Original Article

Electromagnetic Radiation from Cell Phones: A Contributing Factor to Male Infertility

Sarwat Jabeen[1], Aisha Abdul Haq[1], Soofia Nigar[1], Sadia Iqbal[1], Surriyya Sarwat[2] and Sahar Mubeen[1]

ABSTRACT

Objective: To observe changes in thickness of germinal epithelium in seminiferous tubules of testis of Albino rats exposed to electromagnetic radiations emitted by cell phones.

Study Design: Experimental comparative study.

Place and Duration of Study: This study was conducted at the Department of Anatomy, Dow International Medical College Ojha campus of Dow University of Health Sciences from 1st February 2011 to 31st October 2011.

Materials and Methods: Male Albino rats (n=70) were taken from animal house of Dow University of Health Sciences. Rats were divided into Control Group A (n=35) and Exposed Group B (n=35). Exposed group was exposed to electromagnetic radiation from cell phones (3 hours/day) and subdivided into 5 groups according to the time of exposure. Exposed rats were sacrificed along with their control sub-groups. Germinal epithelium in seminiferous tubules was observed for thickness in both groups using a micrometer.

Results: The mean ±SD values of thickness of germinal epithelium of seminiferous tubules of control and respective exposed subgroup were compared, a significant decrease in the thickness of germinal epithelium of seminiferous tubules of exposed subgroup was observed with (P Value 0.000) C.I of 95%. Intragroup comparison of exposed groups between B1 and B2 showed a significant decrease in thickness of germinal epithelium (P-value 0.02) at C.I of 95%.

Conclusion: Electromagnetic radiation from cell phones has adverse effects on the germinal epithelium of seminiferous tubules of Albino rats. Exposed groups showed marked decrease in the thickness of germinal epithelium when compared with their controls.

Key Words: Cell phones exposure, electromagnetic radiation, germinal epithelium, cell phone, Infertility, seminiferous tubules.

Citation of article: Jabeen S, Haq AA, Nigar S, Iqbal S, Sarwat S, Mubeen S. Electromagnetic Radiation from Cell Phones: A Contributing Factor to Male Infertility. Med Forum 2021;32(8):2-6.

INTRODUCTION

At present cell phones are vital for our daily lives, these are used throughout the world and their use is also increasing gradually[(1)]. In 1987, the Global Mobile Communications System (GSM) was developed. The system is used by most European and Asian countries, including Pakistan. In GSM, the frequencies transmitted from mobile phones to mobile phone antennas range from 870 to 915 MHz, while the frequencies transmitted from antennas to cell phones range from 935 to 960 MHz.[(2)].

[1.] Department of Anatomy, DUHS, Karachi.
[2.] Department of Anatomy, Sindh Medical College (JSMU) Karachi.

Correspondence: Dr. Sarwat Jabeen, Associate Professor of Anatomy, Dow Medical College, DUHS, Karachi.
Contact No: 0334-6666727, 0333-2070879
Email: sarwat.jabeen@duhs.edu.pk

Received: March, 2021
Accepted: May, 2021
Printed: August, 2021

Cell phones emit EMR (Electromagnetic radiation) which have adverse effects on body[(3)]. EMR is a self-propagating wave which has two components, an electric and a magnetic field which oscillate in phase perpendicular to each other and to the direction of energy propagation[(4).] James Clerk Maxwell, first described EMR, which was confirmed by Heinrich Hertz. Electromagnetic spectrum waves ranging from very long radio waves to very short gamma rays [(5).]

Literatures prove that radiofrequency electromagnetic waves from cell phones have several hazardous effects on human and animal system by penetration or absorption the human body [(6)]. Studies show that EMR produces changes in the brain electroencephalographic activity causing sleep disturbances, lack of concentration, headache, fatigue, decreased melatonin production[(7)]. A possible link between cell phone use and infertility has been established by studies[(8).] It is observed that most men carry their cell phones in pocket of their trouser while using wireless devices like blue tooth to communicate, which leads to the exposure of testes to a very high power mobile phone radiation as compared to be in "standby mode"[(9)]. In contrast few

studies reported no such adverse effects of EMR from cell phone in the animal experiments. Till now no clinical study was identified to assess the harmful effects of EMF on reproductive system in humans. However some studies suggested a negative impact of cell phone use on spermatogenesis[10].

Concern over the effects of EMR on male fertility has been growing, no conclusive data are available yet. Several data suggested that fertility is going to decline markedly as a result of excessive use of modern technologies like cell phones. There is lack of data available to find correlation between infertility and radiation effects of mobile phones on germinal cells of seminiferous tubules.

We exposed albino rats to radiation from cell phones, for variable time periods to observe the microscopic changes in thickness of germinal epithelium in relation to the duration of exposure. The findings of our study will certainly add new aspects in the field of reproductive science.

Our study was primarily aimed to explore the effect of EMW emitted from cell phones on thickness of germinal epithelium of seminiferous tubules. This could be then correlated with the possibility of infertility with the excessive use of cell phones that might cause destruction of spermatogenic cell series secondarily.

MATERIALS AND METHODS

An Experimental comparative study was done from 1st February 2011 to 31st October 2011at the Animal house and Dow Diagnostic Research and Reference laboratory of Dow University of Health Sciences.

Male albino rats (n=70) were divided into Control group A (n=35) and Exposed group B (n=35). Each group was further sub-divided into five groups of 7 rats each (A1, A2, A3, A4 and A5 and B1, B2, B3, B4 and B5, respectively). Subdivision of exposed group was according to the duration of exposure to EMR.

Adult male albino rats (n=70) of 90 – 120 days were included in the study. Exclusion criteria comprised of **f**emale rats, animals with age >120 days, weight > 250 gms, animals on experimental drugs.

Exposed group B, was subjected to EMR, emitted from conventional GSM cell phone which is a commonly used cell communication system all over the world [11]. The frequency used ranged from 1835 to 1850 MHZ. The rats were exposed to EMR 3 hours daily for 15 weeks. 8 phone sets were used in active silent mode in each cage. A small metal cage with a wooden bottom was used for our study. The rats were then exposed with EMR for a period of 3 hours. [12]. Animals of exposed subgroup B1, B2, B3, B4 and B5 were exposed to EMR from cell phones for a period of 30, 50, 70, 90 and 110 days, respectively. Rats were then sacrificed after giving anesthesia, testes were removed after giving vertical abdominal incision, washed and fixed in 10% formalin.

Testes from each animal was examined histological changes. Testes were kept in 10% formalin and Bouin's fluid respectively for 24 - 48 hours, dehydrated in ascending grades of alcohol from 70% to100%, further cleared in xylene and embedded in paraffin, then blocks were prepared for sectioning. Hematoxylin and Eosin method was used to stain 4 µm thick sections.

To calculate the thickness of germinal epithelium, roughly circular or oval seminiferous tubules were selected, and calculated using the ocular micrometer scale under 10x objective and 8x lens. Ten sections were selected for observation from each animal. Five fields were examined in each section.

Statistical Analysis: Statistical analysis was performed by SPSS version 16. Two sample independent t –test was applied to compare mean differences in the thickness of germinal epithelium amongst the exposed subgroups (B) and respective control subgroup (A). One Way Analysis Of Variance was applied to find significance differences in the thickness of germinal epithelium among exposed subgroups (B1-B5). Statistically significant p value of ≤ 0.05 is taken as significant with 95% confidence interval.

RESULTS

Microscopic study of control group (Group A) showed normal architecture of seminiferous tubules with interstitial tissue, containing leydig cells (Fig: 1). Seminiferous tubules consist of germinal epithelium which comprises of 2 types of cells i.e. spermatogenic cells and sertoli cells surrounded by basal membrane. Sertoli cells are distinguished from spermatogenic cells due to the presence of large, oval and vesicular nucleus. All lineage of spermatogenic cells are visible.

In exposed group (group B), irregularities were observed in the germinal epithelium and basal membrane of the seminiferous tubule, together with vacuolization between germinal epithelial cells, undulations in the basal membranes of numerous seminiferous tubules, non-matured germinal epithelial cells in the lumen and vacuolar degeneration were also observed (Fig:3).

The mean ±SD values of thickness of germinal epithelium of seminiferous tubules in control subgroups A1, A2, A3, A4 and A5 were 93.57±2.93, 92.85±4.29, 93.71±6.94,92.71±5.87 and 89.71±2.36µm respectively.

Mean ±SD values of the thickness of germinal epithelium of seminiferous tubules in exposed subgroups B1, B2, B3, B4 and B5 were 43.17±17.09, 27.16±11.18, 19.91±0.97, 15.93±2.20 and 9.23±0.57µm respectively.

The mean±SD values of thickness of germinal epithelium of seminiferous tubules of control and exposed subgroup was compared, significant change was observed. Reduction in the thickness of germinal epithelium of exposed subgroup was observed with (P Value 0.000) at C.I of 95%. (Table I and Fig: 2)

Statistically insignificant decrease in thickness of germinal epithelium of seminiferous tubules was seen .while comparing, B2 and B3, (P-value 0.58), B3 and B4 (P-value 0.92), B4 and B5 (P-value 0.65) at C.I of 95%. Subgroups B1 and B2 (P-value 0.02) at C.I of 95% showed a substantial decrease in the mean thickness of germinal epithelium of seminiferous tubules.

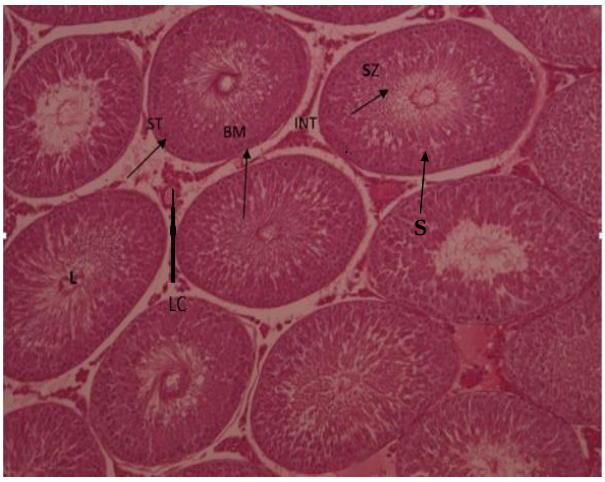

Figure No.1: H & E stained, 4µm thick section from control group(A), shows compact arrangement of seminiferous tubules (ST) with intact basement membrane (BM), interstitial space (INT), Leydig cell (LC), St (Sertoli cell), lumen (L) of tubule containing spermatozoa (SZ) X 100.

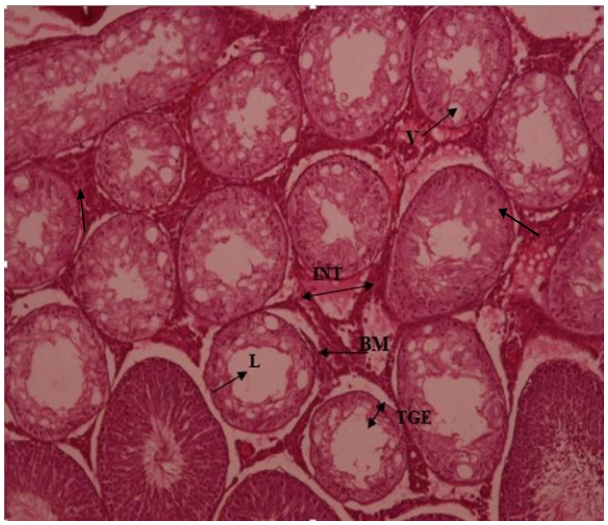

Figure No. 2: H & E stained, 5 µm thick section of testis from group B5, shows distorted seminiferous tubules with vacuoles (V), reduction in diameter of the tubule, distorted basement membrane (BM), reduced thickness of germinal epithelium (TGE) reduction in sertoli cells (St) and widening of interstitial spaces (INT). Leydig cells (LC) can be seen. X100.

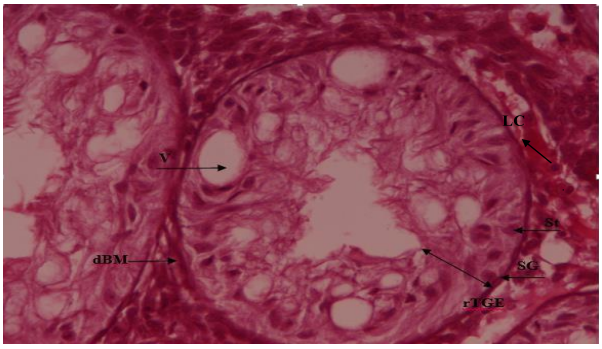

Figure No.3: H & E. stained, 5 µm thick section of testis from group B3, shows thickened, distorted basement membrane (dBM), sertoli cells (St), spermatogonia (SG), reduced thickness of germinal epithelium (rTGE), leydig cells (LC), vacuole (V). X1000 (oil immersion).

Table No.1: Comparison of Mean thickness of germinal epithelium (µm) among control (A) and exposed Subgroups (B)

Animal Subgroups (n=7)	Control Group A (n=35) A1-A5	Exposed Group B (n=35) B1-B5	P-value
30 Days	93.57±2.93	43.17±17.09	0.000***
50 Days	92.85±4.29	27.16±11.18	0.000***
70 Days	93.71±6.94	19.91±0.97	0.000***
90 Days	92.71±5.87	15.93±2.20	0.000***
110 Days	89.71±2.36	9.23±0.57	0.000***
Mean ± SD	92.51±4.74	23.08±14.66	0.000***

DISCUSSION

Currently, the development of cell phones and wireless technology have attained a crucial role in growing technology leading to increased usage and exposing more people are to EMF which could eventually contribute to serious public health problem[13]. Some studies have shown that EMFs cause hostile effects on the morphology and physiology of human and animal tissues**.** Cell phone exposure has an impact on male infertility[14], causing a fall in sperm count, affecting sperm motility, viability and morphology. Many studies identified these findings as a result of oxidative stress[15].

The findings of the present study suggest that a significant decrease in the thickness of germinal epithelium of seminiferous tubules when exposed to cell phones radiation for 2 hour daily for 4 months. This may be due to vulnerability of germinal epithelium to electromagnetic radiation or apoptosis resulting from heat or stress induced by radiation [15]. Study by Bin-Meferij et al. identified the same result, that apoptosis of cells which usually effect spermatogonia may leads to decrease in height of germinal epithelium. This ultimately results in impairment of whole cycle. [16].

Numerous data on animals and humans study showed harmful effects of EMR exposure on histology of testes and affecting male fertility [17], while others contradict

them. The study by Rajaei et al. also ruled out that exposure to EMF for long period might result in reduction in the height of epithelial cell [18]. This is consistent with our finding of decrease in height of spermatogenic cell series in exposed group.

In contrary to our study, that established decrease in the thickness of germinal epithelium in response to EMR, Trosic identified that irradiation of male rats for an hour per day with 915 MHz RF field for 2 weeks produces no changes in function or histological structure of testes. We can conclude that short-term intermittent RF radiation exposure does not represent a significant risk factor for rat reproductive function. However, long-term exposure, should be ruled out for adverse effects [19]. The study by Ozguner found out mean height of germinal epithelium were considerably decreased in EMF group (P<.0.05), expose to radiation by RF generator, frequency ranging between 869-894MHZ.[20]. This is in agreement with our study that too proved a reduction in thickness of germinal epithelium in exposed rats.

It has been suggested that long-term exposure to an EMF could affect the proliferation and differentiation of spermatogonia. In a study by Lee Set al. the number of spermatogonia was reduced, with concomitant increase in exposure to radiation. Histologically, EMF exposed groups showed vacuoles in basal membrane of seminiferous tubules, edema in the intertubular space. Seminiferous tubule diameters and germinal epithelium thickness were reduced and higher apoptotic index was observed [21]. These finding are similar to our study where reduced thickness of germinal epithelium is supposed to be due to apoptosis in the germinal epithelium [13]. This study validated our finding where decrease in thickness of spermatogenic cell series was observed with increase in duration of EMW exposure.

Study by oh JJ et al. support our study, the rats were divided into 4 groups on the basis of length of exposure and distance. Bottom of cage is provided with EMF device. After exposure of 28 days animals were sacrificed. Histological findings showed atrophy of seminiferous tubule, arrest of spermatogenesis, hyperplasia of Leydig cell, edema of interstitium and increase thickness of the basal lamina [22]. These findings are consistent with our result that showed a significant reduction in the height of germinal epithelium on exposure to 110 days as compare to expose for a shorter duration.

In a recent study by Okechuku, histological changes in the testes of rats receiving radiation from cell phones for 6 hours a day for a month include reduction in number of sperms, degeneration of Leydig cell, spermatogenic arrest and tubular necrosis. These findings are consistent with our study.[23].

CONCLUSION

EMR from cell phones has adverse effects on the germinal epithelium of seminiferous tubules of Albino rats. Exposed groups showed marked decrease in the thickness of germinal epithelium when compared with their controls. This eventually may be associated with infertility.

Author's Contribution:

Concept & Design of Study:	Sarwat Jabeen
Drafting:	Sahar Mubeen
Data Analysis:	Sadia Iqbal, Aisha Abdul Haq
Revisiting Critically:	Surriyya Sarwat
Final Approval of version:	Soofia Nigar

Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Sepehrimanesh M, Kazemipour N, Saeb M, Nazifi S, Davis DL. Proteomic analysis of continuous 900-MHz radiofrequency electromagnetic field exposure in testicular tissue: a rat model of human cell phone exposure. Enviorn Sci Pollut Res 2017;24(15):13666-13673.
2. Ghanbari M, Mortazavi SB, Khavanin A, Khazaei M. The Effects of Cell Phone Waves (900 MHz-GSM Band) on Sperm Parameters and Total Antioxidant Capacity in Rats. Int J Fertil Steril 2013;7(1): 21–28.
3. Gevrek F. Histopathological, immunohisto-chemical, and stereological analysis of the effect of Ginkgo biloba (Egb761) on the hippocampus of rats exposed to long-term cellphone radiation. Histol Histopathol 2018;33(5):463-473.
4. Ishimaru A. Electromagnetic wave propagation, radiation, and scattering: from fundamentals to applications.2nd ed. Seattle: Wiley-IEEE Press; 2017. ISBN: 978-1-118-09881-3.
5. Tipler, Paul A, Mosca G. Physics for Scientists and Engineers: Electricity, Mognetism, Light & Elementary Modern Physics. 5th ed. Lincolin, United Kingdom: WH Freeman;2004.ISBN 10:0716783398. ISBN13: 9780716783398.
6. 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(4):432-454.
7. Zang ZJ, Ji SY, Huang SZ, Jiang MH, Fang YQ. Impact of Cellphone Radiation on Sexual Behavior and Serum Concentration of Testosterone and LH in Male Mice. Occup Dis Environ Med 2016; 4(03):56.
8. Hanci H, Kerimoglu G, Mercantepe T, Odaci E. Changes in testicular morphology and oxidative stress biomarkers in 60-day-old Sprague Dawley rats following exposure to continuous 900-MHz electromagnetic field for 1 h a day throughout adolescence. Reprod Toxicol 2018;81:71-78.

9. Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, et al. Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril 2009;92(4): 1318-1325.
10. Liu K, Li Y, Zhang G, Liu J, Cao J, Ao L, et al. Association between mobile phone use and semen quality: a systemic review and meta-analysis. Androl 2014;2(4):491-501.
11. Sonmez OF, Odaci E, Bas O, Kaplan S. Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field. Brain Res 2010;1356: 95-101.
12. Deepinder F, Makker K, Agarwal A. Cell phones and male infertility: dissecting the relationship. Reprod Biomed Online 2007;15(3):266-270.
13. Gye MC, Park CJ. Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 2012;39(1):1-9.
14. Nisbet HO, Nisbet C, Akar A, Cevik M, Karayigit MO. Effects of exposure to electromagnetic field (1.8/0.9 GHz) on testicular function and structure in growing rats. Res Vet Sci 2012;93(2):1001-1005.
15. Kesari KK, Kumar S, Behari J. Effects of radiofrequency electromagnetic wave exposure from cellular phones on the reproductive pattern in male Wistar rats. Appl Biochem Biotech 2011; 164(4):546-559.
16. Bin-Meferij MM, El-Kott AF. The radioprotective effects of Moringa oleifera against mobile phone electromagnetic radiation-induced infertility in rats. Int J Clin Exp Med 2015;8(8):12487.
17. Agarwal A, Desai, NR, Ruffoli R, Carpi A. Lifestyle and testicular dysfunction: A brief update. Biomed Pharmacother 2008;62:550-3.
18. Rajaei F, Farokhi M, Ghasemi N, Sarreshtedari M, Gheibi N, Sahnehsaraei MS. Effect of electromagnetic field on mice epididymis and vas deferen-a morphometric study. J Gorgan Univ Med Sci 2009;11(1):1-7.
19. Trošić I M-PM, Pavičić I, Marjanović AM. Histological and cytological examination of rat reproductive tissue after short-time intermittent radiofrequency exposure. Arh Hig Rada Toksikol 2013;64(4):513-519.
20. Ozguner M, Ketani M A, et al. Biological and Morphological effects on reproductive organ of rats after exposure to electromagnetic field. Saudi Med J 2005;26:405-10.
21. Lee SK, Park S, Gimm YM, Kim YW. Extremely low frequency magnetic fields induce spermatogenic germ cell apoptosis: possible mechanism. Biomed Res Int 2014;(2):1- 8.
22. Oh JJ, Byun S-S, Lee SE, Choe G, Hong SKJBri. Effect of electromagnetic waves from mobile phones on spermatogenesis in the era of 4G-LTE Biomed Res Int 2018;(1):1-8.
23. Okechukwu CEJNJoE, Biosciences C. Effects of mobile phone radiation and exercise on testicular function in male Wistar rats. Nigerian J Exp Clin Biosci 2018;6(2):51-58.