



Open Access

INVITED RESEARCH HIGHLIGHT

Male Health

Are men talking their reproductive health away?

Ashok Agarwal¹, Damayanthi Durairajanayagam^{1,2}

Asian Journal of Andrology (2015) 17, 433–434; doi: 10.4103/1008-682X.140963; published online: 18 November 2014

The advent of mobile phones has revolutionized communication trends across the globe. As the popularity of mobile phone usage continues to escalate, there is now growing concern about the effects of radiofrequency electromagnetic waves (RF-EMW) exposure on biological tissues, such as the brain and testes. Researchers have sought to link the much debated decline in human sperm quality in the last decade, with increased exposure to RF-EMW, particularly through mobile phone usage. In a recent systematic review and meta-analysis on the effect of mobile phone RF-EMW radiation on sperm quality, Adams *et al.*¹ demonstrated an association between mobile phone exposure and reduced sperm motility and viability, with inconsistent effects on sperm concentration.¹ Results from 10 pooled experimental (*in vitro*) and observational (*in vivo*) human studies ($n = 1492$) led these researchers to suggest that exposure to RF-EMW radiation from carrying a mobile phone in the trouser pocket negatively impacts sperm quality.

Mobile phones operate within low RF bands and radiate nonionizing energy in the form of RF-EMW. Mobile phones emit RF energy when in use (talk mode) and the closer the mobile phone is to the tissue when in use, the greater the RF-EMW energy that will be absorbed. When used as a hands free device along with a wired or wireless earpiece/headset (both of which also emit a small amount of RF energy), placement of the mobile phone when in talk mode either in the trouser pocket or clipped to a belt, places the main source of the mobile phone RF-EMW energy away from the head but closer to the genital tissue.²

Electromagnetic waves radiation is absorbed as it interacts with matter and

transfers wave energy into the medium. The amount of RF-EMW radiation energy absorbed by human tissue depends on the frequency, intensity, polarization and duration of exposure.³ Specific absorption rate (SAR) is a measure of the relative amount of RF energy absorbed by the human body (expressed in $W\ kg^{-1}$) when using a mobile phone. SAR value for mobile phones operating at its maximum power level is limited to $1.6\ W\ kg^{-1}$ in the US, Canada and Australia, and $2.0\ W\ kg^{-1}$ in Europe.⁴ The SAR value varies for each type of mobile phone and can also vary greatly in any one particular model based on usage conditions.

Exposure to RF-EMW radiation could potentially exert thermal and nonthermal effects on biological tissue. Heat is mostly generated from the handset, but the thermal effects of mobile phone radiation seem less probable as adverse heating effects occur at SAR values of $4.0\ W\ kg^{-1}$ and greater.⁵ Exposure to various environmental frequencies can induce cellular changes.⁶ Nonthermal effects of mobile phones on the male reproductive system include increased generation of seminal reactive oxygen species and reduction in antioxidant enzymes leading to oxidative stress, chromosomal damage and micronuclei formation, altered spermatozoal membrane potential and signal transduction (decreased calcium efflux, histone kinase and protein kinase C), altered sperm proliferative activity, increased caspase activation leading to apoptosis, suppression of testicular steroidogenesis and reduced testosterone levels, leading to decreased spermatogenesis.^{2,3,7,8}

Current literature on EMW radiation exposure and male reproduction remains controversial, with conflicting results reported in human and animal studies on the effects of RF-EMW on male fertility.^{2,3,7,8} In their meta-analysis, Adams *et al.* pooled results from 6 *in vitro* ($n = 254$ –361 each) and

4 *in vivo* ($n = 8$ –64 each) human studies, consisting of cohorts from the general population and those attending fertility clinics.¹ Of the 10 selected studies, 9 used sperm motility as a parameter, while 5 to 6 studies had data on sperm viability and concentration as a measure of sperm quality. *In vitro* application of RF energy was mostly 850–900 MHz, while SAR values ranged from 1 to $2\ W\ kg^{-1}$. The source of RF-EMR was mainly commercially-available mobile phones and exposure time was mainly 60 min. Heterogeneity was high in all their meta-analyses, and was a study limitation.¹

On the whole, the main limitation in researching the effects of RF-EMW exposure on male reproductive health is the study design and methods applied; as those that have been used or are currently available lacks sufficient strength to reveal conclusively if EMW radiation impairs sperm quality.⁸ It would be ideal if experiments on mobile phones and male fertility use standardized exposure protocols such as a fixed mobile phone frequency (MHz) and intensity with minimal fluctuations in SAR, fixed exposure time (either acute, intermittent or continuous radiation) and study the same key primary outcomes of sperm quality. But then again, this is hardly the case in reality.

The real difficulty lies in recreating a realistic scenario representative of actual habits of mobile phone users in the general population. Study designs may seem perfect theoretically, but when put into practice, they may prove to be less than ideal. For example, in observational studies, the amount and chronicity of exposure could be subject to recall bias. The location of mobile phone storage (shirt or pants pocket, or belt clip) and usage type (hand held or hands-free) should be noted.⁸ Unreported or unknown confounders that may influence study results, such as age and smoking habits need to be factored in.¹ Studies on cohorts that seek fertility intervention may not be

¹Center for Reproductive Medicine, Cleveland Clinic, Cleveland, Ohio, USA. ²MARA University of Technology, Sungai Buloh, Malaysia.
Correspondence: Dr. A Agarwal (agarwaa@ccf.org)

representative of the general population. Semen parameters of fertile men are also subject to variation at each sample collection.⁹ Studies that use purified sperm samples lack the “buffering” effects of other semen components, soft tissues and clothing that may decrease the effective SAR on human sperm.⁸

Animal studies comes with its own limitations in projecting its data onto humans for example, in the commonly used mouse/rat model, it can be argued that these animal models have smaller-sized testes, which are able to ascend freely through the inguinal canal into the abdomen, and scrota, which are nonpendulous.⁸ Further, the distance between the testes and the source of the EMW radiation (the antenna) in these animal studies are varied (placed in or on the cage, approximated to the animal testes or close to the animal's face), which prevent any direct comparisons between study results.⁸

Accurate estimation of the amount of RF-EMW that the testes are exposed to during a mobile phone call can be tricky as the testes are protected by multiple layers of scrotal tissue. Using a two-dimensional computational model simulation of scrotal tissues and the finite difference time domain method, Mouradi's group established that for an *in vitro* experimental set up to mimic real life conditions, the mobile phone emitting RF-EMW should be positioned at a distance of 0.8–1.8 cm further away than the real life model.¹⁰ The group also demonstrated

that RF-EMW emitted from mobile phone located nearby the groin can penetrate testicular tissues to reach spermatozoa in the seminiferous tubules. For further in depth studies, three-dimensional modeling goes an additional step by considering the anatomical details of the male genital soft tissues. The model should also factor in the potential additional effects of clothing layers.¹⁰

Prior to Adam's study, another meta-analysis investigating the effects of mobile phone EMW radiation on sperm quality in men within the reproductive age had also demonstrated that mobile phone usage leads to detrimental effects in sperm quality. The analyses were performed on 11 studies (separated into *in vitro* and *in vivo* studies) from both the general and subfertile cohorts, and the strength of evidence obtained varied from very low to very high for the different parameters.¹¹ Despite the results of these analyses and the large number of studies that associate mobile phone usage with a decrease in male fertility, the evidence remains inadequate at this stage. Until proven otherwise, it is recommended that those with subfertility issues or seeking assisted reproduction minimize their exposure to environmental RF-EMW radiation to alleviate its potential negative impact on sperm quality.

COMPETING INTERESTS

The authors declare no competing interests.

REFERENCES

- 1 Adams JA, Galloway TS, Mondal D, Esteves SC, Mathews F. Effect of mobile telephones on sperm quality: a systematic review and meta-analysis. *Environ Int* 2014; 70: 106–12.
- 2 Merhi ZO. Challenging cell phone impact on reproduction: a review. *J Assist Reprod Genet* 2012; 29: 293–7.
- 3 Agarwal A, Singh A, Hamada A, Kesari K. Cell phones and male infertility: a review of recent innovations in technology and consequences. *Int Braz J Urol* 2011; 37: 432–54.
- 4 Dahal KP. Mobile communication and its adverse effects. *Himalayan Phys* 2013; 4: 51–9.
- 5 Aitken RJ, Bennetts LE, Sawyer D, Wiklendt AM, King BV. Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. *Int J Androl* 2005; 28: 171–9.
- 6 Kesari KK, Kumar S, Nirala J, Siddiqui MH, Behari J. Biophysical evaluation of radiofrequency electromagnetic field effects on male reproductive pattern. *Cell Biochem Biophys* 2013; 65: 85–96.
- 7 La Vignera S, Condorelli RA, Vicari E, D'Agata R, Calogero AE. Effects of the exposure to mobile phones on male reproduction: a review of the literature. *J Androl* 2012; 33: 350–6.
- 8 McGill JJ, Agarwal A. The impact of cell phone, laptop computer, and microwave oven usage on male fertility. In: Du Plessis S, Agarwal A, Sabanegh E Jr, editors. *Male Infertility: a Complete Guide to Lifestyle and Environmental Factors*. New York: Springer; 2014. p. 161–77.
- 9 Cooper TG, Noonan E, von Eckardstein S, Auger J, Baker HW, *et al*. World Health Organization reference values for human semen characteristics. *Hum Reprod Update* 2010; 16: 231–45.
- 10 Mouradi R, Desai N, Erdemir A, Agarwal A. The use of FDTD in establishing *in vitro* experimentation conditions representative of lifelike cell phone radiation on the spermatozoa. *Health Phys* 2012; 102: 54–62.
- 11 Dama MS, Bhat MN. Mobile phones affect multiple sperm quality traits: a meta-analysis. *F1000Res* 2013; 2: 40.