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RESEARCH ARTICLE

Effect of Mobile Phone Base Stations on Antioxidant and Oxidant Serum Levels: Possible Impact on Cancer Development

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Abstract

Background: There have been claims of a potential link between radio frequency (RF) emissions from mobile phone stations and cancer. In addition, widespread public concern has been expressed about the placement of cell phone antennas due to concerns about the risk of cancer. **Objective:** The objective of the study was to assess the effect of mobile phone base stations on oxidant and antioxidant markers and to investigate its potential correlation with cancer progression. **Methods:** The study involved three groups: cancer patients, healthy individuals residing near mobile phone base stations, and a control group living away from such base stations. **Results:** The study revealed significant differences in most biochemical parameters among the groups, highlighting the impact of mobile phone base stations on health. Cancer patients residing near mobile phone base stations (Group 1) showed notable changes compared to healthy individuals living both near (Group 2) and far (Group 3, control group) from mobile phone base stations. Specifically, the harmful effects of mobile phone base stations were evident in the increased total oxidant status (TOS), decreased total antioxidant capacity (T-AOC), and altered liver enzymatic activities (AST, ALP, ALT, LDH). **Conclusion:** This study finding suggests that proximity to mobile phone base stations may negatively influence oxidative stress and liver function leading to cancer. Further research is necessary to fully understand these effects and develop appropriate public health strategies.

Keywords: Mobile phone base stations- Cancer- Antioxidants- Oxidants- Liver enzymatic activity

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Introduction

In recent decades, there has been a significant increase in the installation of mobile phone base stations and various wireless communications antennas globally [1]. This trend is evident in both urban and natural settings, including protected natural areas, alongside existing antennas for television, radio broadcasting, and radar [2, 3]. The focus of this deployment has primarily been on aesthetic considerations and adherence to urban regulations, with limited attention given to evaluating the biological, environmental, and health impacts associated with the emission of non-ionizing electromagnetic radiation [2]. Consequently, the potential effects on individuals living near these artificial electromagnetic field sources (antennas) have not been adequately addressed. The widespread use of cell phones has raised concerns about potential negative health effects, especially the risk of developing tumors [4]. Current research on cancer development in humans suggests that the time interval between initial exposure and clinical cancer diagnosis typically ranges from 10 to 20 years. While the electromagnetic fields emitted by cellular phones lack the energy required to break chemical bonds or harm DNA, making them unlikely to initiate tumor formation, there is a possibility that they may play a role in promoting tumor growth, potentially leading to a shorter induction period [5, 6].

There is great concern about the harmful effects of electromagnetic waves and radio frequencies generated by private communication stations [7]. The electromagnetic field radiation in mobile services originates from two main sources: mobile phones and mobile phone base stations [8-10]. The lower end of the electromagnetic spectrum is

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where these radiations are found. Therefore, their energy is unable to break the chemical bonds of molecules, and thus falls into the category of non-ionizing radiation [11, 12]. Many mobile phone towers are situated near or on top of schools, residential buildings, and hospitals, posing a threat to the public due to electromagnetic pollution. It has been said that mobile phone companies install their base stations wherever they want. Furthermore, the electromagnetic field (EMF) emissions from the base stations reached dangerously high levels.

As an external source of free radicals and reactive oxygen species (ROS), radiation is a potential cause of oxidative stress [13]. Other studies have shown that the levels of several antioxidants in the plasma of individuals living near mobile towers have significantly decreased, especially for glutathione, catalase, and superoxide dismutase [14-16]. Additionally, lipid peroxidation has been found to increase [17]. Radiation from mobile base stations may lead to changes in liver enzyme activity, which could potentially result in negative health effects [18]. The impact of low-level electromagnetic fields on biological systems and their potential association with the development of cancer remain a topic of debate within the scientific community. Numerous epidemiological investigations have explored the potential negative health consequences associated with environmental exposure to extremely low-frequency non-ionizing radiation (ranging from 0 to 300 Hz), commonly emitted by power cables and electric substations. These studies have suggested a correlation between such exposure and various forms of cancer, including leukemia, brain cancer, male breast cancer, as well as skin and eye melanoma.

This study aimed to investigate the effect of mobile phone base stations on total oxidant, total antioxidant, and other biochemical markers (ALT, AST, ALP, and LDH) and explore their potential correlation with cancer progression. The study included three groups: cancer patients, healthy people living near mobile phone base stations, and a control group living away from such networks.

Materials and Methods

2.1. Samples of study

The samples were taken from male volunteers aged between 18 and 59 years living in Al Diwaniyah, Iraq. A total of 90 blood samples were collected from participants. Then the samples were classified into three separate groups for analysis. The serum was separated by centrifugation at 5000 rpm for 10 minutes at 4 °C and then stored at -70 °C until tests were conducted on them.

1. Group 1 (G1) consists of 30 individuals, comprised of cancer patients residing near mobile phone base stations.

2. Group 2 (G2) consists of 30 healthy individuals living in close to mobile phone base stations.

3. Group 3 (G3) consists of 30 healthy individuals living far from mobile phone base stations, serving as the control group for the study.

Exclusion criteria of control and patient groups

1. Renal diseases
2. Heart diseases
3. Liver diseases
4. Smoking

Control group

Individuals appearing healthy were selected from the general population who live near the phone network station.

Inclusion Criteria of Control Group

a. Individuals with no previous medical history of complications. b. No family history of liver disease. c. Parallel to cancer patients with respect to age, sex, and geographical distribution. d. Age at examination >18 years. g. BMI 18.5-25

2.2. Determination of TOS, and T-AOC levels

TOS and T-AOC levels were both quantified using Erel's method. Briefly, the oxidants present in the sample oxidized a ferrous ion-o-dianisidine complex to ferric ion. The oxidation reaction was facilitated by glycerol molecules, which are abundant in the reaction medium. The resulting ferric ion forms a colored complex with xylenol orange in an acidic medium. The intensity of the color, which was measured spectrophotometrically (Apel PD-303, Japan), correlates with the total concentration of oxidant molecules in the sample. The assay was calibrated using hydrogen peroxide, and the results were expressed in micromolar hydrogen peroxide equivalent per liter (μmol H_2O_2 Equiv/L) [19]. The method for T-AOC measurement initiates the production of hydroxyl radicals, known as the strongest biological radicals. In the procedure, Reagent 1 containing ferrous ions is combined with Reagent 2 containing hydrogen peroxide. This amalgamation generates sequential radicals, including the brown-colored dianisidine radical cation, prompted by the hydroxyl radical. These radicals are also potent in nature. The outcomes are presented as millimoles of Trolox Equivalent per liter (mmol Trolox Equiv/L) [20].

2.3. Determination of ALT, AST, ALP, and LDH levels

Serum level of LDH level were assessed using commercial kits (Biosystem Spain) according to the manufacturer's protocol. The serum level of AST, ALP, ALT were measured using Bayer Reagent Packs on an automated chemistry analyzer (Advia 1650 Autoanalyzer; Bayer Diagnostics, Leverkusen, Germany) and the values were determined and expressed as units per liter (U/L).

2.4. Statistical Analysis

All data were statistically analyzed using SPSS software version 26 (2019). One-way ANOVA is a test procedure used to compare groups. p-values are calculated to signify statistical significance ($P < 0.05$). All experiments in the present study were repeated three times, and all data were expressed as mean ± standard deviation (SD).

Results and Discussion

Total oxidant status (TOS) reflects the overall prooxidant status in the body [21], it is used alongside total antioxidant status (T-AOC) to provide a comprehensive view of the redox balance between oxidative stress and antioxidant status [22]. TOS measurements are crucial in understanding the general condition of oxidative stress within the body. T-AOC measurement is instrumental in evaluating the general antioxidant defense status in various health conditions, such as schizophrenia [23].

Table 1 shows a significant increase (P≤0.05) in G1 compared with G2 and G3 in Total oxidant (TOS) value and a non-significant increase in G2 compared with G3 (control group). It also shows a significant decrease (P≤0.05) in G1 compared to G2 and G3 in Total antioxidant (T-AOC) levels. The T-AOL level has also decreased significantly in the G2 group compared to the G3 group.

Numerous articles have been published on the potential biological consequences of exposure to EMF and the biological interactions with EMF [24]. Contemporary research has demonstrated that electromagnetic fields affect the activity of endogenous antioxidants, leading to an increase in cellular free radical production [25]. Other studies of several antioxidants in the plasma of people who live near mobile towers found that their levels had significantly dropped, especially for GSH and CAT and SOD, and that lipid peroxidation had increased [26]. So, the continuous exposure of the body to EM radiation may result in a rise in the hepatic production of free radicals and present an increased oxidative stress status resulting from a significant elevation of the malondialdehyde (MDA) level (oxidation/antioxidant balance shifts to the oxidation state) thus, it leads to a decrease in active of some important antioxidant enzymes like this catalase and glutathione peroxidase [27]. Despite its complexity, LDH is a biomarker that is very desirable for cancer treatment since it is linked to the activation of several oncogenic signaling pathways, metabolic activity, invasiveness, and immunogenicity of many cancers [28]. Also, the activity of the enzyme (LDH) increases under the condition of oxidative stress [29].

Table 2 shows a significant increase (P≤0.05) in G1 compared with G2 and G3 in liver enzyme activity (AST) and shows a non-significant increase in G2 compared with G3 (control group). Significant decrease in G2 compared with G3 while shows a significant increase (P≤0.05) in G1 compared with G2 and non-significant increase in G1 and G2 compared with G3 in LDH. Also shows a non-significant increase in G1 compared with G2, and G2 compared to G3, and a significant increase (P≤0.05) compared to G3 in activity enzyme (ALP), while it was a non-significant increase in G1

Table 1. The Effect of Mobile Phone Base Stations on Some Biochemical Parameters, the Findings Indicated a Notable Elevation (P≤0.05) in TOS Levels in G1 as Opposed to G2 and G3 (control group), with a Non-significant Rise Observed in G2 Compared to G3. Furthermore, a significant reduction (P≤0.05) in TT-AOC levels was observed in G1 in comparison to G2 and G3.

G	TOS (μmol H_2O_2 equiv./L)		T-AOC (mmol/L)	
NO.				
	Mean ±S.D	p-value	Mean ±S.D	p-value
G1	2.300±0.187	G1 vs G2	0.364±0.008	G1 vs G2
		0.000*		0.000*
		G1 vs G3		G1 vs G3
		0.000*		0.000*
G2	1.782±0.064	G2 vs G3	0.479±0.059	G2 vs G3
		0.229		0.036*
G3	1.746±0.088		0.508±0.063	

*The mean difference is significant at (p ≤ 0.05)

Table 2. The Effect of Mobile Phone Base Stations on Liver Enzymes. The findings show a significant elevation (P≤0.05) in liver enzyme activity (AST) in G1 compared to G2 and G3. G2 exhibited a slight increase compared to G3 (control group), but it was not statistically significant

G	AST(U/L)		ALP(U/L)		ALT(U/L)		LDH (U/L)	
NO.	Mean±S.D	p-value	Mean±S.D	p-value	Mean±S.D	p-value	Mean±S.D	p-value
G1	26.753±12.993	G1 vs G2	152.621±98.425	G1vs G2	10.758±10.916	G1vs G2	222.160±181.035	G1 vs G2
		0.000*		0.224		0.736		0.004*
		G1vs G3		G1 vs G3		G1 vs G3		G1 vs G3
		0.000*		0.032*		0.05		0.098
G2	11.629±9.293	G2 vs G3	128.937± 60.273	G2 vs G3	9.883±10.034	G2 vs G3	160.539±106.285	G2 vs G3
		0.113		0.285		0.069		0.326
G3	7.530±7.965		110.302± 43.894		5.619±5.811		124.123±55.162	

*The mean difference is significant at (p ≤ 0.05)

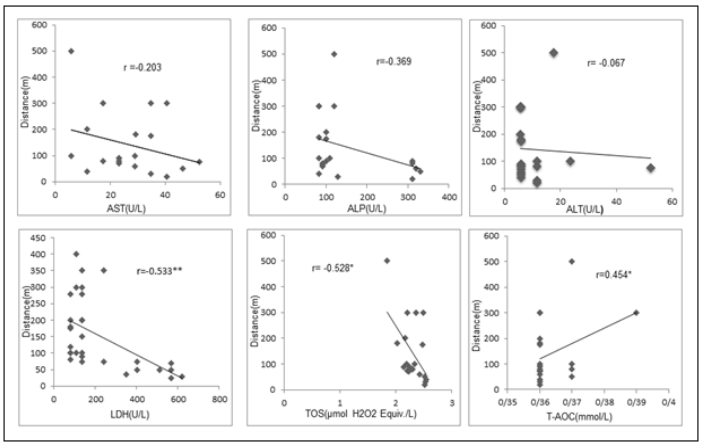

Figure 1. The Scattered Dot Diagram Shows the Correlation between Distance with AST, ALP, ALT, LDH, TOS, and T-AOC Levels in Group 1.

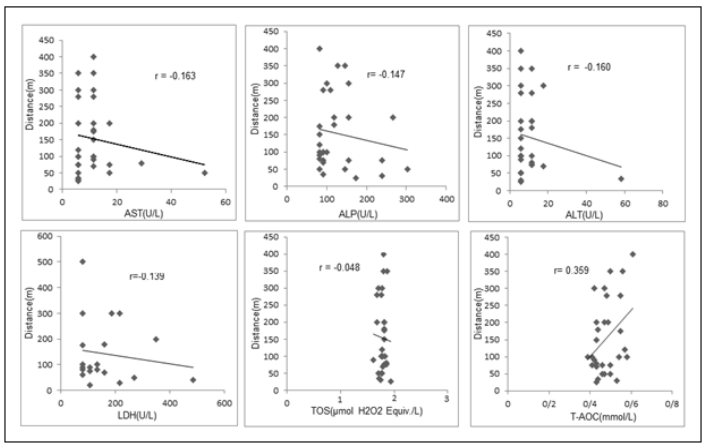

Figure 2. The Scattered Dot Diagram Shows the Correlation between Distance with AST, ALP, ALT, LDH, TOS, and T-AOC Levels in Group 2.

compared with G2 and G3 and G2 compared to G3 in enzyme activity (ALT). AST and ALT are recognized to be sensitive and specific liver disease enzymes that are produced by hepatocyte cells [30]. These enzymes may be detected in other tissues such as the heart, and kidney muscle, even though the liver is where they are most highly expressed. Chronic drinking, hepatocellular cancer, and tissue damage all cause elevated AST and ALT levels in people [31]. Alkaline phosphatase is an enzyme that is primarily found in the hepatobiliary tract, bone, placenta, and to a smaller extent in intestinal tissue. ALP is involved in multiple dephosphorylating reactions. Alkaline phosphatase is generally higher in children and adolescents due to the increased osteoblastic activity associated with bone growth [32]. Humans exposed to electromagnetic fields have an increase in stress-oxidative compounds and glucocorticoids (cortisol). The increased transamination process is a result of electromagnetic fields. The production of oxidative stress compounds may be the cause of the previously mentioned process. The reason for this increase may be due to the generation of free radicals in the human body from an exogenous source (electromagnetic radiation), which leads to oxidative stress and affects the effectiveness of liver enzymes [33].

Pearsons's correlation coefficient (r) was used to analyze the correlation between distance of mobile phone network and the variables of the study. The Table 3 shows the correlation between distance of mobile phone network and AST, ALP, ALT, LDH, TOS, and T-AOC level in G1 group of the study. The AST, ALP, and ALT levels show non-significant correlation with distance from mobile phone network, on the other hand LDH and TOS levels shows negative correlation with distance from mobile phone network and this correlation was significantly high

Table 3. Correlation between Distance of Mobile Phone Network with Biochemical Parameters in Group 1. The levels of AST, ALP, and ALT show an insignificant relationship with proximity to a mobile phone network. In contrast, LDH and TOS levels display a negative correlation with distance from the mobile phone network, with a particularly strong correlation noted specifically with LDH levels.

Parameter	Correlation	p-value
AST	-0.203	0.392
ALP	-0.369	0.11
ALT	-0.067	0.78
LDH	-0.533**	0.002
TOS	-0.528*	0.017
T-AOC	0.454*	0.044

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

Table 4. Correlation between Distance of Mobile Phone Network with Biochemical Parameters in Group 2, According to the Results, None of these Biochemical Parameters have a Significant Correlation with the Distance from the Mobile Phone Network

Parameter	Correlation	p-value
AST	-0.163	0.389
ALP	-0.147	0.44
ALT	-0.16	0.398
LDH	-0.139	0.559
TOS	-0.048	0.801
T-AOC	0.359	0.051

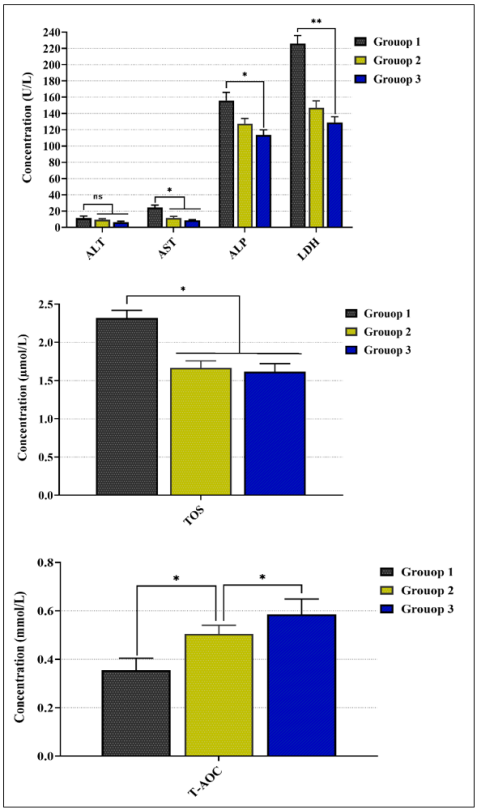

Figure 3. The Effect of Mobile Phone Base Stations on the Serum Levels of TOS, T-AOC, ALT, AST, ALP, and LDH between Three Groups (G1, G2, G3).

with LDH level. Only T-AOC shows a significant positive correlation with distance from mobile phone network in this group. Perhaps the reason for this is that the proximity of mobile phone base stations to homes increases the body's exposure to EM radiation and thus affects the effectiveness of enzymes [34]. The Table 4 indicated the correlation values between distance mobile phone network and AST, ALP, ALT, LDH, TOS, and T-AOC level in G2 group of the study. According to these results none of these biochemical parameters has any significant correlation with distance from mobile phone network.

According to Figure 1 and Figure 2 the mean AST level in G1 was significantly higher than in G2. There was no significant difference in the mean ALP level between G1 and G2 groups. The mean ALT level in G1 group was not significantly different from G2 group according to results. Finally, the mean LDH level in G1 group (Figure 1) is significantly higher than in G2 group (Figure 2). Finding suggests that there is a statistically significant difference in TOS and T-AOC levels between groups G1 and G2.

There is a moderate negative correlation between TOS and distance from mobile phone base stations in G1 group. This correlation is statistically lower in G2 group, and the lowest correlation between TOS and distance from mobile phone base stations was in G3 group (Figure 3). The T-AOC level was the only parameter in this study with positive correlation with distance from mobile phone networks in all three groups. Accordingly, T-AOC level and distance from mobile phone base stations were significantly different between these groups. Figure 3 demonstrated a moderate negative correlation between LDH level and distance from mobile phone base stations. This correlation was statistically significant compared to the G3 group. According to Figure 3, there is a weak negative correlation between AST and distance from mobile phone base stations in G1 group, but this correlation was significantly higher in this group compared to G2 and G3 groups. There was a moderate negative correlation between ALP and distance from mobile phone base stations in G1 group, the correlation was also statistically significantly higher than G3 group. ALT demonstrated a negative correlation with mobile phone base stations in all G1, G2, and G3 groups, and there was no significant difference between these groups. In this study because of the limitation we included 90 individuals, we suggest studying a large number of participants and analyzing other cancer-related markers and other oxidant and antioxidant markers.

In conclusion, according to the results, the mobile phone base stations have harmful effects on some enzymes activity and can affect the health. It can be concluded that living near the mobile phone towers, have harmful effects on human health and long-term exposure to electromagnetic radiation from towers can cause cancer.

Acknowledgments

Conflict of interest

The authors declare that they have no conflict of interests.

Authors Contributions

Sara Ali Hadhod: Methodology, Investigation, Data curation, Original draft preparation.

Ali NooryFajer: Supervision, Conceptualization, Writing- Reviewing and Editing.

Availability of data and materials

The data and materials that support the findings of this study are available from the corresponding author, upon reasonable request.

Ethical Approval

This research protocol was evaluated and approved by Researches Ethics Committee of AL-Qadisiyah University, Iraq.

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