Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study

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Objective: To investigate the effect of cell phone use on various markers of semen quality.
Design: Observational study.
Setting: Infertility clinic.
Patient(s): Three hundred sixty-one men undergoing infertility evaluation were divided into four groups according to their active cell phone use: group A: no use; group B: <2 h/day; group C: 2–4 h/day; and group D: >4 h/day.
Intervention(s): None.
Main Outcome Measure(s): Sperm parameters (volume, liquefaction time, pH, viscosity, sperm count, motility, viability, and morphology).
Result(s): The comparisons of mean sperm count, motility, viability, and normal morphology among four different cell phone user groups were statistically significant. Mean sperm motility, viability, and normal morphology were significantly different in cell phone user groups within two sperm count groups. The laboratory values of the above four sperm parameters decreased in all four cell phone user groups as the duration of daily exposure to cell phones increased.
Conclusion(s): Use of cell phones decrease the semen quality in men by decreasing the sperm count, motility, viability, and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality. (Fertil Steril® 2008;89:124–8. ©2008 by American Society for Reproductive Medicine.)

Key Words: Cell phone, electromagnetic radiations, sperm parameters, male infertility

Cell phones have become indispensable devices in our daily life. These phones operate between 400 MHz and 2000 MHz frequency bands and emit radiofrequency electromagnetic waves (EMW). Reports of potential adverse effects of radiofrequency EMW on brain, heart, endocrine system, and DNA of humans and animals are widely reported in the literature. Electromagnetic waves alter brain electroencephalographic activity and cause disturbance in sleep (1); cause difficulty in concentration, fatigue, and headache (2); and increase reaction time in a time-dependent manner (3). They increase the resting blood pressure (4) and reduce the production of melatonin (5). They are also implicated in DNA strand breaks (6). However, the concern that cell phone use might have adverse impacts on the semen quality has not been extensively addressed.

Infertility affects approximately 15% of couples of reproductive age, and with nearly half of these cases resulting from male factor infertility this area of research is of great interest to both physicians and research scientists (7, 8). The relationship between cell phone use and male infertility remains unclear. Harmful EMW emitted from cell phones may interfere with normal spermatogenesis and result in a significant decrease in sperm quality. There are two reports available that show an effect of cell phones on sperm motility in humans (9, 10). Animal studies indicate that EMW may have a wide range of damaging effects on the testicular function and male germ line (11, 12). Electromagnetic waves can affect reproductive function through both thermal and nonthermal effects (13).

The objective of the present study was to assess the effects of cell phone use on various sperm parameters among patients undergoing infertility evaluation at a male infertility clinic. Our goal was to better understand the role of cell phone use in male infertility and assess the need for any

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protective measures to prevent harmful effects of EMW, if any, on the male reproductive system.

MATERIALS AND METHODS

The study was approved by the Institutional Review Board, and informed consent was obtained from all patients. In this observational study we examined 361 men attending an infertility clinic from September 2004 to October 2005. The age of the study population was 31.81 ± 6.12 years (mean ± SD). Subjects with a history of smoking, chewing tobacco, alcohol consumption, orchitis, varicocele, tuberculosis, diabetes mellitus, and hypertension were excluded from the study. In addition, patients who suffered from viral/bacterial infection in the past 4 weeks, presented with a history of cardiac, neural, or nephrotic disease, or had a family history of any genetic disease were also excluded.

Semen samples were collected by masturbation in a sterile wide-mouthed calibrated container after an abstinence period of 5 days. Semen analysis was performed according to World Health Organization guidelines to evaluate eight sperm parameters: volume, liquefaction time, pH, viscosity, sperm count, motility, viability, and percentage normal morphology (14). The information on cell phone usage of the patients was recorded and the subjects were divided into 4 groups according to their daily active cell phone usage, i.e., talking time: group A: no use (n = 40); group B: <2 h/day (n = 107); group C: 2–4 h/day (n = 100;); and group D: >4 h/day (n = 114). The technicians analyzing the semen samples were blinded to the use of cell phones by the subjects.

Correlation was determined between eight sperm parameters by Pearson correlation coefficients. Multivariate analysis of covariance (MANCOVA) was used to assess the eight sperm parameters among four groups of cell phone users simultaneously, adjusted by patient age (as covariate). When age as a covariate in the MANCOVA was found to be nonsignificant (F = 0.92; P=.4975), subsequent analysis was done by multivariate analysis of variance (MANOVA). Sperm parameters were transformed to multivariate normals where appropriate before analysis, and results were reported on a back-transformed scale unless otherwise indicated.

Because patients are often grouped as normal or abnormal based on the sperm count, we also assessed if sperm parameters differed among cell phone use groups within sperm count groups. This was accomplished by dividing our study population into two groups: normospermic (≥20 million/mL; n = 297) and oligospermic (<20 million/mL; n = 64). We also reclassified the subjects into two cell phone user groups based on their frequency of active cell phone use: >4 h/day (n = 114) and <4 h/day (n = 247) to use a two-way MANOVA for statistical evaluation. Difference in each sperm parameter between these groups was assessed using Bonferroni simultaneous confidence intervals with a significance level at α=.05. Statistical software packages R (Version 2.3.0; R Foundation for Statistical Computing, Vienna, Austria) and SAS (Version 9.1, SAS Institute, Cary, NC) were used.

RESULTS

A strong correlation was seen between sperm count, motility, viability, normal morphology, and pH; motility and viability were almost perfectly correlated. Semen analysis in the four cell phone user groups showed a decrease in sperm count, motility, viability, and normal morphology with the increase in daily use of cell phone (Table 1; Fig. 1). The difference between cell phone user groups for each sperm parameter was assessed simultaneously using Bonferroni simultaneous confidence intervals (SCI). The 95% Bonferroni SCI for each variable showed that sperm count, percentage motility, viability, and normal morphology differ significantly among most cell phone use groups (Table 2). A significant difference was seen in the sperm parameters motility, viability, and normal morphology among the two sperm count groups (F = 21.86; P<.0001) when evaluated by using two-way MANOVA (Table 3).

DISCUSSION

Currently there are over 700 million cell phone users in the world. These phones operate at different frequencies in

TABLE 1

Semen analysis results in four cell phone use groups (values are mean ± SD).

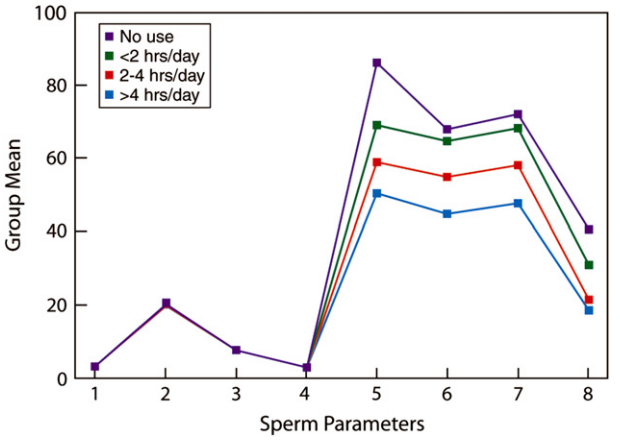
Parameters	Group A	Group B	Group C	Group D
Volume (mL)	2.86 ± 1.67	3.16 ± 1.62	2.83 ± 1.40	3.37 ± 1.80
Liquefaction time (min)	20.00 ± 3.58	20.04 ± 3.18	20.85 ± 3.56	20.39 ± 4.11
pH	7.67 ± 0.20	7.67 ± 0.18	7.76 ± 0.19	7.78 ± 0.16
Viscosity	3.00 ± 1.01	2.98 ± 1.03	3.11 ± 1.21	2.95 ± 1.14
Sperm count ($\times 10^6$/mL)	85.89 ± 35.56	69.03 ± 40.25	58.87 ± 51.92	50.30 ± 41.92
Motility (%)	67.80 ± 6.16	64.57 ± 8.47	54.72 ± 10.97	44.81 ± 16.30
Viability (%)	71.77 ± 6.75	68.21 ± 8.65	57.95 ± 11.28	47.61 ± 16.67
WHO morphology (% normal)	40.32 ± 13.06	31.24 ± 12.24	21.36 ± 10.12	18.40 ± 10.38

Note: Group A: no use (n = 40); group B: <2 h/day (n = 107); group C: 2–4 h/day (n = 100); and group D: >4 h/day (n = 114). Means and SD were based on data on the original scale; all analyses were done with appropriately transformed data.

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FIGURE 1

Sperm parameter profile for cell phone use groups. The x-axis lists eight sperm parameters: 1 = volume; 2 = liquefaction time; 3 = pH; 4 = viscosity; 5 = sperm count; 6 = motility; 7 = viability; and 8 = percent normal morphology. The y-axis depicts the mean value of the corresponding sperm parameters for each cell phone use group.



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different countries and continents. Exposure of radiofrequency energy depends upon the frequency of the cellular phone. Analog phones operate at 450–900 MHz, digital phones (Global System for Mobile Communications [GSM]) at 850–1900 MHz, and third-generation phones at approximately 2000 MHz (15). For years the cell phone companies have assured people that cell phones are perfectly safe. For assessing exposure from transmitters located near the body, the most useful quantity is the specific absorption rate (SAR), the amount of radiofrequency energy absorbed from the phone into the local tissues. The SAR of cell phones varies from 0.12 to 1.6 W/kg body weight depending upon the model. In the United States, the upper limit of SAR allowed is 1.6 W/kg (16).

We studied the sperm parameters of 361 males attending an infertility clinic after segregating them into four different groups based on their daily active use of cell phone. We found that most of the comparisons of four sperm parameters: sperm count, motility, viability, and normal morphology between all the cell phone user groups were significantly different. This led us to suggest that the use of cell phones may adversely affect the quality of semen by decreasing the sperm counts, motility, viability, and morphology, which might contribute to male infertility. However, these four sperm parameters showed significant positive correlation among each other. Therefore, the decrease in value of one sperm parameter is bound to reduce the other parameter also. Another significant finding of our study is the decline in the quality of semen based on the active cell phone usage time. The laboratory values of the four sperm parameters were lower in the

TABLE 2

Simultaneous confidence intervals of differences between cell phone use groups evaluating eight sperm parameters.

Parameters	Groups A & B	Groups A & C	Groups A & D	Groups B & C	Groups B & D	Groups C & D
Volume (mL)	−0.091 to 0.072	−0.084 to 0.083	−0.102 to 0.058	−0.389 to 0.053	−0.046 to 0.040	−0.063 to 0.026
Liquefaction time (min)	−2.27 to 2.18	−3.10 to 1.40	−2.60 to 1.87	−2.47 to 0.87	−1.96 to 1.27	−1.19 to 2.10
pH	−0.115 to 0.105	−0.209 to 0.014	−0.223 to −0.004	−0.175 to −0.009[a]	−0.189 to −0.02[a]	−0.098 to −0.065
Viscosity	−0.66 to 0.70	−0.80 to 0.58	−0.63 to 0.72	−0.64 to 0.38	−0.47 to 0.52	−0.35 to 0.66
Sperm count ($\times 10^6$/mL)	−1.67 to 4.40	1.29 to 7.49[a]	4.05 to 10.03[a]	−0.85 to 2.57	0.60 to 3.81[a]	−1.35 to 1.97
Motility (%)	−6.16 to 45.83	12.86 to 65.11[a]	22.71 to 74.49[a]	11.04 to 56.09[a]	22.21 to 66.52[a]	6.65 to 51.36[a]
Viability (%)	−5.55 to 48.84	14.04 to 68. 70[a]	24.42 to 78.59[a]	11.69 to 58.82[a]	23.55 to 69.92[a]	7.29 to 54.07[a]
WHO morphology (% normal)	0.12 to 1.11[a]	2.65 to 3.66[a]	4.14 to 5.12[a]	0.70 to 1.26[a]	1.60 to 2.12[a]	−0.12 to 0.41

Note: Group A: no use (n = 40); group B: <2 h/day (n = 107); group C: 2–4 h/day (n = 100); and group D: >4 h/day (n = 114). Means and SD were based on data on the original scale; all analyses were done with appropriately transformed data.

[a] Significant ($P < .05$) using multivariate analysis of variance and Bonferroni simultaneous confidence intervals.

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TABLE 3

Difference between two sperm count groups within cell phone use groups evaluating seven sperm parameters.

Sperm Parameters	Group 1,[a] mean ± SD	Group 2,[b] mean ± SD	Simultaneous confidence intervals of difference between groups 1 and 2
Volume (mL)	2.75 ± 1.57	3.17 ± 1.64	−0.078 to 0.029
Liquefaction time (min)	20.39 ± 3.81	20.37 ± 3.61	−1.85 to 1.85
pH	7.80 ± 0.17	7.71 ± 0.18	−0.01 to 0.15
Viscosity	2.90 ± 1.43	3.03 ± 1.03	−0.72 to 0.49
Motility (%)	42.00 ± 17.16	58.96 ± 12.35	−59.49 to −10.31[c]
Viability (%)	44.62 ± 17.47	62.41 ± 12.77	−62.58 to −11.45 [c]
WHO morphology (% normal)	14.98 ± 9.11	27.71 ± 13.11	−1.69 to −1.05[c]

Note: Means and SD were based on data on the original scale; all analyses were done with appropriately transformed data.
[a] Group 1: sperm count: $9.26 \pm 5.54 \times 10^6$/mL (n = 64).
[b] Group 2: sperm count: $73.57 \pm 41.57 \times 10^6$/mL (n = 297).
[c] Significant ($P < .05$) using two-way MANOVA and Bonferroni simultaneous confidence intervals.

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group using cell phones for longer periods of time. When we tried to evaluate the effects of cell phone use within two different sperm count groups (normospermic and oligospermic), we found that the sperm motility, viability, and morphology were still significantly different in subjects using cell phone for less than 4 h/day than those who were using it more. Our initial data have led us to believe that the effect of cell phone use on sperm parameters do not depend on the initial semen quality of the subjects.

In a recent study done by Fejes et al. (9) on 371 men undergoing infertility evaluations, the duration of possession and the daily transmission times of cell phones correlated negatively with the proportion of rapid progressive motile sperm and positively with the proportion of slow progressive motile sperm, although there were no changes in the total motility. Therefore they concluded that prolonged use of cell phones might have negative effects on sperm motility. Davoudi et al. (10), in a prospective study involving 13 men with normal semen analysis, also found that using GSM phones for 6 h/day for 5 days decreased the rapid progressive motility of sperm. The present results are in accordance with these authors, although we found that not only motility but also sperm count, viability, and morphology are negatively affected by the use of cell phones.

In their study on mice, Aitken et al. (12) suggested that radiofrequency EMW might have a genotoxic effect on epididymal spermatozoa, which needs further investigation (12). Contrary to this, Malyapa et al. (17) were unable to find any damaging effects of Code Division Multiple Access phones, with frequency modulation 847.74 MHz, on mouse fibroblasts and human glioblastoma cells. Dasdag et al. (18) also failed to report any adverse effect of cell phone exposure on sperm count, morphology, and histologic structure of testis in rats. However, it is impractical to compare a rat model to humans because of its small testicular size, nonpendulous scrotum, and the fact that its testis can migrate between the abdomen and scrotum in the inguinal canal (19).

Although the present study suggests the role of cell phones in male infertility, the mechanism of action of EMW emitted from cell phones on male reproductive system is still unclear. Electromagnetic waves can possibly affect reproductive function via three mechanisms: 1) an EMW-specific effect; 2) a thermal molecular effect; or 3) a combination of these (13). Wang et al. (20) suggested in their study on mice that Leydig cells are among the most susceptible cells to EMW, and injury to Leydig cells may affect spermatogenesis. Increase in tissue or body temperature on exposure to EMW may also cause reversible disruption of spermatogenesis (21–23). Electromagnetic wave–dependent decrease in melatonin (5) an antioxidant, can predispose sperm to oxidative stress. Because a negative correlation is seen between sperm motility and sperm chromatin damage (24), and EMW have been shown to effect sperm motility, another possible mechanism of effects of EMW on sperm is DNA damage. Further research is needed to identify the mechanism of action of EMW emitted from cell phones on the male reproductive system.

The present study has a few limitations. We relied only on the self-perceived history of the subjects and did not validate their cell phone use. We did not take into account the occupational history of the subjects and EMW exposure from other sources such as radiotowers, PDAs, Bluetooth devices, computers, etc. We also did not consider the effects of cell phone possession in standby position. Inability to analyze covariates other than age is also a limiting factor. Because each cell phone model has a different specific absorption rate, differentiating between the effects of various models is also important. We are trying to address these issues in a follow-up

study. Nevertheless, the present study has revealed significant findings which pave way for future research in this area.

In conclusion, our results suggest that the use of cell phones by men is associated with a decrease in semen quality. The decrease in sperm count, motility, viability, and normal morphology is related to the duration of exposure to cell phones. These effects may not depend on the initial semen quality of the subjects. More studies are needed to identify the mechanism involved in the reduction of semen quality.

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