plus DR 1298	1
	Insignia I Ultra DR 1290	5
	Pulsar DR 1272	1
	Pulsar Max 1270	3
	Pulsar Max II DR 1280	11
Intermedics	Unity 292-07	1
Medtronic	EnPulse DR	1
	Kappa DR 401	1
	Kappa DR 403	1
	Kappa DR 701	3
	Kappa DR 730	1
	Kappa DR 731	7
	Kappa DR 801	1
	Kappa DR 901	2
	Kappa DR 931	2
	Thera DR 7960 I	2
Sorin	Neway DR	2
St. Jude Medical	Identity XL DR 5376	2
	Trilogy DC 2308L	1
Vitatron	Clarity DDDR 860	1
	Prevent AF 920	1
	Vita 2 VDD 630	2

Table III.

In Vivo Studies

References	Total Sample	Type of Cellular Phone	Interference	Distance
Ref. 4	101	GSM	26%	10 cm
Ref. 10	39	GSM	18%	10 cm
Ref. 16	31	GSM	0%	–
Ref. 5	29	GSM	28%	10 cm
Ref. 21	50	GSM	4%	No information
Ref. 9	104	C-Net, GSM	41%	120 cm
Ref. 7	980	NADC, TDMA, CDMA, PCS	20%	No information
Ref. 2	200	GSM, TACS	22%	20 cm
Ref. 11	95	GSM	1%	0 cm
Ref. 20	100	GSM	2%	2 cm

GSM = global system for mobile communication; C-Net = analog system with frequency division multiple access; NADC = North American digital cellular; TDMA = time division multiple access; CDMA = code division multiple access; PCS = personal communications service; TACS = total access communication system.

Discussion

The potential for electromagnetic interference of implanted pacemakers by cellular phones has been recognized since 1994.[7,11,12] Several investigators have demonstrated *in vitro*[3,8,13–15] and *in vivo*[2,4,5,7,9–11,16] the possibility of interference between cellular phones and pacemakers. Table III gives an overview of the *in vivo* studies. The reported incidence of interference was between 0 and 41%.

Assessment of the effects of cellular phones on pacemakers has been complicated by the wide variety of technologies in use.[1,6] Table IV shows the different wireless communication devices used worldwide.[1,6,7,12,17] There are three different generations of mobile phones characterized by the type of multiple access. First-generation phones are analog with frequency division multiple access. Second-generation phones are digital with time division multiple access, whereas third-generation phones are also digital with code division multiple access.

In the past, some investigators favored the use of analog phones by pacemaker patients, because interference was found to be less with these devices.[1,6] With digital transmission modes becoming dominant worldwide, such a recommendation is no longer practical.

In this study, we examined the effects of two UMTS cellular phones with a peak power of 0.25 W, which was recently introduced in Europe. Not all studies were done under worst-case conditions. Therefore, we changed the program mode of all tested pacemakers in order to make them most sensitive to electromagnetic interference. Atrial and ventricular sensitivity settings were programmed to their most sensitive values, and all pacemakers were programmed to unipolar atrial and ventricular sensing. In patients with spontaneous rhythm, the pacemaker rate was programmed higher in order to detect inhibition of the pacemaker.

The sensitivity setting is most critical, which was confirmed in several studies.[1,7,12,18] The manufacturers allow different most sensitive values for permanent programming of the pacemaker. Whereas in CPI Guidant pacemakers a permanent sensitivity setting of 0.25 mV is possible, Medtronic pacemakers allow permanent sensitivity setting only to 2.0 mV values.

Limitations

We tested only two UMTS mobile phones with a maximum power of 0.25 W. The UMTS cellular phone modifies the power output between 0.01 and 0.25 W. Therefore, we are not able to give any information about the peak power values. To our knowledge, there is currently no method to evaluate this, because no UMTS simulator is available. Sparks et al.[19] have used 25-W stimulated Global System for Mobile Communication (GSM) signals generated by a frequency synthesizer for testing second-generation mobile phones. In the future, this might also be possible for UMTS signals.

Conclusion

Third-generation mobile phones are safe for patients with PPM. This is due to the high-frequency band for this system (1,800–2,200 MHz) and the low power output between 0.01 and 0.25 W. Both mobile phones switched between

Table IV.

Wireless Communication Devices

Category	Generation	Multiple Access	Transmission Mode	Power	Band	Predominant Countries
C-Net	1	FDMA	Analog, continuous	0.005–0.75 W	450 MHz	Germany, Austria, South Africa, Portugal
TACS	1	FDMA	Analog, continuous	0.6 W	900 MHz	England, Italy, Spain
AMPS	1	FDMA	Analog, continuous	0.6–3.0 W	900 MHz	USA
NMT	1	FDMA	Analog, continuous	0.005–0.75 W	450 MHz, 900 MHz	Scandinavia
GSM	2	TDMA	Digital, pulsed with 217 Hz DTX-mode (2 and 8 Hz)	0.02–2.0 W (1.0 W)	890–960 MHz (1,800 MHz USA = DCS) (1,900 MHz USA = PCS)	Europe, worldwide
NADC (USCD)	2	TDMA	Digital, pulsed with 50 Hz	0.6–3.0 W	800–900 MHz	USA, South America
PDC	2	TDMA	Digital, pulsed with 11 Hz	1.0 W	1,900 MHz	Japan
IS 95 (N-CDMA)	3	CDMA	Digital, variably pulsed	0.2–6.3 W	820–960 MHz, 1,900 MHz	USA, Asia
UMTS (W-CDMA, IMT 2000)	3	CDMA	Digital, not pulsed	0.01–0.250 W	1.8–2.2 GHz	Worldwide

FDMA = frequency division multiple access; TDMA = time division multiple access; CDMA = code division multiple access; DCS = digital cellular system; PCS = personal communications service; DTX = discontinuous transmission; W-CDMA = wideband code division multiple access; IMT 2000 = international mobile telecommunications at 2,000 MHz; AMPS = advanced mobile phone system; NMT = Nordic mobile telephone; PDC: Pacific or personal digital cellular; UMTS = Universal mobile telecommunication system.

UMTS and GSM modes, which is potentially dangerous for pacemaker patients. Although we did not see any interference in this study, it is well known that the 900-MHz band of the GSM mode can cause inhibition in pacemakers. We would like to recommend to the cellular phone manufacturers to produce phones that operate only the UMTS mode.

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