

Effect of Lipid Peroxidation on Dental Healthcare Workers

Fazladin T. Temurov, Gamal K. Ashyrbekov, Serikkali K. Esengeldi, Maksut B. Tolepbergenov, Bekjan A. Akhmet

Department of Surgical and Pediatric Dentistry, Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkestan, Republic of Kazakhstan

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ABSTRACT

Aim and Objective: The relevance of the study was explained by the fact that free radicals, known to be a product of lipid peroxidation, damage the integrity of cell membranes and corresponding intracellular structures, disrupting their functioning. The purpose of this cross-sectional study was to investigate the effect of free-radical lipid peroxidation in the blood on the body of dentists without diseases of the bronchi and lungs. **Materials and Methods:** The chemiluminescent properties of the blood hemolysate of 65 dentists were measured. Blood was collected in a test tube with an anticoagulant, and the plasma was aspirated with a Pasteur pipette. The hemolysate was aspirated two times. Distilled water was added to the sediment of erythrocytes, the mixture was shaken, and centrifuged. Statistical processing of morphometric indicators was carried out using the software package “Statistica 6.0.” **Results:** The direct dependence of the spontaneous chemiluminescence (SCL) growth parameters in the blood hemolysate of dentists on their length of service was determined. **Conclusion:** The conclusions indicate a direct correlation between the growth parameters of the SCL index in the blood hemolysate of dentists and their length of service. The applied value of this study lies in the possibility of practical application of the results obtained to qualitatively investigate the effect of lipid peroxidation processes on the body of dentists.

KEYWORDS: Chemical activity, chemiluminescent properties of blood hemolysate, free radicals, unpaired electron

INTRODUCTION

An increase in the content of lipid oxidation products (LOPs) occurs in many inflammatory diseases of the bronchopulmonary apparatus. With intense and extensive physical activity, the negative impact of lipid peroxidation increases, significantly slowing down the processes of recovery and subsequently reducing the general and special functional capability of the body.^[1-3] There are reports of increased lipid peroxidation processes in erythrocyte membranes, as well as changes in the amount of α -tocopherol and superoxide dismutase (SOD) activity in the blood of patients with bronchial asthma. In addition to enzymatic biochemical defense systems, there are non-enzymatic antiradical and antiperoxide systems, which include

endogenous antioxidants, primarily vitamins of group A (β -carotenoids) and α -tocopherol.^[4-6]

Medical practice has established that a considerable number of biochemical reactions in the body occur with the participation of free radicals with extremely high chemical activity. Free radical oxidation is a process of direct transfer of oxygen to a substrate with the formation of peroxides, ketones, and aldehydes. Moreover, a characteristic feature of this reaction is its chain, self-inducing nature. A classic example of

Address for correspondence: Prof. Fazladin T. Temurov, Department of Surgical and Pediatric Dentistry, Khoja Akhmet Yassawi International Kazakh-Turkish University, 161200, 29 Bekzat Sattarkhanov Ave., Turkestan, Republic of Kazakhstan. E-mail: temurov6319-3@kpi.com.de

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free radical processes in the body is lipid peroxidation, which occurs mainly in biological membranes.^[7,8]

Inflammatory processes in the body caused by infectious factors are based on the destruction processes of cell membranes.^[9-11] The transformation of ordinary lipids into fatty acid hydroperoxides leads to the appearance of “holes” in the membranes, through which, as if through pores, the contents of the cells themselves and their organelles rush outward. Excessive accumulation of calcium ions occurs inside the cells, which, in turn, also leads to the activation of endogenous phospholipases and stimulation of lipid peroxidation processes.^[12,13] The end products of lipid peroxidation are ketones, aldehydes, including malondialdehyde (MDA), and saturated hydrocarbons. Disruption of the stationary state of free radical oxidation processes and an imbalance toward increased lipid peroxidation can be one of the important pathogenetic factors in the development and course of herpes virus infection, as one of the side effects of the lipid peroxidation influence on the body.^[8,14]

Identification of the specific features of the influence of lipid peroxidation on the body of practicing dentists is of great importance from the standpoint of planning and implementing their practical activities. The chemiluminescence method allows us to determine the concentration of products of oxidation reactions, to study the antioxidant properties of organs and tissues, and to study the activity of enzymes that utilize peroxide products (glutathione peroxidase, glutathione reductase) or affect the content of active forms of oxygen (SOD, catalase, peroxidase) directly according to the chemiluminescence parameters of biological substrates. That is why the chemiluminescent parameters of blood hemolysate can measure the effect of lipid peroxidation. The purpose of this study was to investigate the changes in the chemiluminescent parameters of blood hemolysate in dentists depending on the length of service.

MATERIALS AND METHODS

The objectives of the study were the chemiluminescent properties of the blood hemolysate of 65 dentists who took part in the experiments conducted within the framework of this study. The leading approach in this paper involved a systemic investigation of issues under study, with a logical construction of conclusions based on the results obtained. The systemic study is based on the practical study of the chemiluminescent properties of the blood hemolysate of 65 dentists who took part in the experiment conducted within the framework of this study, in combination with the analysis of available

scientific publications within the framework of the subject matter. Depending on the work experience (up to 4 years, of 15 years and more), chemiluminescent parameters [spontaneous chemiluminescence (SCL); chemiluminescence index; average rate of peroxide radical formation; and chemiluminescent index of intoxication] were determined.

Blood from a vein was collected in a test tube with an anticoagulant. An aliquot of 1 mL of non-coagulated blood was centrifuged (approximately 10 min at 1000 rpm), and the plasma was aspirated with a Pasteur pipette. An aliquot of 3 mL of physiological solution was added to the erythrocytes, and the mixture was carefully mixed with a glass rod and centrifuged (approximately 10 min at 1000 rpm). The supernatant (hemolysate) was aspirated with a Pasteur pipette. This procedure was repeated two times (centrifuged for approximately 5 min at 1000 rpm) for the complete removal of fructose from blood plasma. After suctioning the hemolysate, 3 mL of distilled water was added to the sediment of erythrocytes, the mixture was vigorously shaken, left to stand for 10 min, and centrifuged (approximately 5 min at 1000 rpm). The data obtained during a scientific experiment were analyzed and systematized in accordance with the subject matter and the selected sequence of its coverage.^[15,16]

Saliva was collected on the day of admission. The content of thiobarbituric acid (TBC)-active products in the oral fluid was determined by a color reaction with TBC. The basis of the method is the reaction between MDA and TBC, which, under conditions of high temperature and low pH, proceeds with the formation of a trimethine complex containing one molecule of MDA and two molecules of TBC. For this purpose, 4.5 mL of 20% phosphotungstic acid was added to 1 mL of tissue homogenate, and after protein precipitation, it was centrifuged at 2500 rpm for 15 min. The supernatant liquid was drained, and 1 mL of the 0.8% TBC solution was added to the sediment and kept for 1 h at a temperature of 100°C. Under such conditions, MDA reacts with TBC to form a trimethine-colored complex. After that, the tubes were cooled and centrifuged for 10 min at 6000 rpm.

RESULTS

The level of spontaneous luminescence of the dentists' blood hemolysate changes depending on the length of service [Table 1]. With work experience up to 4 years in the first group, the SCL of blood hemolysate increased by 12%; in the second and third groups, this indicator was higher compared with the control of SCL of healthy people (taken as 100%) by 36% and 52%, respectively.

For a work experience of 15 years and more, the peak systolic velocity level was 176%, which was 1.76 times higher compared with the controls and 64%, 40%, and 24% higher compared with the first, second, and third groups of doctors studied. Thus, it can be argued that with an increase in the length of service, the rate of SCL in the blood hemolysate of dentists increases.

The total amount of initiated luminescence of the blood hemolysate of dentists with work experience of up to 4 years increased by 15%; in the group with work experience of 5–9 years, this indicator increased by 39.6% compared with the control group of the studied people. With a work experience of 10–14 years in a dental clinic, the total light sum of the initiated light emission of the blood hemolysate was 155.5%, that is, the increase in this indicator was 55.5%. In the group of dentists with 15 years of work experience and over, the total light sum of the initiated light emission increased by 80% compared with the controls, that is, compared with the first, second, and third groups of the studied workers, it was respectively 65%, 40.4%, and 24.5%

higher. The average rate of peroxide radical formation in the blood hemolysate also changed depending on the dentists' length of service. So, in the first group, this indicator was 123.6% of the control (in the control group, this indicator was taken as 100%), in the second group, the increase in this indicator was 39%, and in the third group it was 54.1%.

In the blood hemolysate of dentists with a work experience of 15 years and more, the average rate of peroxide radical formation reached 179.6%, that is, the increase in the indicator compared to the control was 79.6%; compared with the first, second, and third groups, this indicator was higher by 56%, 40.6%, and 25.5%, respectively. Thus, the chemiluminescent properties of the dentists' blood hemolysate changed depending on the length of service and their pathological properties increased.^[17] These changes in the chemiluminescent parameters of blood hemolysate in dentists depending on the length of service are shown in Figure 1.

The studies convincingly showed that the content of thiobarbituric acid (TBA)-active products in the

Table 1: Changes in the chemiluminescent parameters of blood hemolysate in dentists depending on the length of service

Group	Chemiluminescent parameters			
	Spontaneous chemiluminescence (kV/s)	Chemiluminescence index (10 ³ kV/5 min)	Average rate of peroxide radical formation (kV/s)	Chemiluminescent index of intoxication (c.u.)
Control, % n=54	2.5 ± 0.14, 100%	23.4 ± 0.61, 100%	78.5 ± 2.3, 100%	1.0 ± 0.05, 100%
1st group (up to 4 years), % n=15	2.8 ± 0.15, 112%	26.9 ± 0.62, 115%	97 ± 1.9, 123.6%	1.14 ± 0.06, 114%
2nd group (5–9 years), % n=17	3.4 ± 0.16, 136%	32.6 ± 0.65, 139.6%	109 ± 1.8, 139%	1.38 ± 0.08, 138%
3rd group (10–14 years), % n=18	3.8 ± 0.18, 152%	36.4 ± 0.61, 155.5%	121 ± 2.3, 154.1%	1.54 ± 0.10, 154%
4th group (15 years and over), % n=19	4.4 ± 0.25, 176%	42.2 ± 1.0, 180%	141 ± 3.3, 179.6%	1.78 ± 0.12, 178%

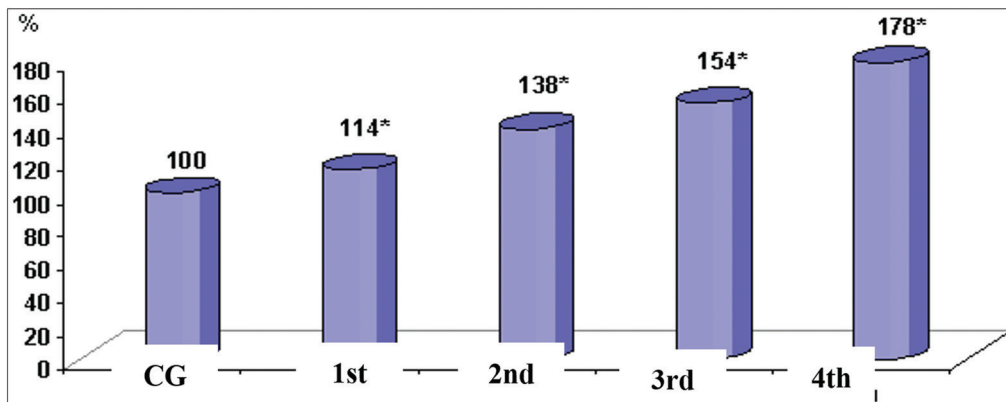


Figure 1: Changes in the chemiluminescent parameters of blood hemolysate in dentists depending on the length of service

Note: CG = control group. *P < 0.05 compared with CT; first group (work experience up to 4 years); second group (work experience 5–9 years); third group (work experience 10–14 years); fourth group (work experience 15 years and over)

oral fluid of male dentists after outpatient dental appointment increased: before incubation by 1.51 times and during 60-min incubation by 1.52 times. At the same time, the increase in TBA-active products during incubation in male dentists after an outpatient dental appointment was 1.2 times higher than that before work. Similar changes were observed in the group of female dentists: the content^[18] of TBA-active products in the oral fluid after outpatient dental appointment increased: 1.48 times before incubation, 1.61 times during incubation; the increase in TBA-active products during incubation was 2.25 times higher compared with the indicators before the outpatient dental appointment.

DISCUSSION

The performed studies clearly demonstrated the direct dependence of the SCL index growth parameters in the blood hemolysate of dentists on the length of their work. Discussion of the issues raised in the topic of this scientific research contributes to the highest quality disclosure in the context of the objectives set.^[19-22] Thus, a team of authors represented by Khabibova *et al.*^[10] in a joint study note that with aphthous stomatitis in the saliva of patients, there is a change in individual indicators of free radical oxidation. According to researchers, this fact indicates concomitant disruption of the antioxidant defense in the oral cavity, which is manifested by an increase in the content of LOP—hydroperoxides and secondary products—MDA, a decrease in the antioxidant activity of saliva.

This fact has a negative effect on the body of dentists. Zavarukhina studied various aspects of the effect of aerobic exercise on lipid peroxidation processes and pointed to the fact that changes in the content of isopropanol-soluble LOPs in response to submaximal exercise reflect the degree of adaptation of a person to intense muscular activity: the higher the level of fitness, the less dramatic shifts in the content of LOPs are caused by exercise.^[7] At the same time, Melnikova,^[9] in her scientific study of the influence of dentists' workload on changes in lipid peroxidation indicators in the body, notes that the correlation analysis of LOP indicators with other physiological indicators revealed that female dentists after outpatient dental appointments had a positive correlation between the level of TBA-active products and hemoglobin ($\tau=0.242$; $P < 0.048$), and a negative correlation with the number of monocytes ($\tau=-0.445$; $P < 0.001$) and erythrocyte sedimentation rate indicators ($\tau=-0.309$; $P < 0.016$). In male dentists after outpatient dental appointments, a positive correlation was found between the level of TBA-active products and the number of monocytes ($\tau=0.384$;

$P < 0.003$), α -amylase activity ($\tau=0.316$; $P < 0.01$), and the number of segmented neutrophils ($\tau=0.327$; $P < 0.01$). A negative correlation between the levels of TBA-active products was found with the number of eosinophils ($\tau=-0.532$; $P < 0.001$).

A significant place in the discussion of the issues submitted for consideration is given to the works of foreign authors conducting research in the indicated area. Logan *et al.*^[12] note that lipid oxidation in food systems is one of the most important factors affecting food quality, nutrition, safety, color, and consumer acceptance. Controlling lipid oxidation remains an ongoing challenge as most foods are highly complex matrices. Lipids are mainly incorporated as emulsions, and chemical reactions occur at various interfaces throughout the food matrix.^[23-25] Recently, the incorporation of healthy lipids into food systems to deliver essential nutrients has become increasingly popular in the food industry. Many food ingredients contain a wide range of components, many of which are unknown or constitute different or indeterminate molecular structures, which make it necessary for the food industry to develop effective approaches to mitigate lipid oxidation in food systems.^[12] Thus, the discussion of the issues considered in this study emphasized the diversity of scientists' opinions on the subject matter and the possibilities of its practical solution.

The strengths of this study are the possibility of the practical application of the results to study the effects of lipid peroxidation on the body of dentists. In turn, the limitations of the study are the small sample. In addition, changes in only the chemiluminescent parameters of blood hemolysate in dentists were studied.

It is controversial that changes in the content of oxidation products of lipids soluble in isopropanol in response to submaximal exercise reflect the degree of adaptation of the dentist. In this study, direct dependence of the parameters of growth of SCL in the hemolysate of the blood of dentists on their experience was determined. However, future research should focus on solving the problem of lipid oxidation control by dentists of different ages.

CONCLUSIONS

The presented study indicates a direct correlation between the growth parameters of the SCL index in the blood hemolysate of dentists and their length of service. As the total length of service of dentists increases, this indicator increases. It was shown that the content of TBA-active products in the oral fluid of dentists after outpatient dental appointment increased. Furthermore, this study has shown an increase in the pathological

properties of blood hemolysate. Therewith, there is a change in the average rate of peroxide radical formation in the blood hemolysate, also depending on the length of service of dentists. In general, this study clearly demonstrated the need for further in-depth research on the features of lipid peroxidation influence on the body of dentists of various age groups.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHORS' CONTRIBUTIONS

FTT, GKA: Conceptualization, writing-original draft preparation, final draft review. SKE, MBT: Methodology, writing-original draft preparation, supervision, writing-reviewing, and editing. BAA: Software, writing-original draft preparation, supervision, writing-reviewing, and editing.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional and National Research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

PATIENT DECLARATION OF CONSENT

Not applicable.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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