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The Effects of Electromagnetic Field on the Microstructure of Seminal Vesicles in Rat: A Light and Transmission Electron Microscope Study

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Abstract: In the industrial world, almost everyone is unavoidably exposed to ambient electromagnetic field (EMF) generated from various technical and household appliances. Controversy exists about the effects of EMF on various tissues of the living bodies. Seminal vesicles as one of these accessory glands play an important role in natural seminal fluid formation and the effects of EMF on its tissue is worthy of investigation. In order to examine this 30 rat were selected and kept for one weeks in quarantine and 15 (experimental group) were exposed to 50 Hz (non-ionizing radiation) during postnatal life for 2 months. The materials were processed and observed under a light and transmission electron microscope. In the experimental rats epithelial and basal cells showed significant destructions presented by heterochromatin and dense nuclei. Cell debris and abnormal areas was recognizable in the stromal connective tissue. Obvious vacuolization was present within the epithelial cell cytoplasm and also between the cellular organelles. The nuclei of the endothelial cells of the blood vessels were more rigid and endothelial cell cytoplasm contained a lot of vacuoles and pinoctotic vesicles. The results suggested that EMF exposure may cause profound changes in the vesicle seminal tissues. Therefore exposure to EMF may result in pathological changes that lead to sub fertility and infertility.

Key words: Electromagnetic field, seminal vesicle, microstructure

INTRODUCTION

In a modern world countless number of people is exposed to an elevated electromagnetic field (EMF) with a wide frequency range because of the ever increasing rise of utilization of electric power for running domestic appliances and industrial gadgets. The transport and use of electricity generates both electrical and magnetic fields with a wide spectrum of frequencies, intensities and waveforms. There are two types of EMF, ionizing and non ionizing. We usually associate EMF being generated in relation to electrical substations, transformers, overhead transmission and distribution lines, but significant other sources of EMF exposure include endless list of house-hold gadgets and appliance of everyday use such as laser printers, vacuum cleaners, electric shavers, hair dryers, microwave ovens, television transmissions, cellular phones, Video Display Terminals (VDT) etc. Accordingly, most mammalian reproductive research has focused on these frequencies because of their ubiquitous presence in the environment (Bracken *et al*., 1995; Chiang *et al*., 1984; Quaglino, 2000).

One critical issue is whether EMF may potentially affect the reproductive system. Many studies have reviewed the numerous outcomes of the potential effects of EMF on infertility, miscarriage, premature births, intrauterine growth retardation, low birth weight, congenital malformations, genetic diseases and prenatal deaths. The possibility of an association of early pregnancy loss with residual exposure has been investigated by case-control studies (Juutilainen *et al*., 1993).

It has been shown that exposure to EMF adversely affects spermatogenic cells, Sertoli cells, Leydig cells and boundary tissue of the seminiferous tubules of the male reproductive system (Dym and Fawcett, 1970; Forgacs *et al*., 2004; Khaki *et al*., 2004, 2006; Lee *et al*., 2004; Shafik, 2005). Although all the mentioned structures play important roles in spermatogenesis, mechanical support and sperm discharge (Chung *et al*., 2005; Lacy and Rotblat, 1960; Leeson and Leeson, 1964; Yamamoto *et al*., 1987), accessory exocrine glands of male reproductive system, including seminal vesicles, prostate and Cowper's glands do have a crucial significance in

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seminal fluid formation and intact physiological ejaculatory process (Stevens and Lowe, 2005).

The seminal vesicles are male accessory sexual gland found in many species of more than 4000 mammalian species alive on the earth today. They lie inferior and lateral to the ampullae's of the ducts deferens against the fundus of the bladder. After puberty, the gland secretes a fluid called Seminal Vesicle Secretion (SVS), which accumulates in its lumen. SVS contains both protein and no protein components. When ejaculated, SVS squirts into the urethra, contributing the major part of the liquid portion of seminal plasma, which is the complex biological fluid formed from mixing of various fluid in the male reproductive tract. It has been found that extirpation of the seminal vesicle from mice and rats greatly reduces fertility (Pang *et al*., 1979; Peitz and Olds-Clarke, 1986), demonstrating the importance of SVS to sperm modification under natural circumstances. It has been also demonstrated that protein and enzyme production is dependent to testosterone, which is formed mainly by testes in males (Mansson *et al*., 1981; Koenig *et al*., 1976). Moreover, epithelial cell proliferation in the seminal vesicles seems to be testosterone dependent in male mice (Tsuji *et al*., 1991; Justulin *et al*., 2006). It is assumed that EMF exposure may have destructive effects on cytoarchitecture and microstructure of seminal vesicles and accordingly, cause abnormal or inadequate seminal fluid production and subsequent male sub fertility and infertility. In addition, as mentioned earlier, EMF exposure could have destructive effects on the testes (Dym and Fawcett, 1970; Forgacs *et al*., 2004; Khaki *et al*., 2004, 2006; Lee *et al*., 2004; Shafik, 2005) and thus, a deficiency in blood testosterone can alter epithelial proliferation and protein synthesis in seminal vesicles. There are little known about the effects of non-ionizing EMF on microstructure of seminal vesicles and that is why the authors wanted to investigate the possible effects of exposure to 50 Hz EMF (non-ionizing radiation) on the cytoarchitecture and microstructure of the seminal vesicles during postnatal periods no light and transmission electron microscopy. The harmful effects of EMF ionizing radiations (e.g., X-rays and gamma rays) have previously been demonstrated on gonadal tissues (Lee *et al*., 2004; Cecconi *et al*., 2000; De Vita *et al*., 1995; Lokmatova, 1993; Parsons, 1962).

Elbetieha *et al*. (2002) demonstrated that exposure to EMF (50 Hz, 25 mT for 90 days) had no significant effect on the weight of the testes or the number of implantation sites and viable fetuses.

The result of this study is of potential use, as exposure to electromagnetic waves is ubiquitous; a large portion of the world's population is constantly exposed to a variety of this radiation as a result of professional, residential, medical, industrial or other uses.

MATERIALS AND METHODS

Animals and maintenance: A total of 30 male Wistar rats (of approximately 5 weeks old) were used for the study. Rats were housed in cages and kept in quarantine for one week to rule out any disease. Rats were fed on compact food in the form of granules and water. This food consisted of all the essential ingredients, including vitamins and minerals. The environmental conditions (temperature and humidity) in all the animal holding areas were continuously monitored. Temperature was maintained in the range of 20-30°C and relative humidity was monitored at 35-60%. Fluorescent light was provided on a 12 h light/dark cycle and kept turned on from 8 am till 8 pm. Lights (electric fluorsent) were located at a distance of three meters from the cages so that these did not interfere with EMF of the experimental design.

EMF-producing system: The equipment was based on the Helmholtz coil, which works following Fleming's right hand rule. This produced an alternate current of 50 Hz, creating an EMF of 80 G. The intensity of the EMF could be controlled by a transformer. The equipment had two main parts. In the first there were two copper coils placed one above the other and separated by a distance of 50 cm. Between the coils (the exposure area) there was a cylindrical wooden vessel, the interior of which had a chamber for holding the cages of the experimental animals. The second part was the transformer, which checked the input and output voltage with a voltmeter and the current with an ampere meter. To prevent increases in temperature inside the chamber a fan was utilized as necessary. Five cages at a time were placed within the chamber with seven or eight rats per cage (Fig. 1).

Fig. 1: Electromagnetic field producer system

EMF exposure: Of the total of 30 rats of the experiment, 15 were selected as experimental group and 15 as control group. In experiments group, rats were exposed to EMF 8 h per day for two months. The control group had the same biological and nutritional condition as the experimental group during these two months and the difference was only EMF exposure. The entire rats, both experimental and control groups, were anaesthetized and sacrifices at the end of the two-month EMF exposure and were sent to tissue fixation laboratory.

Tissue fixation: At the termination of the stipulated exposure period as laid down in the experimental design the rats were anaesthetized with chloroform and 10% formalin was then injected through the inferior vena cava. The seminal vesicles were removed and fixed in formalin for light microscopy. Haematoxylin and eosin were used to stain the 6 mm thick histological sections.

Transmission electron microscopy: For Transmission Electron Microscopy (TEM) the tissue samples were cut into pieces (2×2 mm) and fixed in 2.5% glutaraldehyde and 1% paraformaldehyde in 0.1 M phosphate buffer (pH 7.4) for 6-8 h at 4°C. They were washed and postfixed in 2% OsO_4 for 1 h at 4°C. The tissue was dehydrated through ascending grades of ethanol and embedded in araldite CY212. Semithin sections (1 μm) were cut and stained with toluidine blue. Ultrathin sections (60-70 nm) were cut, mounted onto copper grids and stained with uranyl acetate and alkaline lead citrate. Sections were observed under a Philips CM10 transmission electron microscope.

Data analysis: All data were expressed as means±SD. All statistical analyses were performed using SPSS software, version 13.0, on the basis of the student's t-test. A p-value less than 0.01 were considered significant. Leven's test for the equality of the means was also done prior to the t-test.

RESULTS

Light microscopy

Control group: In morphological investigation of the light micrographs of the control group, seminal vesicles were seen like highly twisted tubules (Fig. 2A). Each glad had a musculoelastic capsule (Fig. 2E), the smooth muscle of their wall had organized and recognizable fibers their nuclei were euchromatic and visible (Fig. 2B). The musculoelastic capsule was lined by two layers of cells. Secretary epithelial cells and basal cells. The basal cells seemed to act as proliferate cells and the pseudo stratified epithelial cells had secretary, protein synthesizing appearance (Fig. 2D). The nuclei of the basal and secretary cells were detected euochromatic (Fig. 2D). Inside of the glands were seen twisted and honeycomb by low magnification, because of penetration of capsular connective tissue. The transverse sections of blood vessels were seen in the spaces between the secretary tubules, the endothelial cells of the vascular walls and their nuclei were also visible and the Red Blood Cells (RBCs) were recognizable (Fig. 2C).

Experimental group: Light micrographs of the experimental group illustrated cell and tissue damage in musculoelastic capsule. Muscular fibers were destructed and pathological, abnormal areas were numerous in the capsule (Fig. 3). Smooth muscle fibers did not demonstrate their organized arrangement. They were spread out in various directions. The nuclei of the smooth muscle and epithelial cells were heterochromatic and dense (Fig. 3B, C and D, Table 1). The epithelial cell layers were unorganized abnormal spaces were seen between the cells mentioned above clearly. Spaces between the smooth muscle cells seemed abnormal (Fig. 3A). The epithelial and basal cells nuclei were significantly destruct ore presented by heterochromatin and dense appearance (Fig. 3C and D, Table 1). It seemed that the number of basal cells had been reduced (Fig. 3C). The cytoplasm of the epithelial cells showed an obvious decline (Fig. 3D) Cell debris was recognizable in the stromal connective tissue (Fig. 3E). Abnormal areas and frothy spaces were seen together with the cell debris. Blood vessels showed a thinner wall than normal and the nuclei of endothelial cells were dense. Hyper perfusion of blood and an increase in RBCs were seen within the vessels (Fig. 3F).

Transmission electron microscopy findings

Control group: Epithelium of the seminal vesicle is in fact consisted of high columnar cells. Apical parts of epithelial cells were stretched to the inside of lumen and the free border had numerous microvilli in different sizes. There were specific intercellular canals between the apexes of epithelial cells. Lateral and basal parts of these cells were interdigitated into each other (Fig. 4A). The nuclei of the epithelial cells were located in range of base to the middle. Each nucleus had a nucleolus together with its condensed chromatin (Fig. 4B). Rough endoplasmic reticulum was seen widely in the basal part of the secretary epithelium. Their cistern were also wide, long and parallel to each other. Ribosomes were spread in the cytoplasm. Golgi complexes were seen to occupy a vast area at the top of

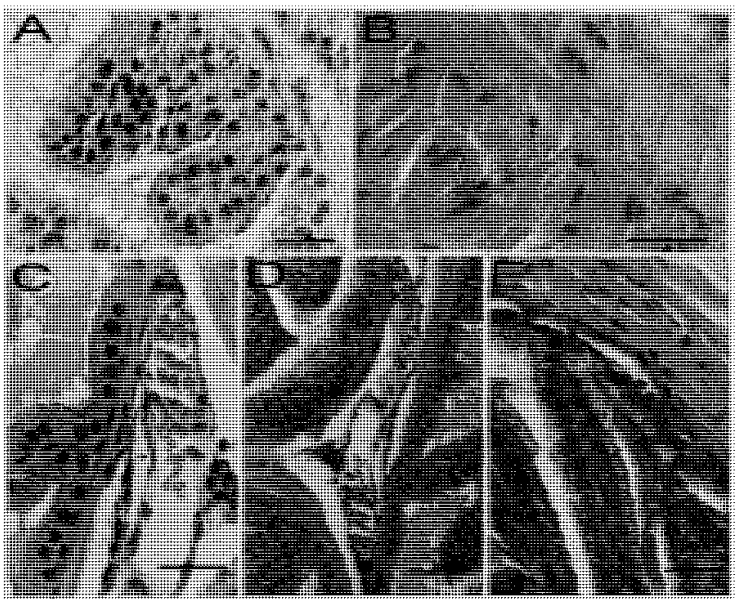

Fig. 2: Light micrographs of the seminal vesicle tissue of the control group, epithelial cells, basal cells and smooth muscle cells are seen (A), smooth muscle cell and its nucleus is shown by an arrow (B), blood vessel and nucleus of the endothelial cell is shown by an arrow (C), red blood cells (RBCs) are seen within the blood vessels (D) and the smooth muscle cell in the seminal vesicle wall is shown by a strike (E). Bar : 100 μm

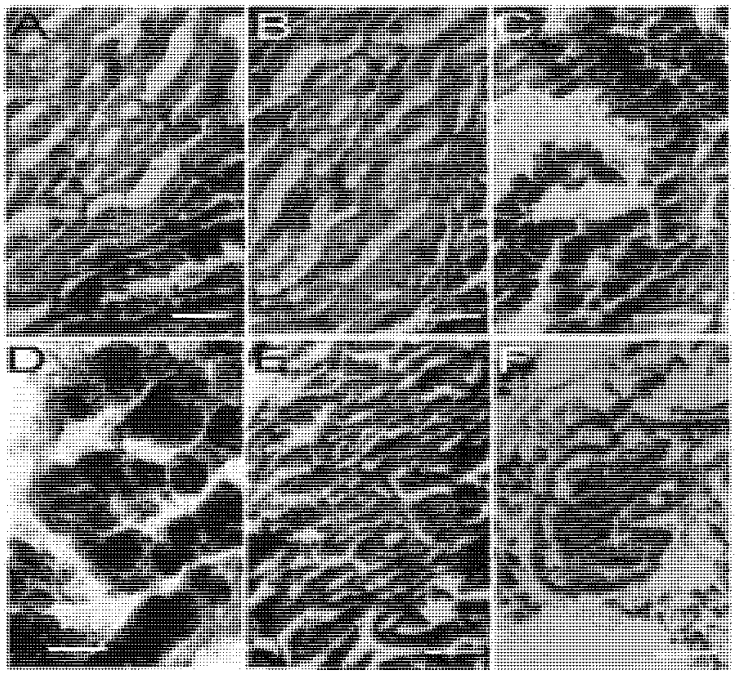

Fig. 3: Light micrographs of the seminal vesicle tissue of the experimental group, abnormal spaces between the smooth muscle cells of the seminal vesicle wall is shown (A), heterochromatinism is seen in the nuclei of the smooth muscle cells are heterochromatin (B), the nuclei of the epithelial cells are dense and exhibit heterochromatinism (C), dense and heterochromatin nuclei of the epithelial cells (D), cell debris in the connective tissue of the seminal vesicle (E) and abnormal cell debris among seminal vesicle tissues together with blood hyperperfusion within blood vessels of the gland (F). Bar : 100 μm

Table 1: Effects of 60 Hz EMF on vesicle seminal tissue

Groups	Heterochromatinism (ECs)	Mitochondria (dilated/dense)	Vacuoles (ECs)	Vacuoles (BCs)
EG	1.27±0.46[a]	0.49±0.15[b]	5.20±1.37[c]	4.80±1.01[d]
CG	0.60±0.74[a]	0.20±0.08[b]	1.93±1.44[c]	1.00±0.93[d]
t-test	p<0.01	p<0.01	p<0.01	p<0.01

EG: Experimental Group; CG: Control Group; ECs: Epithelial Cells; BCs: Basal Cells. The number of heterochromatinic epithelial cells, ratio of dilated to dense mitochondria and numbers of cytoplasmic vacuoles within the epithelial and basal cells have been shown; [a,b,c,d]: Comparison between groups show significant statistical differences with p-value <0.01

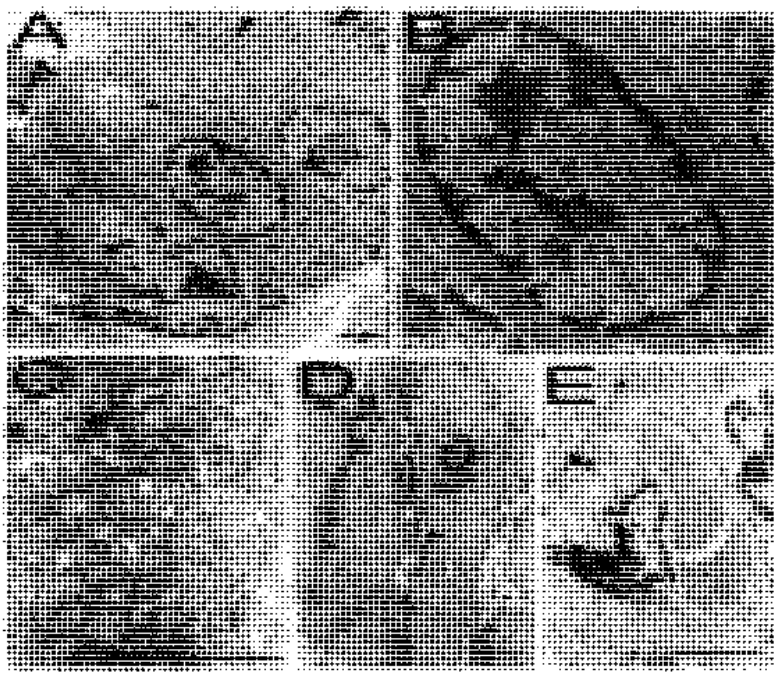

Fig. 4: Electron micrographs of the seminal vesicle tissue of the control group, epithelial and basal cells are shown by a strike and microvilli are shown (A), nuclei of the epithelial cells and their nucleoli, mitochondria are also seen (B), mitochondria of the epithelial cells (C), smooth muscle cells and their nuclei (D) and blood vessels and nuclei of the endothelial cells (E). Bar : 1 μm

the epithelial cells. A number of vacuoles were also present and those that were located at the apical border of the cells contained a dark and dens material (Fig. 4A). Mitochondria were recognized dense nearby the endoplasmic reticulum. They had clear walls together with numerous cristae. The spaces between the mitochondrial cristae were also normal and clear (Fig. 4C). Basal cells were visible nearby the basal part of the secretary epithelial cells. These cells are small, satellite shaped and their nuclei are located centrally. Basal cell nuclear chromatin was condensed and there were not any clear nucleoli within the nuclei. Golgi complexes were seen to be located near the cell nucleus and there were some ribosome's within the cytoplasm. The rough endoplasmic reticulum, meanwhile, was wide and dilated. Mitochondria were found in a large amonnt within the cytoplasm and they contained a number of fatty particles. Basal cells act as supplementary and proliferate cells to differentiate into epithelial cells when necessary (Fig. 4A). The smooth muscle of the capsule had spindle-shaped cells, which contained oval, central nuclei. Meanwhile, myofilamants were located longitudinally within the muscular tissue. Smooth muscle cells' cytoplasm contained a small Golgi complex and the mitochondria were seen clearly. Ribosome's were seen as specific masses within the cytoplasm (Fig. 4D). Blood vessels had clear walls and endothelial cells and their nucleoli were visible. Basement membrane and the connective tissue were also seen in the vascular walls. The nucleoli of the endothelial cells were oval shaped and wide and they were curved into the lumen of the vessels. The endothelial cells contained mitochondria and a Golgi complex. There were also a

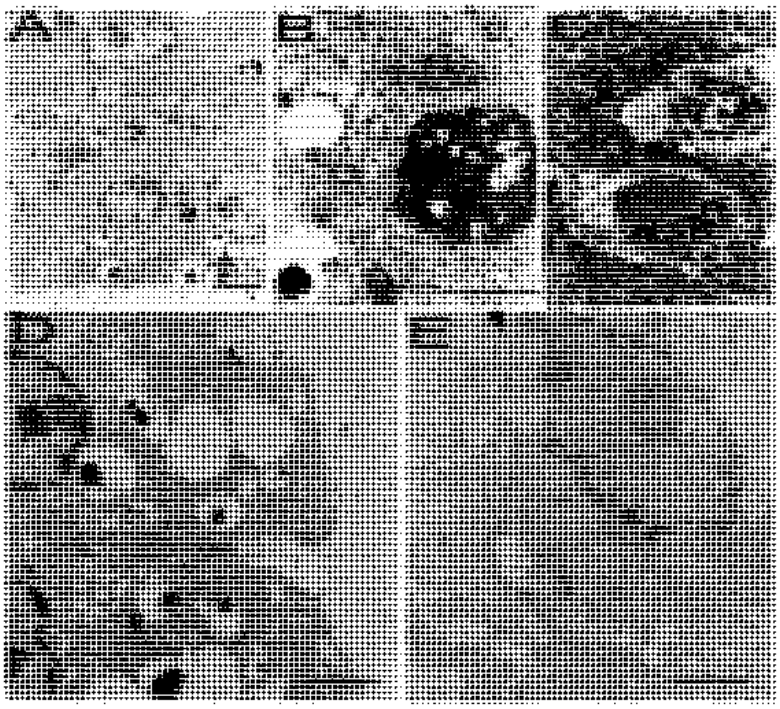

Fig. 5: Electron micrographs of the seminal vesicle tissue of the experimental group, epithelial and basal cells and their nuclei, note the microvilli, vacuoles and lysosomes (A), nuclei of the epithelial cells, note the vacuolization (B), basal cell (is shown by the letter B in part C) increasing of dilated mitochondria in basal cells is seen and blood vessels, vacuolization is also seen in the cell cytoplasm (C), reduction of microvilli (mic) and increasing of vacuoles (vac) at the apical border of the epithelial cells, note that the Golgi complex (G) is dilated (D) and nuclei of the smooth muscle cells (N) and their nucleoli, note the abnormal spaces between the cells (E). Bar : 1 μm

number of ribosomal masses in the cytoplasm. A great amount of pinoctotic vesicles were seen in the cytoplasm. These vesicles might probably have played a role in the transport of various materials (Fig. 4E).

Experimental group: Secretary epithelial cells were seen to save their columnar shape but the microvilli located in their apical border were reduced significantly (Fig. 5A). Intercellular connections were seen normal and as described for control group i.e., interdigitated. The nuclei of the epithelial cells were located the same as the control group. The nucleoli were absent or unclear in the experimental group. The chromatins were dense and located marginally near the nuclear membrane (Fig. 5B). Rough endoplasmic reticule were dilated and located in the basal part of the epithelial cells Golgi complex was located in the apical part of the cells and it was dilated too (Fig. 5D). Obvious vacuolization demonstrated within the cytoplasm which was more significant in the apical part of the epithelial cells. A number of the vacuoles contained the large liposome's. Moreover, the cytoplasm itself had a number of liposomes. Mitochondria were electron opaque which were considered dilated or none energized (Fig. 5B, Table 1). Basal cells were present among the epithelial cells in the experimental group. These cells were tiny and satellite-shaped. Their nuclei were lied centrally; they were heterochromatic and picuotic. A number of basal cells showed fragmented nuclei. An abnormal area was illustrated around the nuclei of the basal cells, which contained a great number of mitochondria. The mitochondria were dilated. Endoplasmic reticulum and Golgi apparatus seemed dilated too. The cytoplasm contained a lot of liposome's (Fig. 5C). Vacuolization was seen as a clear appearance within the cellular cytoplasm both in epithelial and basal cells. A lot of vacuoles were seen in the cytoplasm and intercellular spaces (Fig. 5A, B, C and D, Table 1). The smooth muscle cells were spindle-shaped and their nuclei lied in the central localization. Heterochromatic and dense nuclei were seen in the marginal zone of the nucleus i.e., near the nuclear membrane. There were numerous spaces between the muscular cells. Cytoplasm of the muscular cells had a

lot of small vacuoles and in turn, it indicates the presence of vacuolization in the smooth muscle cells. Myofilamants were disoriented from the longitudinal axis. Muscular cell mitochondria showed dilation and were decreased in amount (Fig. 5E). Within the blood vessels, oval-shaped nuclei of the endothelial cells presented dense chromatins in the marginal zone of the nucleus. The cytoplasm of the endothelial cells contained a lot of vacuoles and pinoctotic vesicles were present. Basement membrane was ruptured in some areas. Vascular connective tissue showed vacuoles and abnormal spaces (Fig. 5C).

DISCUSSION

A number of studies have assessed the harmful effects of X-irradiation on vesicle seminal tissue and their secretary activities in rat (Gupta and Bawa, 1970; Kotscher and Voelkel, 1957; Melampy *et al*., 1956; Roeske *et al*., 1995) evaluated the effects of radiation therapy on the size and location of the prostate, seminal vesicles, bladder and rectum in patients with localized prostate carcinoma and they found that changes in the location of the prostate, seminal vesicles and normal tissue volumes during the course of radiation therapy occur and have dosimeter consequences that may impact tumor control and normal tissue complication probabilities. Chan and Kressel (1991) have also evaluated the effects of pelvic irradiation on prostate and seminal vesicle tissues. They revealed that in the irradiated patient, the prostate and seminal vesicle can develop several patterns of signal intensity abnormalities; in particular, diffuse low signal intensity in the prostate and seminal vesicle should establish radiation fibrosis as an important differential diagnosis to consider. McGivern *et al*. (1990) revealed that low-frequency intermittent EMF exposure during the critical prenatal period for neurobehavioral sex differentiation can demasculinise male scent-seeking behavior and increase the weight of accessory sex organs in adulthood. Lundesberg *et al*. (1995) found no association between occupationally related categories of EMF exposure and male sub fertility as evaluated by sperm morphology, motility and concentration. Chung *et al*. (2005) showed that exposure to EMF (from 60 Hz up to 500 mT), both prenatal and postnatal, did not alter offspring spermatogenesis in the rat. Khaki *et al*. (2004, 2006) assessed the effects of 50 Hz EMF (non-ionizing radiation) during in utero development and postnatal life on rat testicular tissue and revealed that exposure to EMF have a destructive effect on Sertoli cells and the boundary tissue of the seminiferous tubules. In this study we demonstrated the effects of EMF (non-ionizing) on seminal vesicle tissue of rat investigated by light and transmission electron microscopy. Light Micrographs (LM) studies in experimental group revealed that epithelial cells had been unorganized, damaged and destructed containing heterochromatin zed and dense nuclei. The number of basal cells was reduced in amount (Hayward *et al*., 1996). Transmission Electron Micrographs (TEM) of the experimental group showed in turn heterochromatizim and dense nuclei in the epithelial and basal cells. Obvious vacuolization was present inside these cells and within the intercellular spaces. Mitochondria were dilated significantly, which were considered none energized i.e., nonfunctioning. Rough endoplasmic reticule had dilated cistern. Hence, epithelial cells changed to present abnormal mitochondria, rough endoplasmic reticule and nuclei. Seminal vesicles secret an exocrine viscous yellowish fluid composed of fructose, citrate, prostaglandins and a number of proteins. These secretions are essential for a normal seminal fluid formation. Thus, the destructed epithelial cells would be deficient in their contribution in the normal seminal fluid formation and cause subsequent sub fertility and infertility (Curry and Atherton, 1990; Brewster, 1985). Our ultrastructrual findings confirmed that the following reduction of organelles i.e., SER, mitochondria, Golgi apparatus, synthesis of testosterone probably suppressed. Similar effects demonstrated by other investigators previously. It was concluded that the reduction of gondotropins resulted in reduction of testosterone that impair the spermatogenesis. Seminal vesicle products' decline could also occur in response to the lack of testosrone resulting from damaged testicular tissue esp. Leydig cells (in addition to the seminal vesicles, EMF exposure adversely affects the testes (Dym and Fawcett, 1970; Forgacs *et al*., 2004; Khaki *et al*., 2004, 2006; Lee *et al*., 2004; Shafik, 2005), because secretary activity of the seminal vesicle epithelial cells is testosterone dependent (Tsuji *et al*., 1991; Justulin *et al*., 2006). The damaged basal cells would also fail to perform their proliferate and supplementary activities. Smooth muscle cell nuclei were also heterochromatin zed and dense. Mitochondria were dilated and vacuolization were present, in their cytoplasm. The muscular cells showed pathological spaces between them. The myofilaments were disoriented from their longitudinal axis. Pathologic changes may lead to the muscular dysfunction of the seminal vesicles. Thus it caused deficient release of its products and abnormal seminal fluid formation. Myoid cells, which are modified smooth muscle cells and probably maintain a certain pressure in order to facilitate sperm discharge (Lacy and Rotblat, 1960), undergo destruction under the EMF exposure. Similar smooth muscle cell destruction was seen in the seminal vesicle

tissue of the experimental animals of the present study. In the study done by Khaki *et al.* (2006) it was found that the fourth layer of the boundary tissue of the seminiferous tubules of the EMF exposed rats was thin and composed of lymphatic and endothelial cells, which formed an extensive system of per tubular lymphatic sinusoids. The irregular gaps and formation of blisters with a break in the endothelium of the lymphatic could be responsible for lack of lymph drainage and the resultant edema, which was evident from the frothy spaces among the seminiferous epithelial cells under LM. In this study, equivalent endothelial cell destruction was present as well evidenced by dense chromatin nuclei, vacuolization and pinoctotic vesicles. In addition, hyper perfusion, RBCs accumulation, basement membrane rupturing and vascular connective tissue vacuolization were present. EMF has determinately effect in the suppression of immune suppressive affect which my lead to increase the harmful effects of EMF by increase the free radicals, whatever had destructive effects on the cells and tissues. The present study revealed the harmful effects of EMF on the seminal vesicle tissue in rats. At the molecular level EMF produces biological stress and free radicals, which can make the susceptible animal population prone to congenital malformations, tissue and cell damage or death (Lai and Singh, 2004; Soeradi and Tadjudin, 1986; Wolf *et al.*, 2005). Free radicals released can cause oxidative stress at the cellular level, interfering with protein synthesis. These elements also play an important role in acute inflammation, endothelial destruction, increased vascular permeability and exudation of plasma, resulting in tissue edema. It has been postulated that short-term exposure to EMF produces high levels of oxidative stress as a result of its effect on the immune response (Zhitkevich *et al.*, 2001) and long-term exposure to EMF may be linked to even higher levels of oxidative stress (Fernie *et al.*, 2000).

CONCLUSION

Although we can not surely connect non-ionizing radiation (EMF) to various disease or damage of biological system, this study suggested that to achieve a real measure for evaluation the effects of EMF on glands of male genital system, more and extended investigations in laboratories are necessary. Generally these findings indicated that exposure to EMF had a deleterious effect on seminal vasicule gland in rat, thus result in irreversible effects which may lead to sub fertility and infertility in male.

It seemed that if results of animal and epidemiologic studies can be combined, we will have a vivid conclusion about the connection of EMF that is used in electricity transfer, transportation and etc, with public health.

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