Effect of Cellular Phone on Fetal Heart Rate Patterns

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Abstract: There are reports showing that electromagnetic fields (EMFs) emitted at non-thermal levels may be associated with biological alterations in target cells. In this study it is objected to assess the potential influences of EMFs produced by cellular phones on fetal heart rate. Non Stress Test (NST) is a widely used method of fetal monitoring and assessing fetal health and well-being. Sixty volunteers with uncomplicated term pregnancies were studied by a Spacelabs AM-67 Doppler ultrasound monitor. Fetal Heart Rate recordings were obtained while there were no Cellular Phone around for 10 minutes. Afterwards, all patients were exposed to EMFs for 10 minutes. NST was performed while they were holding the CP on stand-by mode and then on dialing mode, each for 5 minutes. The recordings were analyzed with respect to baseline heart rate, accelerations and decelerations. The Wilcoxon matched-pairs signed-ranks test was used to compare these variables. The results indicate that EMFs emitted by CP do not cause any demonstrable effects on baseline FHR, acceleration or deceleration.

Keywords: Electromagnetic fields; Cellular Phones; Fetal heart rate

1. INTRODUCTION

The phenomenon of electromagnetic interference by mobile phones is real and potentially clinically significant. This has been recognised by the Department of Health and the Medical Devices Agency, leading to bans on phone use in hospitals. Current evidence suggests that mobile phones can cause malfunction of medical equipment, but only when used in close proximity. Allowing phone use in non-patient care areas and improving staff education may improve compliance with hospital policies [1].

Fetal heart rate (FHR) monitoring is a widely used method of assessing fetal health and well-being [2]. The common use of cellular phones (CP) has given rise to concerns about the potential influences of electromagnetic fields (EMFs) on human physiology [3]. There are reports showing that EMFs emitted by CP at non-thermal levels may be associated with biological alterations in target cells [4]. Abnormal FHR pattern due to CP use has not been described in the medical literature, but if there is a subtle effect on FHR pattern, it might be detected by the help of changes in non-stress test (NST), Figure 1 , 2.

Fig 1. FHR in silent mode

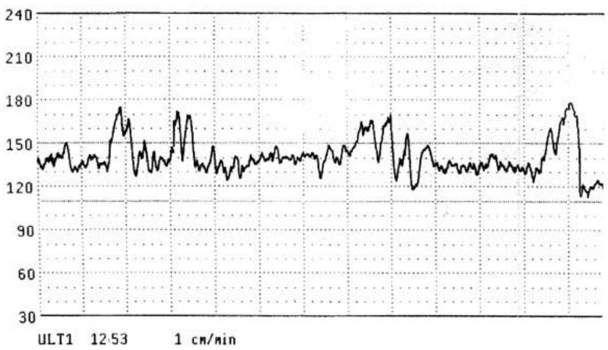
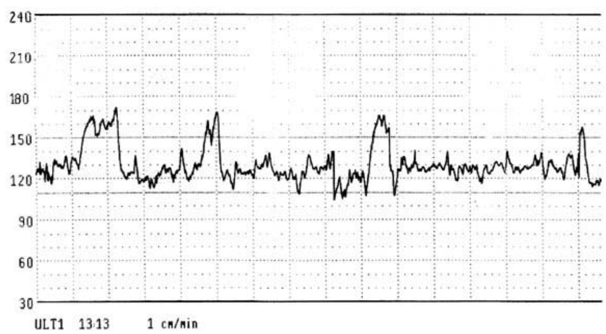


Fig 2. FHR in calling mode



Numerous investigations have confirmed the occurrence of various biological effects evoked in humans by pulse microwave radiation emitted from radars or cellular phones. In such exposures, the electromagnetic energy may reach very high values of power density in peak at relatively low time-averaged levels of power density. Up till now, no one has evidenced that the relationship between radiation dose and biological effects has the same correlation function for weak field as well as for a very strong field in peak [5].

Over twenty years of its existence, cellular radio systems have become one of the major sources of human exposure to electromagnetic field (EMF) of high frequency. With the increasing number of cellular phones, the interest in health effects of exposure to EMF emitted by them continues to grow. At present, there is a general opinion that thermal effect (change of electromagnetic energy into thermal energy) is an essential mechanism of possible biological effects. The majority of world standards for exposure to EMF are based on this effect. In a Polish article the author presents Polish standards and those of the International Commission on Nonionizing Radiation Protection (ICNIRP) for EMF of frequencies used in cellular radio systems, both basic that limits SAR (Specific Absorption Rate), and derived that limits the power density, as well as intensity of electric and magnetic fields. Attention was also turned to the problems concerning the application of cellular phones and those resulting from the character of the field emitted by them to which their users are exposed. Bearing in mind the results of the laboratory analyses of SAR values occurring in the user's head, and measurements of power density in the vicinity of the base station antennas, it can be stated that, in view of binding and recommended standards, cellular phones do not present any hazard to their users (private or professional). However, it should be stressed that standards adopted protect the user's head against the thermal effect, whereas the question on whether they also protect against non-thermal effects still remains without answer [6].

In a survey in order to compare fetal heart rate reaction to external physical stimulation with the non-stress test (NST) a prospective study was done evaluating documentation of fetal heart accelerations by two methods. The standard NST was performed prior to the ultrasound evaluation. The NST results were not available to the ultrasonographer. M-mode ultrasound was used to establish a stable fetal heart rate. The ultrasound transducer was used to stimulate fetal movement by indentations of the uterus over the fetal small parts. A second fetal heart rate was determined within 15 s after stimulation. Results show that a total of 122 patients had 159 studies performed. The fetal heart rate range due to fetal startle (recoil) was -22 to 14 (median of 3) in the 45 fetuses with non-reactive NSTs and 1 to 38 (median of 15) in the 114 fetuses with a reactive NST ($p < 0.001$). A receiver operating curve comparing the fetal response to the startle and the NST revealed an area under the curve of 0.972, consistent with high specificity and sensitivity. In conclusion the fetal heart rate response to external stimulation correlates with the formal NST [7].

Reference ranges for the various components of fetal heart rate (FHR) patterns with gestation were established from the study of 119 fetuses at 20-39 weeks. These fetuses were proved by cordocentesis to be normoxaemic and nonanaemic. The mean baseline FHR decreased, while the baseline variability, both for amplitude and oscillation frequency, increased with gestation. The number and amplitude of accelerations increased, and the frequency and duration of decelerations decreased with gestation. These data indicate that in the interpretation of FHR patterns adjustments according to the gestational age of the fetus should be made [8].

2. METHODS AND MATERIALS

FHR recordings were obtained in 60 volunteers with uncomplicated pregnancies while there were no CP around for 10 min. Afterwards, all patients were exposed to EMFs for 10 min. NST was performed while they were holding the CP on stand-by mode and then on dialing mode, each for 5 min. All patients were at term, with singleton fetuses in cephalic presentation. A Spacelabs AM-67 Doppler ultrasound monitor obtained FHR recordings. The recording was successfully completed in all patients and all recordings were made for a period of at least 20 min. The FHR analysis was based on the description of heart rate patterns by Nijhuis et al. [9]. The recordings were blinded and analyzed by one of the authors with respect to baseline heart rate, accelerations and decelerations. The Wilcoxon matched-pairs signed-ranks test was used to compare these variables. When the variables were analyzed there were no significant differences in any of the parameters (Table 1).

The FHR analysis was based on the description of heart rate patterns by Nijhuis et al. [10]. The description of the various heart rate patterns is as follows:

1. FHR pattern A: Heart rate is stable, with a small oscillation bandwidth. Isolated accelerations may occur. These are strictly related to movements.

2. FHR pattern B: There is a wider oscillation bandwidth than with FHR pattern A and frequent accelerations during movements.

3. FHR pattern C: Heart rate is stable but with a wider oscillation bandwidth than with FHR pattern A and no accelerations.

4. FHR pattern D: Heart rate is unstable, with large and long-lasting accelerations frequently fused into a sustained tachycardia.

The recordings were blinded and analyzed with respect to baseline heart rate, accelerations, decelerations, and FHR patterns (A, B, C, and D). The Wilcoxon matched-pairs signed-ranks test was used to compare the above-described variables in calling and silent modes.

3. RESULTS

Fifteen variables were compared while the FHR recordings were analyzed. The variables included the baseline heart rate, accelerations lasting for 15 seconds, accelerations lasting for 3 minutes, decelerations, type of heart rate pattern (A, B, C or D), time spent in each pattern, accelerations and decelerations in each pattern, and, finally, transition between these patterns. Table I shows the median values for the variables, with the range in parentheses, and the *P* values for each of them.

Table I. FHR characteristics in calling and silent mode

FHR characteristic	**Value (median and range)**		**Statistical significance**
	Calling mode	**Silent mode**	
Baseline heart rate (beats/min)	135 (115-150)	127.5 (120-140)	$P = .3387$
Accelerations >15 s (total No.)	4.5 (0-11)	4.5 (1-13)	$P = .6089$
Accelerations >3 min (total No.)	0.0 (0-2)	0.0 (0-1)	$P = .5637$
Decelerations (Total No.)	0.0 (0-0)	0.0 (0-1)	$P = .3173$
Transitions (No.)	1.0 (0-3)	1.0 (0-3)	$P = 1.0000$
Time spent in cardiotocographic pattern A (%)	59.2 (0-100)	27.8 (0-100)	$P = .8886$
Accelerations in cardiotocographic pattern A (No./10min)	0.0 (0-1.9)	0.0 (0-2.8)	$P = .5930$
Decelerations in cardiotocographic pattern A (No./10 min)	0.0 (0-0)	0.0 (0-1)	$P = 1.0000$
Time spent in cardiotocographic pattern B (%)	29.2 (0-100)	41.5 (0-100)	$P = .8886$

Accelerations in cardiotocographic pattern B (No./10min)	9.95 (6.4-14.2)	7.7 (5.4-14.5)	*P* = .5000
Decelerations in cardiotocographic pattern B (No./10min)	0.0 (0-0)	0.0 (0-0)	*P* = 1.0000
Time spent in cardiotocographic pattern D (%)	0.0 (0-61.7)	0.0 (0-84.4)	*P* = 1.0000
Accelerations in cardiotocographic pattern D (No./10 min)	2.5 (0-3.8)	2.9 (0-4.7)	*P* = .5930
Decelerations in cardiotocographic pattern D (No./h)	0.0 (0-0)	0.0 (0-0)	*P* = 1.0000

There were no significant changes in any of the parameters.

3. DISCUSSION

There has been continuing concern about possible harmful effects of EMFs, due to increased use of CP in pregnancy. CP emit microwaves pulsed at extremely low frequency (800–1800 MHz) but have been reported to produce subjective disorders such as headache, sleep irregularity, hematological and cardiovascular abnormalities [11]. Anatomically, the fetus may be in close proximity to the CP during transport and use. Therefore, EMFs emitted by CP may affect the FHR patterns by means of changing nerve conduction and cardiac contractility [2, 12].

The considerable increase in using mobile communication which will increase when new technologies, such as UMTS, are introduced has resulted in further public interest concerning the possible health risks from electromagnetic fields of cellular phone networks. In view of evaluating the scientific state-of-the art, it has been shown that based on the available scientific results, the individual risk in view of proved health consequences is considered low. There are, however, indications of biological effects of high-frequency electromagnetic fields, even at intensities below the currently applied limit values or recommendations for limit values. Although the health relevance of these effects is still unclear, they give reason to precautionary measures with the object to minimise possible health risks which might affect a large number of persons. The precautionary measures recommended by the Federal Office for Radiation Protection include three principles: 1. Exposure of the general public to electromagnetic fields should be as low as possible. This applies for both the fixed parts of cellular phone networks and for mobile phones. 2. The population should be informed of risks in an objective and comprehensive way and be involved in the decisions on the construction and operation of cellular phone networks. 3. Scientific uncertainties should be reduced by means of well-directed research programmes [13].

In a study objecting to define normative fetal heart rate (FHR) tracing characteristics between 25-28 weeks' gestation in a low-risk population with normal pregnancy outcomes and to determine which criteria best determine FHR reactivity, continuous FHR tracings were reviewed from 188 low-risk women participating in a trial of the Mammary Stimulation Test (MST) at 25-28 weeks' gestation. A reactive tracing required the presence of > or =two accelerations in 20 min. Different acceleration criteria were evaluated based upon the width of the acceleration (short vs. long) and the amplitude of the acceleration (10 vs. 15 bpm). Seventy-one percent of the FHR tracings were reactive using the higher amplitude (15 bpm), short criteria. This number increased significantly to 92% when the lower amplitude (10 bpm), short criteria were used (p <0.01). As gestational age advanced, there was a trend toward increased reactivity irrespective of which criteria were used, but these differences were not significant. Reducing the acceleration amplitude criteria to 10 bpm in preterm pregnancies will maximize the number of reactive nonstress tests. This is advantageous because it would improve test specificity and decrease the false-positive rate [14].

The radiofrequency pulse introduced by EMFs induces electrical currents within the tissues of the patient. The majority of the radiofrequency power is transformed into heat within the tissues. These induced currents caused by the radiofrequency pulse could potentially cause thermal and nonthermal effects. As opposed to the negligible thermal effects caused by switched gradients, thermal effects from currents induced by radiofrequency pulses are a major concern. The greatest heating occurs at the surface of the body, and hence fetal tissue heating would be expected to be minimal, although there are reduced mechanisms for heat loss in a fetus as the maternal and fetal circulations are uncoupled. The specific absorption rate is dependent on the power of the radiofrequency pulse, the number of radiofrequency pulses applied per unit time, and the type of radiofrequency coil used. During cellular phone connections, radiofrequency power applied is low because of the relatively low number of radiofrequency pulses applied [15].

Nevertheless, our results indicate that EMFs emitted by CP do not cause any demonstrable effects on baseline FHR, acceleration or deceleration. We hypothesize that the amniotic fluid surrounding the fetus is an important barrier against EMFs emitted by CP.

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