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Original Article

The Wistar Rat Parietal Lobe Cell and Pain Perception Changes after Frequent of Mobile Phone Electromagnetic Wave Expose

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Abstract

Background : The increasing number of mobile phone users raises concerns about the effects. Mobile phone electromagnetic wave radiation harms pain perception due to granular cell changes in the cerebral parietal cortex. The aimed of this study was to determine the effect of exposure to electromagnetic waves mobile phone on pain perception due to changes in the granular cells of the cerebral parietal cortex Wistar rats.
Methods : Experimental research using randomized posttest with control group design. Samples were 28 rats divided into 4 groups. The control group was not exposed, the treatment group was exposed to 2100 MHz electromagnetic waves for 2 hours/day with a distance of 3 cm for 15 days in treatment group 1, for 30 days in treatment group 2, and 45 days in treatment group 3. Measurement of pain onset using the hot method. Changes in pain threshold were taken from the difference in pain onset after exposure to before exposure. Granular cell changes in the cerebral parietal cortex were assessed from the total score with the provisions of normal cells (sumx0), hydropic degenerated cells (sumx1), and necrotic cells (sumx2).
Results : The longer the exposure to mobile phones, the higher the pain threshold and the cerebral parietal cortex granular cell damage score. There was a significant difference in pain threshold and changes in cerebral parietal cortex granular cells between groups (p=0.000). There was a significant relationship between changes in the parietal cerebral cortex granular cells and pain threshold in Wistar rats exposed to electromagnetic waves (p=0.000).
Conclusion : Exposure to mobile phone electromagnetic waves affects pain perception due to changes in the granular cells of the cerebral parietal cortex in wistar rats.

Keywords : mobile phone, electromagnetic, pain threshold, granular cells, parietal lobe

INTRODUCTION

In the COVID-19 pandemic situation starting in 2020 which requires people to keep their distance from each other and not communicate directly, causing the use of mobile phone, especially the internet, to increase by around 7% or ±875,000 new users every day around the world, raising concerns about the effects.[1] Mobile phone electromagnetic wave radiation has side effects or negative impacts that have the potential to interfere with health.[2] The negative impact of mobile phones on the brain from previous research shows that exposure to 900 MHz electromagnetic waves at a short distance causes an increase in brain tissue temperature.[3] Prolonged exposure to 837.8 MHz electromagnetic waves can increase brain glucose metabolism in the area closest to.[4,5] Excessive smartphone use is likely to fail cognitive control during emotional processing, and this impairment might be influenced on emotional processing related to social interaction.[6] Exposure to a mobile phone when it is placed 5 cm from the head causes less brain activation than when the mobile phone is placed next to the ear/head on both sides.[7] Exposure to 900 MHz electromagnetic waves in the brain can increase oxidative stress due to an increase in free radicals, causing changes in the histopathological structure of the brain in the form of shrinkage of pyramidal neurons, mild perivascular and perineural edema, vacuolation of neurons and glial cells of the cerebral cortex and rat hippocampus.[8,9] Reduction of Purkinje cells, vacuolization of neurons and glial cells, interstitial edema in the cerebellum and apoptosis of glial cells in the frontoparietal lobe of the cerebral cortex.[8,10] The cerebral parietal lobe, which plays an important role in pain perception, might interfere due to structural changes following mobile phone electromagnetic exposure. Recently the brain wave activities seemed to raise in the frontal and temporal lobes.[7] Whereas the cellular structure changes remain not much has been explored, and the pain symptoms are influenced by mood or individual perception. The pain involved multifactorial subjective experience, which developed from a neuromatrix brain working. Meanwhile, the affective-cognitive as the neuroanatomical function also plays role in it.[11] Based on it, we thought that pain perception might be important to learn, so it is necessary to observe the perception of pain due to changes in the granular cells of the cerebral parietal cortex.

METHODS

This is an experimental study conducted from January 2022 – March 2022 at the Experimental Animal Laboratory of Medical Faculty UNDIP and the Anatomical Pathology Laboratory of the Diponegoro National Hospital by using the randomized posttest method with a control group design. The 28 healthy male Wistar rats (Rattus norvegicus) with the age of 24 weeks and body weight of ± 200 g were divided into 4 groups, and each was placed in a different cage with the dimension measured 7cm x 20cm x 5cm. The control group was only placed in a treatment cage for 2 hours/day for 45 days, and the treatment group was exposed to 2100 MHz electromagnetic waves for 2 hours/day with a distance of 3 cm for 15 days (Group 1), for 30 days (Group 2), and 45 days (Group 3). Pain threshold might be assessed for all samples by placing them on a hot plate with a temperature of 55°C. The initial

Figure 1. The mobile phone devices are placed within a 3 cm distance from the cage which the electromagnetic exposure effect observe.

time exams of pain sensations were counted by stopwatch and recorded when the rats pulled or licked their feet. Thus reflected pain sensation feeling according to the grimace rat scale (GRS),[12,13] and its record as base line time of pain threshold sensation. The delta changes in pain intensity presented as the differentiation between the baseline data before mobile phone exposure, and the time recorded after the duration time of exposure as the groups divided.

Immediately after completion of the last mobile phone exposure, the rats will be decapitated according to each group, then the brain tissues carry out for the parietal cortex histological tissue preparation. It will be stain with Haematoxylin Eosin and examine by pathology anatomy (PA) experts for observing and counting the pathologic cell finds. PA experts observe granular cells in the granular layer of the parietal cortex, and its carried out in 5 fields of view under of 400x magnification light microscope. Assessment of cell morphology was carried out using a scoring system with the provisions of normal cells (number x0), cells undergoing hydropic degeneration (number x1), and cells undergoing necrosis (sum x2).[9] Statistical tests were used to determine the significance of differences in changes in the granular cells of the cerebral parietal cortex and pain threshold between groups and the significant relationship between changes in the granular cells of the parietal cortex and the pain threshold in Wistar rats exposed to electromagnetic waves. This research was approved by Medical Faculty Diponegoro University Semarang with an ethical clearance no 01/EC/H/FK-UNDIP/I/2022.

RESULTS

The following are histopathological description of the parietal cortex of all groups. Higher parietal cell changes were observe in groups with increase duration time of mobile phone exposures. It presented the hydropic degenerated cells alteration or even went to the necrosis stage (Table 1).

The longer exposed time duration presented of higher mean score of granular cells damage in the granular layer of the parietal cortex (Table 2). The non-parametric Kruskal-Wallis with p = 0.000, which meant the significant differences of the parietal cortex cells histology exposed by mobile phone in accordance to the time exposed duration (Group 1, 2, and 3). Whereas the Control group with no parietal cortex cellular changes.

The longer duration time exposure to mobile phones might increase the average time to reach the pain threshold. Our study showed significant differentiation of pain threshold altered between samples exposed by mobile phones and those not frequently exposed (the one-

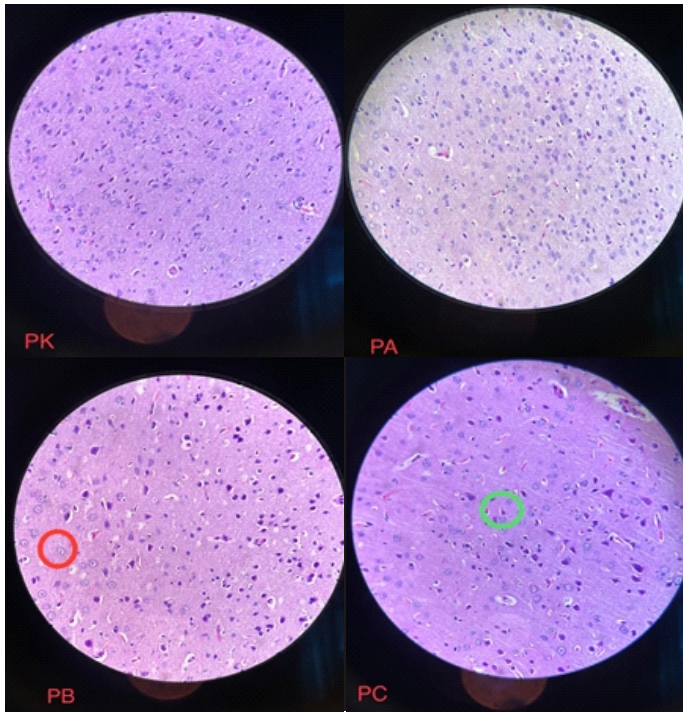

Figure 2. PK: histopathological picture of the cerebral parietal cortex in the control group; PA: histopathological picture of the cerebral parietal cortex in treatment group 1; PB: histopathological picture of the cerebral parietal cortex in treatment group 2 with red circles in the form of granular cells that experienced hydropic degeneration; PC: histopathological description of the cerebral parietal cortex in treatment group 3 with a green circle in the form of granular cells undergoing necrosis.

TABLE 1
Description of the mean of hydropic degeneration and necrosis cells in all groups

Group	The mean of hydropic degeneration cells	The mean of necrosis cells
Control	0	0
Group 1	1.2	0
Group 2	2.2	0
Group 3	2.1	1

TABLE 2
Description of the histopathological scores of the parietal cerebral cortex of wistar rats in all groups

	Histopathological scores of the parietal cerebral cortex		
Group	**Mean ± SD**	**Median (min–max)**	**p**
Control	0 ± 0	0 (0–0)	0.000
Group 1	1.28 ± 0.48	1 (1–2)	
Group 2	1.71 ± 0.75	2 (1–3)	
Group 3	4.28 ± 1.25	4 (3–6)	

Note: *p : Kruskal-Wallis, significant (p < 0.05)

TABLE 3
Description of changes in the pain threshold of wistar rats in all groups

	Changes in the pain threshold		
Group	**Mean ± SD**	**Median (min–max)**	**p**
Control	4.85 ± 3.48	5 (1–11)	0.000
Group 1	36 ± 8.86	36 (23–49)	
Group 2	60 ± 9.79	59 (48–75)	
Group 3	91.71 ± 14.46	87 (77–114)	

Note : * p : One way ANOVA, significant (p < 0.05)

way ANOVA test, p = 0.000). When the time duration is exposed more frequently, the pain threshold will raised (Table 3). The Spearman test showed significant association between the parietal cell changes and of and the pain threshold alteration due to exposure to electromagnetic waves exposure of mobile phones (p= 0.000). The Correlation Coefficient value is 0.906, reflecting a strong and positive correlation between the higher score of the parietal changes and the pain treshold changes.

DISCUSSION

The longer the exposure to mobile phones might caused of higher mean score of granular cell damage in the deep granular layer of the rat cerebral parietal cortex. In Groups 1, 2, and 3, the cells were dominated by hydropic degeneration, while in Group 3 the necrosis cells began to appear. In the treatment group, there was structural damage marked by histopathological changes in the form of degeneration which is a reversible injury, and cell death which is an irreversible injury. Hydropic degeneration occurs when cells cannot maintain ionic and fluid homeostasis (mainly due to ion pump activity in the plasma membrane). If the cause of the injury persists, granular cells that have been injured can experience tearing of the plasma membrane and changes in the cell nucleus so that the cells die or are necrotic.[14] The Kruskal-Wallis comparative test analysis showed significant (p=0.000), so there were significant differences

in the histopathological features of the parietal cerebral cortex in rats exposed to mobile phone electromagnetic waves with difference duration exposure time and those not exposed. Recently the striking effects on neuronal damage of the hippocampus were observed underwent a single 2-hours exposure to a 915 MHz mobile phone. Thus with the average whole-body specific energy absorption rates (SARs) as low as 2, 20, or 200 mW/kg.[15] After exposure to 1,375 MHz mobile phone radiation at 3 cm from the cage for 72 hours, the pyramidal cells might shrinkage, mild perivascular and perineural edema are founded, and the neurons and glial cortex cells with vacuolization are present. There was also a reduction in Purkinje cells, vacuolization of neurons and glial cells, and interstitial edema in the cerebellum.[8] On the other hand, the 900 MHz mobile phone exposed at a distance of 1 cm for 2 hours/day, showed apoptosis of frontoparietal glial cells after 10 months followed up.[10]

The granular cells damage can be caused by continuous exposure to mobile phone electromagnetic waves, thereby increasing free radical activity in cells and disrupting the metabolism of Reactive Oxygen Species (ROS) by increasing the production of ROS such as increased NMDA and MDA or decreased activity. antioxidants such as catalase, SOD, and GSH.[16,17] In normal circumstances, the ROS formed will be neutralized by antioxidants in cell tissue, but if the production of ROS increases abnormally such as due to exposure to electromagnetic waves, the antioxidants in the body tissues are unable to neutralize everything which ultimately leads to oxidative stress.[18] As a result of oxidative stress, there will be consequences for granular cells in the granular layer in the cerebral parietal cortex through several mechanisms, namely increased lipid peroxidation in cell membranes, oxidative damage to DNA, including modification of purine or pyrimidine bases, protein damage that causes conformational changes, polymerization and protein fragmentation, as well as the induction of apoptosis and necrosis.[16,18,19]

The pain threshold changes showed significantly different in Groups 1, 2, and 3, and the long-term mobile phone exposure might be a cause of the threshold increase (ANOVA test, p= 0.000). Thus higher threshold alteration could be implicated in lesser pain sensitivity. It means when the threshold gets higher, the rats might not be as sensitive as the lower threshold state. Mobile phone electromagnetic exposed might promote a significantly thermal pain sensation reduction (Mann-Whitney p=0.001).[13] The electromagnetic waves originated from mobile phones with amplitude modulation setting on 73.5 MHz and SAR 0.4 w/kg for 45 days (2 hours/day), observed delayed retraction response of the rat's hind limb after noxious stimuli (p=0.01). Otherwise, the tail withdrawal response might not statistically significant (p=0.2).[20] Those phenomenon based on the increasing pain threshold in association with the pain impulses interferes, as the mobile phone electromagnetic exposure leads to the primary sensory alteration, and the pain perception changes due to the threshold increase.[21–23] The histopathological examinations of the parietal cortex and the pain threshold changes seemed significantly related (Spearman test, p=0.000). The Correlation Coefficient is 0.906, which means the strength of the relationship is strong and positively correlated (the higher the histopathological picture score of the parietal cerebral cortex, the higher the change in pain threshold). The granular cells' damage plays a role as a pain impulse receiver from the thalamus (the thalamocortical tracts), which with responsible for the intensity and location of the pain. Structural cell damage might cause an increase in the pain threshold.[21–23]

CONCLUSION

Exposure to mobile phone electromagnetic waves affects pain perception due to changes in the granular cells of the cerebral parietal cortex of Wistar rats. The longer the exposure to mobile phones might caused higher granular cell damage in the deep granular layer of the rat cerebral parietal cortex. Further study will need to be perform in order to know whether the changes in cerebral parietal cortex granular cells are reversible or irreversible.

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