Electromagnetic interference from GSM and TETRA phones with life-support medical devices

Maila Hietanen[a] and Viktor Sibakov[b]
[a] *Finnish Institute of Occupational Health, New Technologies and Risks, Helsinki, Finland*
[b] *Helsinki University of Technology, Espoo, Finland*

Summary. Disturbances in hospital devices caused by cellular telephone signals were investigated. The interference sources were GSM900, GSM1800, and TETRA380 phones. The number of medical appliances tested was 23. Most measurements were taken in a semi-anechoic laboratory. To simulate the worst situation, the phones were adjusted to emit at their maximum power levels. No interference was observed if the distance from GSM1800 phone was over 5 cm. Corresponding safety distance for GSM900 phone was 70 cm, and for TETRA phones over 3 m. Hence, the use of GSM1800 type mobile phones can be considered safe, whereas GSM 900 and TETRA phones may cause considerable interference in hospital devices, which can result in life-endangering situations.

Key words: electromagnetic fields, equipment and supplies, hospital, cellular phone.

Riassunto *(Interferenze elettromagnetiche da telefoni GSM e TETRA su dispositivi medici di supporto vitale)*. In questo lavoro vengono studiati i disturbi su dispositivi medici in ospedale causati da telefoni cellulari. Le sorgenti di interferenza erano telefoni GSM a 900 MHz, a 1800 MHz e TETRA 380. Il numero di dispositivi medici testati era 23. La maggior parte delle misure sono state raccolte in camera semianecoica. Per simulare le condizioni di caso peggiore, i telefoni sono stati regolati per trasmettere alla loro massima potenza. Nessuna interferenza è stata osservata con i telefoni GSM1800 per distanze superiori a 5 cm. La corrispondente distanza di sicurezza per i GSM900 è risultata 70 cm, per i TETRA oltre 3 m. Quindi l'uso di telefoni GSM1800 può essere considerato sicuro, mentre i GSM900 e i TETRA possono creare interferenze che possono dare luogo a situazioni pericolose.

Parole chiave: campi elettromagnetici, apparecchiature e forniture ospedaliere, telefono cellulare.

INTRODUCTION

Safety of patients and acute medical treatments in hospitals require fast and constant attainability of the staff. Traditionally, the hospitals use a paging system that can usually show only phone number of the caller. The person answers the call by using a special number code in the nearest telephone. The limitation of the paging system is that it functions only in the hospital area. The best technical solution for the staff would be the use of mobile telephones. They are, however, forbidden in most hospitals, indicated by warning labels outside the front door of a hospital as shown in *Figure 1*. This prohibition is based on the suspicion that mobile phones cause disturbances in medical equipment, hence endangering safety of the patients.

This study aimed to test interference by cellular telephones in the hospital environment, and to find areas where the use of mobile phones is safe. The objective was, therefore, to clarify whether the traditional paging system could be replaced by cellular phones.

Requirements for electromagnetic compatibility of medical equipment have been defined generally in the IEC standard 601-1-2 [1, 2]. Concerning radiofrequency (RF) fields emitted by cellular phones, the immunity of medical devices is defined by the electromagnetic compatibility requirement which is 10 V/m for life-support equipment in the frequency range of 26 to 2500 MHz.

MATERIALS AND METHODS

Mobile phones used as the interference source during the immunity tests were GSM900 MHz and GSM1800 MHz-phones (global system for mobile communication), and TETRA380 MHz (terrestrial trunked radio) functioning in the TETRA network and restricted for the authorised use, such as police, firemen and ambulance staff. In the normal use the base stations adjust the transmission power of the phones according to the traffic. In order to simulate the worst possible situation, the emitted power of the test phones was set at the maximum level using a specific service program.

GSM phones transmit pulsed signals, which consist of short carrier wave bursts of 580 μs of dura-

Indirizzo per la corrispondenza (Address for correspondence): Maila Hietanen, Finnish Institute of Occupational Health, Topeliuksenkatu 41 a A, 00250 Helsinki, Finland. E-mail: maila.hietanen@ttl.fi.

Fig. 1 | *Label indicating that use of cellular phones is forbidden inside a hospital.*

tion, at repetition frequency of 217 Hz. The duration of a pulse is only 12.5% of the duration of the whole transmission period, and the average power of a GSM signal is 1/8 of its peak power. The pulse power was set to 2 W for the GSM900 phone and to 1 W for the GSM1800 phone during the tests. TETRA-phones transmit digital 380 MHz signals with a pulse frequency of 17 Hz. During the immunity tests the transmission power was set to 3 W.

The testing focused particularly on the equipment that could endanger patients' safety because of electromagnetic disturbance *(Table 1)*.

During the immunity tests all equipment were measured using the same measurement methods. The general principal was to arrange effective interference conditions in order to disturb the appliances as strongly as possible. Most of the measurements were made in the semi-anechoic, electronically isolated laboratory where the only sources of interference were the active mobile telephones. The possible disturbances in the function of the tested equipment were thus caused by RF fields transmitted by the mobile phone.

The medical appliances tested were connected to a patient simulator aimed to test the operations of the appliance. If there was no simulation equipment available, the appliance to be tested was connected to electric circuitry mimicking the function of the simulation equipment or to an assisting test person. Some of the tested appliances were so complicated that they could only be partly simulated.

The functions of the tested appliance were disturbed with the mobile phones by approaching the appliance from various directions. The antenna of phone was held both in vertical and horizontal position during the testing in order to assess the effect of the field polarization. The wiring, couplers and other similar components were set to stay straight for approximately one meter's distance and the possible metal objects that could cause reflections were removed from the vicinity of the equipment.

Measurement errors caused by a fault in a simulator were eliminated by following measures:

- simulation equipment was placed outside the testing room or as far as possible from the source of interference;
- electromagnetic immunity of the simulator was tested before the actual testing of the hospital equipment;
- some of the appliances were tested several times with different types of measurement circuits.

Some of the appliances were tested in the premises of a hospital due to transportation problems. Although the repeatability of these tests was not so effective as in the semi-anechoic laboratory, the testing in real surroundings corresponded to the normal hospital conditions and hence added validity of the research. In hospital conditions, the tested appliance was measured either by connecting the appliance to a patient-simulator or to a test subject. The measuring coupling used in the laboratory tests was not always possible to use in the hospital. Also the test phone, the tested appliance and the simulator were often close to one another due to the lack of space. When using a simulator, the possible interference was tested separately.

RESULTS

The results of the project indicate that the phone GSM1800 disturbs the tested appliances the least.

Table 1 | *The hospital equipment tested*

Equipment type	Name and model
Anaesthesia machine	Engström EAS 9010
Dialyzer	Fresenius 4008B DrakeWillock SYS1000
Defibrillator	HP 43120A Cardiolife TEC 7200H
Diathermy device	Martin ME 401 Radiotom 704
ECG Monitor	Cardiocap II CH-2S Cardiocap II CH-S-25-01 AS/3 F-C4B5
Endoflator	Endoflator 257
Sphygmo-manometer	Dinamap 8100 Dinamap 1846
Insufflator	Laparof Electronic 3509
Pulseoxymeter	Criticare 503 Datex OSP 200 Biochem BCI 3303
Respirator	Bird 6400 Evita 2 Dura 8413930
Ultrasound device	Aloka SSD-830 Aloka SSD-1400

Table 2 | *Distance (cm) of interference caused by the TETRA phone*

Device in test	Interference on the screen	Function interrupted	Faulty action	Interference sound	Device reported error
Fresenius 4008B	-	-	-	-	5
DrakeWillock SYS	5	-	5	-	5
HP 43120A	60	-	60	-	-
Cardiolife TEC	-	-	100	-	40
Biochem BCI 3303	30	-	-	30	-
Bird 6400	-	10	150	-	150
Evita 2 Dura	90	-	50	-	50
Cardiocap II CH-2S	60	-	300	-	-
Cardiocap II CH-S-25-01	-	-	50	-	-
AS/3 F-C4B5	10	-	10	-	-
Aloka, SSD-830	80	-	15	-	-
Aloka, SSD-1400	300	-	-	300	-
Dinamap 1846	50	50	-	-	50

No interference was observed when the distance of the phone to the device in test was more than 5 cm. None of the tested hospital equipment was disturbed to the extent the interference would have caused danger to a patient during the treatment.

Similarly, none of the equipment was disturbed when the distance from GSM900 phone was over 70 cm, with the exception of an interference sound in the ultrasound appliance when the distance was still 2,5 meters.

The hospital equipment tested was disturbed most by the TETRA380 network phones which caused interference as far as at a distance of 3 m *(Table 2)*.

DISCUSSION

In this study, the interference sensitivity of various hospital appliances to RF fields emitted by cellular telephones was tested. The functions of some of the appliances were so complicated that their simulation, and testing could only be carried out partially.

The results showed that GSM1800 phones did not cause significant disturbances and they can therefore normally be considered safe to use in the hospital environment. GSM900 phones, on the other hand, are recommended to be used only in the limited area where there are no interference-sensitive appliances. It must also be reminded that GSM1800 phones used presently are so called dual band-phones, which transmit randomly either 1800MHz or 900 MHz frequency unless the phone has been supplied only by a 1800 MHz card. Therefore, the security instructions given for GSM900 phones must also be applied to the dual-band phones if there is no certainty of the transmission frequency.

Cellular phones of the TETRA380 network caused the most serious disturbances in the tests. Their use should thus be allowed only in strictly limited areas. In certain circumstances, such as in urgent transportation of patients, in fire and rescue service and in police work, the use of TETRA phones in the hospital area cannot be avoided. Particularly the use of TETRA phones inside an ambulance should be minimized.

The disturbances caused by the phone in transmission mode to the equipment critical for patient's vital functions, such as defibrillator or respirator, could cause life-endangering situations.

CONCLUSIONS

In conclusion, the use of GSM1800 type mobile phones can be considered safe provided that the users are aware of the possibility of disturbance. Also, the staff which is allowed to use these phones should observe the functions of medical equipment and report all the suspected interference. GSM900 phone types can, on the other hand, have considerable interference effects, and their use should be assessed separately in each place. When defining safe areas, one should take into consideration the background field strength in the area, which depends on the base station's distance and settings. Normally the transmission power of a cellular phone and hence the interference risk of the equipment are the smaller the nearer from the hospital the base station is located.

The use of mobile phones by the patients and visitors should be allowed, if a hospital has specific rooms reserved for this purpose, where medical equipment is not being used ("cellular phone safe - wards"). Permitting the use of mobile phones freely in the hospital environment would require testing of a considerably larger variety of equipment and hospital-specific risk assessments.

Submitted on invitation.
Accepted on 24 January 2007.

References

1. International Electrotechnical Commission. IEC 601-1-2. *Medical electric equipment. Part 1: General requirements for safety; 2. Collateral standard: Electromagnetic compatibility. Requirements and tests.* Geneva: IEC; 1993.
2. International Electrotechnical Commission. IEC 601-1-2. *Medical electric equipment. Part 1: General requirements for safety; 2. Collateral standard: electromagnetic compatibility. Requirements and tests*. (2nd ed.). Geneva: IEC; 2001.