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Effect of 50-Hz Powerline Exposed Magnetized Water on Rat Kidney

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Double distilled water samples were exposed for 48 hr. to 50 Hz-powerline electromagnetic field (EMF) strength of 51.2 μT (36.2 RMS). This EMF exposed water was made available to experimental adult Charles-Foster male rats for drinking ad libitum for 30 days. On the 31st day the rats were anaesthetised with ether and then fixed by perfusion with 10% neutral formalin. The Kidneys were dissected out and further fixed in the same fixative. The corresponding control rats provided with unexposed triple distilled water were similarly treated. On gross examination, no anomaly was observed in the kidney of the exposed group. On histological examination, marked spongiform changes leading to degeneration and compensatory proliferation of the glomerular tufts and degeneration of the lining epithelia of the tubules was observed. This study adds a link in demonstrating that powerline exposure induces stable changes in water structures and effects biomechanisms of tissue fluid.

Key Words: Magnetic field; Powerline; glomerular tufts; Degeneration; Kidney

INTRODUCTION

Although a number of experimental and epidemiological studies have been conducted to evaluate the potential biological influence of electromagnetic

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field (EMF) exposure, and many known physical mechanisms for direct EMF exposure have been proposed (ion cyclotron resonance, parametric resonance, radical pair mechanisms), none of the proposed mechanisms is widely accepted [1, 39, 20, 23, 28, 34]. Lacking an essentially complete definition of the EMF exposure/environment for both control and experimental groups, no single unambiguous bioeffect mechanism for EMF exposure has been found acceptable.

The bioeffect of direct exposure to powerline fields (i.e., the effect resulting from exposure of a biosystem itself) has been studied and a few attempts have been made to study indirect influences on biosystems through EMF-exposed water. Water, being a dielectric, was not thought to sustain EMF-influences for long periods. Recently, it has been speculated that EMF may induce changes in the structure of water, which appears to produce significant biological effects [9, 24, 25, 31]. The structure of water-ice polymers and water clusters under various EMF exposures as detected by different instrumental detection procedures e.g., x-ray diffraction and electrophotography, has already been reported [17, 26, 5, 33, 42, 43, 32].

Bioeffects of indirect EMF exposure through EMF-treated water on fungi, bacteria, and plant system are well-documented [4, 6, 16] but these effects have not been studied thoroughly in animal systems except for a few reports [2, 13, 22]. A need exists to establish the nonthermal bioeffect mechanism(s) of powerline exposure in biological systems. Therefore, the present study has been planned to study the mechanism of indirect exposure of 50 Hz powerline EMF-treated water on kidney in adult rats.

MATERIAL AND METHODS

Animals

In the present study, laboratory inbred male rats (approximately 10 weeks old) of the Charles-Foster strain were used. All experimental rats weighing 180 ± 10 gm were housed under standard laboratory conditions ($25 \pm 2^{\circ}$C and 60% relative humidity) in a natural dark cycle. Two animals were housed in each polyvinyl animal cage measuring $30 \times 23 \times 23$ cm wherin rice husk was used as the bedding material. The animals were fed pelleted animal food and water (control and treated) ad libitum. The experimental rats (number = 30) were randomly selected and divided into two groups; Group A (Control, $n = 10$) and group B (48-hr exposed, $n = 20$).

Powerline Exposure of Water

A powerline step down transformer of 2500 KVA was used as the source for exposure of water. The total height of the transformer was 3.65 m.

Triple distilled water ($0.32 \times 10^{-4} \Omega^{-1}\,cm^{-1}$) samples in cotton-plugged 250 mL conical flasks were placed directly on the transformer fins, at a height of 1.4 m for 48 hr. To minimize possible effects of heat from the transformer, water exposures were limited to the coolest period of the year, between Dec. 15 and Jan. 15.

The sine wave and magnetic flux strength at the site of exposure was uniformly 51.2 μT and 36.2 μT (RMS). It was measured by a coil and voltmeter calibrated in a solenoid measuring 10 cm in diameter × 15 cm in length. The time of starting the exposed water was fixed daily at 9 a.m. all metallic contacts to the exposed water were avoided. Unexposed triple distilled water from the same source was used as a control (geomagnetic field = 30 μT) under the same laboratory conditions.

Animal Treatment

The powerline-exposed water samples were transferred to feeding bottles fitted with glass tubes for free access to experimental rats. Water was replaced every day with fresh EMF-exposed water samples at approximately 9:30–10 A.M. The control rats were treated similarly with unexposed double-distilled water. The experiment continued for 30 days. During the treatment, the leftover water in each group was observed every day to determine the amount of water used to rule out any dehydration of animals from reduction in consumption of water.

On the 31st day, at the termination of the experiment, the rats were anaesthetized with ether and perfused with 10% neutral formalin.

After perfusion, the kidneys were removed and then further fixed in 10% neutral formalin. Paraffin sections (8 μm thick) of these specimens were stained with haematoxylin and eosin for micromorphological observations.

RESULTS

On gross examination, the kidneys did not show any abnormalities. In control rats only a few degenerating glomeruli were present never associated with edema. Although normal glomeruli were also present in treated rats, a majority of those had damaged kidneys.

On microscopic examination, the renal cortex showed spongiform changes due to marked edema. As compared to the controls (Fig. 1) the normalcy of the lumen of tubules was lost in the treated specimen. The intratubular lumen was markedly dilated. The living cells of the proximal tubules were swollen with loss of the microvilli. Many of the dilated tubules had ruptured with concomitant confluence of lumen (Fig. 2), with living cells in different stages of degeneration. The necrotic nuclei were exuded from the cells and the cellular matrix was homogenised. Clumps of the necrotic cellular debris were

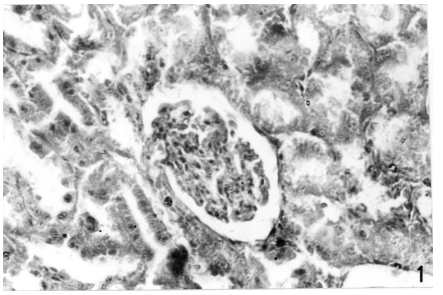

Figure 1: Control kidney-showing glomerulus and renal tubules. H & E × 350.

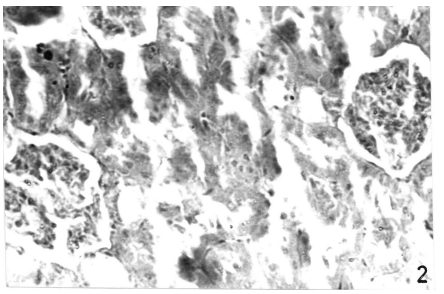

Figure 2: Treated kidney showing lobulated glomerulus and dilated nephrons with confluent spaces and degenerating cells. H & E × 350.

present in abundance. Lobulation of the glomeruli was observed with marked dilatation of the proximal part of the nephrotic tubule (Fig. 2).

In the glomerular capsule, the mass injury was observed in different stages. Some of the glomeruli were fragmented and some were completely lobulated with segmental sclerosis and darkly stained cellular debris with effacement of the visceral and parietal epithelia. The glomerular space was dilated with edematous infiltration of the renal cortex (Fig. 3). The collecting tubules were less severely affected. This phenomenon resulted into gradual reduction and loss of the glomerular mass and so, loss of functioning nephrons. As a compensatory phenomena, glomerular hypertrophy occurred in other nephrons resulting in a decrease in the glomerular space and mesangial hypercellularity. The glomerular cells were granular in appearance with diffuse, especially nodular hyaline deposits at the vascular pole. The glomerular visceral epithelium was denuded. In all these cases, initial segment of the proximal convoluted tubules was dilated with degeneration of the affected cells (Fig. 4).

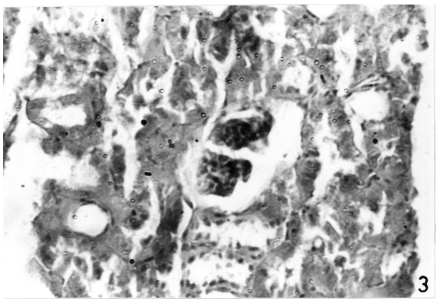

Figure 3: Lobulated and necrosed glomerulus with increased glomerular space. Tubular cells are showing necrosis and hyalinisation. H & E × 350.

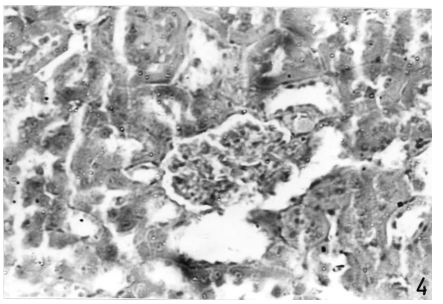

Figure 4: Glomerular hypertrophy showing decreased glomerular space and nodular hyaline deposit at the vascular pole. H & E × 350.

DISCUSSION

In glomerular filtration, water passes containing various dissolved small molecules from the blood to the urinary space in the glomerular capsule. Large molecules, such as plasma proteins, polysaccharides and lipids are largely retained in the blood by the selective permeability of the glomerular basement membrane [41, 12].

Filtration occurs along a steep pressure gradient existing between the large glomerular capillaries and the urinary space, the only structure separating the two being the glomerular basement membrane. This gradient far exceeds the colloid osmotic pressure of blood which opposes the outward flow of filtrate. In the peripheral renal cortex, the arteriolar pressure gradient is enhanced by an inequality in the calibres of afferent and efferent glomerular arterioles, the former having larger diameters. In all the glomeruli, the rate of filtration can be altered by changes in the tonus of the glomerular arterioles. The glomerular filtrate, when first formed, is isotonic

with glomerular blood and has an identical concentration of ions and small molecules [3, 15].

In proximal convoluted tubules, selective resorption of many substances, such as glucose, amino acids, phosphate, chloride, sodium, calcium and bicarbonates occurs by an active process. Cells of the proximal tubules are permeable to water, which leaves the tubules along an osmotic gradient created by resorption of these solutes, particularly sodium and chloride ions, so that the filtrate remains locally isotonic with blood [32].

The principal function of oxygen contained in the circulating blood is to provide high energy phosphates (ATP and phosphocreatine) for transmembrane ion transport for the synthesis of cellular constituents required for the maintenance of tissue integrity. In this study, the general homeostatic balance of the body of experimental rats was maintained by magnetized water which was given to them to drink and libitium. Since there is evidence that water exposed to electromagnetic (EM) fields undergoes structural changes, and that the water 'remembers' the field strength for an extended period of time, [7, 9, 12, 14, 23, 34] it may be responsible for changing the osmolarity of tissue fluids, thereby affecting the homeostatic balance of the body.

This magnetised water, as it passes through the glomerular arterioles, also changes the osmolarity of the fluid content of the blood. It affects the function of the glomerular cells also affecting their intracellular chemistry. So gradually they get necrosed. The water, filtered by the glomerulus, as it passes through the capsule and the renal tubules, affects the active and passive function of the lining cells. As a result, with the changed osmolarity, the cells as they absorb the magnetised water undergo gradual necrosis due to changes in intracellular chemistry.

In magnetised water, the angle between the two hydrogen atoms perhaps no longer remains fixed at nearly a right angle, but becomes variable, rendering the molecule flexible. Each oxygen atom now attracts, by electrostatic forces, not only two hydrogen atoms, as in ice, but three or more. Thus, an oxygen atom may be surrounded by five or six hydrogen atoms, while one hydrogen atom may be surrounded by as many as three oxygens. In the closely knit flexible structure, the hydrogen ions constantly shift positions and displace one another. Each such chain is propagated in a chain or "Zipper" fashion throughout the liquid, consequently affecting the viscosity, electric constant and electric conductivity of water [26, 15, 14]. Hydrogen bonds play a crucial role in the behaviour of water, their spatial patterns and fluctuations characterising the structure and dynamics of the liquid [38, 8, 10, 35, 36, 37, 21, 19]. Given the lack of biological mechanisms of action of EMF-treated water, it is not possible to precisely delineate the inhibitory effect mechanisms of such EMF-altered water structures [24, 25, 30, 29].

The present study suggests that stable changes in water structure produced by magnetic fields may have caused the inhibitory effects by differentially changing the cytoplasmic organization, structural chemistry and activities of the extracellular and intracellular fluid components. This mechanism, caused by a changed osmolarity in the water, appears to have been responsible for the functional, organisational and structural changes of the nephrons, ultimately leading to degenerative changes, regardless of the primary site of injury [7, 18, 40].

This effect on kidney reveals that prolonged exposure to powerline frequency MF-induced restructured water may cause bio-effects by inducing alterations in the osmolarity of body fluids, thus affecting the functional, structural and chemical changes of the tissues.

CONCLUSION

Double distilled water, exposed for 48 hr. to 50 Hz-powerline electromagnetic field (EMF) strength of 51.2 μT (36.2 RMS), when given to adult Charles Foster male rats for drinking ad libitum for 30 days, induced spongifom changes leading to degeneration and compensatory proliferation of the glomerular tufts and degeneration of the lining epithela of the renal tubules of kidney.

This provides evidence that EMF treated water can affect renal functions in rats. Thus, this model may be singularly useful in trying to understand the nature of the changes that occur in water when exposed to magnetic fields, in that kidney glomeruli may be very sensitive to the associated changes in water structure, considering the ionic filtration process that is involved.

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