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The effects of mobile phones on pacemaker function

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Abstract

Objectives: The electromagnetic field generated by different systems have well-recognized adverse effects on pacemaker functions. The aim of this study is to evaluate the adverse effects of mobile phones on pacemaker functions.
Methods and results: A total of 679 patients with permanent pacemakers were enrolled in this study. The study was performed in two steps. Pacemaker lead polarity was unipolar in the first step and bipolar in the second step. Pacemaker sensitivity was first at nominal values, it was then reduced to the minimal value for that pacemaker and tested again. Two mobile phones were symmetrically located on both sides of the pacemaker pocket with the antennas being equidistant at 50, 30, 20 and 10 cm and in close contact with the pocket. The tests were performed when both mobiles were opened, on stand-by, were receiving a call, during the call and were closed. Thirty-seven patients with pacemakers were adversely affected (5.5%) (33 VVI-R pacemakers were converted to asynchronous mode, and 3 were inhibited, 1 DDD-R pacemaker developed ventricular triggering). When the lead polarity was unipolar, the rate of adverse effect was higher when compared to the bipolar state (4.12% and 1.40%, $p<0.01$). The increase in sensitivity was not an independent factor on the rate of being affected ($p>0.05$). The rate of observing an adverse effect increased as the pacemaker got older ($p<0.05$).
Conclusions: Mobile phones might have adverse effects on pacemaker functions under certain conditions. This does not result in any symptoms other than the inhibition of pacemakers, and pacemaker functions return to normal when the mobile phones are removed away from the patient.

Keywords: Pacemaker; Mobile telephone; Electromagnetic interference

1. Introduction

The effects of the electromagnetic field created by various systems on medical devices and pacemakers are well recognized [1–3]. Mobile phones are being used at an increasing pace worldwide, thereby bringing the adverse effects of the electromagnetic field to a level of public health problem [4–8]. One of such adverse effects is the one exerted on permanent pacemaker functions.

Mobile phones transmit voice messages by employing radiowaves of different length. The perception by the pacemaker perception circuit of the signals generated during opening, stand-by, accepting a call and closing the mobile phone might result in oversensing and undersensing. These might result in permanent or temporary changes in pacemaker functions. The mode of the pacemaker, its lead polarity and sensitivity, the output power and the antenna length of the mobile phone and the distance between the mobile phone and the pacemaker have all been reported to be influential on the adverse effects of the mobile phones on pacemakers [9–11]. There are in vitro [10,12–14] and clinical studies [9,15–18] reporting that Global System for Mobile Communication (GSM) mobile phones operating with digital technology might have adverse effects on pacemaker functions. Yet, the question of whether the use of mobile phones is safe for patients with pacemakers remains unanswered.

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Table 1
Clinical features of the study patients

Patients	679
Women/Men	188/491
Age (year)	68±7
ECG findings before the implantation	
Sick sinus syndrome	285 (42%)
AV block	312 (46%)
Other	82 (12%)
Pacemaker type	
VVI	68 (10%)
VVI-R	535 (79%)
DDD	8 (1.2%)
DDD-R	35 (5.2%)
VDD	14 (2%)
AAI	18 (2.6%)
AAI-R	1 (0.1%)

In our study, we tested the effects of GSM 900 MHz mobile phones on pacemakers. We made an attempt to identify the presence of a possible adverse effect, if present, the conditions within which it was influential and tried to identify the measures for prevention.

2. Method

2.1. Patients and pacemakers

The study was carried out from 1999 to 2001 on 679 patients implanted with transvenous pacemakers at different time intervals and were coming to routine pacemaker control visits. The aim of the study was explained to all of the patients. The oldest pacemaker was implanted 16 years ago and the newest one only 1 day before the study was initiated. There were pacemakers from eight different manufacturers. Of the 679 pacemakers; 535 were in VVI-R mode, 68 were VVI, 35 were in DDD-R, 8 were in DDD, 14 were in VDD, 1 was in AAI-R and 18 were in AAI mode. Except for the seven VVI pacemakers which were unipolar, all the others were multiprogrammed and were using six different rate response sensors.

2.2. Mobile phones

Two mobile phones were utilized in the study (Nokia 6150 power output 2 W, Nokia 6110 power output 2 W); they were operating with GSM 900 MHz digital system.

2.3. Study protocol

The study was performed under emergency department conditions with continuous electrocardiography monitorization. In patients who had their own heart rhythms during the test, the rate of the pacemaker was changed with a programmer to a value that was 10 beats/min above that of the patient, and pacemaker rhythm was established.

The study had two steps. In the first step, the lead polarity of all the pacemakers were converted to unipolar, the pacemaker sensitivity first had nominal values, then it was reduced to the minimum value for that pacemaker (sensitivity was increased to maximum) and tested. In the second step, the lead polarity of the pacemaker was converted to bipolar, and again, pacemaker sensitivity was first at nominal values and then reduced to minimum values for that pacemaker and tested. At both steps, two mobile phones were located on either side of the pacemaker being equidistant from the pocket. This distance was 50 cm in the beginning. One phone was used to call the other. After 20 s of ringing, the other phone accepted the call. The call was terminated after talking for 20 s. Afterwards, the same procedure was repeated by placing both of the mobiles at 30, 20 and 10 cm of distance and then direct contact with the pacemaker pocket.

For assessing the effect, pacemaker sensitivity and lead polarity, pacemaker mode, the age of the pacemaker, the type of the existing effect, the distance between the mobile and the pacemaker pocket and the symptoms that developed in the patients were evaluated. If the pacemaker was affected at any stage of the study, the test was stopped due to ethical considerations, and further steps were not performed.

When the lead polarity was unipolar and the test was attempted with the pacemaker sensitivity at minimal values,

Table 2
The effects of pacemaker lead polarity and sensitivity on the results

		Pacemaker patients	Affected pacemakers
Unipolar†	Nominal‡ sensitivity	679 (535 VVI-R, 68 VVI, 35 DDD-R, 8 DDD, 14 VDD, 1 AAI-R, 18 AAI)	16 (% 2.4) (9 VVI-R, 7 VVI)
	Maximal sensitivity	644 (519 VVI-R, 61 VVI, 28 DDD-R, 8 DDD, 9 VDD, 1 AAI-R, 18 AAI)	12 (% 1,8) (3 VVI-R, 9 VVI)
Bipolar	Nominal‡ sensitivity	644 (523 VVI-R, 45 VVI, 35 DDD-R, 8 DDD, 14 VDD, 1 AAI-R, 18 AAI)	2 (%0.3) (2 VVI-R)
	Maximal sensitivity	624 (514 VVI-R, 45 VVI, 29 DDD-R, 8 DDD, 9 VDD, 1 AAI-R, 18 AAI)	7 (% 1,1) (5 VVI-R, 1 VVI, 1 DDD-R)

† vs. bipolar $p<0.01$.
‡ vs. maximal sensitivity $p>0.05$.