The role of lipid peroxidation disorders and antioxidant protection enzymes in the dynamics of experimental periodontitis development

(Znaczenie zaburzeń peroksydacji lipidów oraz enzymów antyoksydacyjnych w dynamice rozwoju eksperymentalnego zapalenia przyzębia)

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Abstract – Introduction. The activation of lipid peroxidation is one of the mechanisms of triggering cellular damage. This mechanism can also play an important role in the development of pathological changes in the mouth cavity.
The aim of the study. The aim of the study was to determine the significance of the disorders of oxidation processes in the dynamics of experimental periodontitis development.
Materials and methods. The experiment was carried out on clinically healthy white rats weighing 150-200 g in the vivarium conditions. Tests were carried out in accordance with the general rules and provisions of the European Convention for the protection of vertebrate animals used for experimental and other scientific purposes. Experimental periodontitis was produced in the animals by introducing microbial mixtures in the periodontal tissues. The blood serum of the experimental animals was examined for diene conjugates and triene conjugates as well as the activity of the superoxide dismutase and catalase on the 7th and 14th day of the experiment. The results were subject to statistical analysis.
Results. It has been determined that with the increased of the production of reactive oxygen species, the intensity of periodontitis is higher.
Conclusions. The development of experimental periodontitis is accompanied with the increase of lipid peroxidation processes as well as changes in the activity of antioxidation factors.

Key words – periodontitis, diene conjugates, triene conjugates, catalase, superoxide dismutase.

Streszczenie – Wprowadzenie. Aktywacja peroksydacji lipidów jest jednym z mechanizmów wyzwalań uszkodzeń komórkowych. Mechanizm ten może także odgrywać istotną rolę w rozwoju patologii w obrębie jamy ustnej.
Cel badań. Celem badań było określenie znaczenia zaburzeń procesów oksydacyjnych w dynamice narastania eksperymentalnego zapalenia przyzębia.
Materiał i metodyka. Eksperyment przeprowadzono z użyciem białych zdrowych klinicznie szczurów 150-200 g w warun-
kach vivarium. Badania wykonano zgodnie z ogólnymi zasadami i przepisami Europejskiej konwencji o ochronie kręgowych używanych do celów doświadczalnych oraz do innych celów naukowych. Doświadczalne zapalenie przyzębia wywołano w zwierzęt, wprowadzając do tkank przyzębia mieszaniny drobno-
strojów. W surowicy krwi zwierząt doświadczalnych badano zawartość koniugatów dienu i koniugatów trienu oraz aktywność dysmutazy ponadtlenkowej i katalazy w 7 i 14 dniu trwania eks-
erymenu. Wyniki badań poddano analizie statystycznej.
Wnioski. Rozwojowi eksperymentalnego zapalenia przyzębia towarzyszy narastanie procesów peroksydacji lipidów i zmiany aktywności czynników antyoksydacyjnych.

Słowa kluczowe – eksperymentalne zapalenie przyzębia, dienu koniugaty, trienu koniugaty, dysmutaza ponadtlenkowa, katalaza.

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Authors’ contributions to the article:
A. The idea and the planning of the study
B. Gathering and listing data
C. The data analysis and interpretation
D. Writing the article
E. Critical review of the article
F. Final approval of the article

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The results of the assay were statistically analyzed using the non-parametric statistical methods [11].

III. RESULTS AND DISCUSSION

The introduction of complex microbial mixtures diluted in egg protein into periodontal tissues had caused hyperergic inflammatory process with expressed changes in the soft tissue of the lower jaw, accompanied by edema and hyperemia of the mucous membrane and the characteristics of the symptoms were the same as the changes in humans [10, 12]. Significant quantitative changes were found in prooxidant-antioxidant system [13].

The results of the study show that in the early period of the development of inflammation in the periodontal complex, which ranged from the 1st to the 7th day of the experiment, there was an excessive accumulation of lipid peroxidation products in serum, as evidenced by increased concentration of CT (by 2.20 times; p<0.01) and TC (by 1.93 times; p<0.01), respectively, as compared with the control group of the experimental animals (Table 1, Figure 1). In the later period, on the 14th day of the experimental periodontitis model, there was a gradual decline in DC (by 1.53 times; p<0.01) and TC (by 1.52 times; p<0.01) in the serum, as compared with the group of animals studied on the 7th day of the experiment, but these indexes were higher than in the intact animals group (by 1.44 times; p<0.01 and by 1.26 times, p<0.01, respectively). The data showed increased generation of reactive oxygen species and the activation of free radical oxidation of lipids throughout the periods of the inflammatory response development, which were however most expressive in the peak of inflammation, which corresponded to a more severe clinical picture of the animals in this group. In the later period of the development of periodontitis, despite some decrease in the intensity of lipid peroxidation, full attenuation in the inflamed periodontal tissues did not occur.

By means of biochemical investigation of enzyme link of the antioxidant system, antioxidant defense by superoxide dismutase and catalase activity (SOD, CT) was determined in the group III of the experimental animals (Table 2). As a result, it was established that the activity of these enzymes changed in different directions depending on the duration of the pathogenic factors.
Table 1. Concentration of diene and triene conjugates in rats’ blood serum for different periods of experimental periodontitis (M ± m)

<table>
<thead>
<tr>
<th>The form of experiment</th>
<th>Experiment duration (days)</th>
<th>Number of animals</th>
<th>DC, conditioned units/ml</th>
<th>TC, conditioned units/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group, intact animals</td>
<td>7</td>
<td>10</td>
<td>2.383±0.071</td>
<td>2.756±0.022</td>
</tr>
<tr>
<td>Animals with periodontitis</td>
<td>7</td>
<td>8</td>
<td>5.250±0.242 p&lt;0.01</td>
<td>5.310±0.187 p&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>8</td>
<td>3.431±0.089 p&lt;0.01</td>
<td>3.485±0.107 p&lt;0.01</td>
</tr>
</tbody>
</table>

Notes: 
1. p1 - significance of differences in relation to intact animals; 
2. p2 - significance of differences in relation to animals with experimental periodontitis on the 7th day of the study.

Table 2. CT and SOD activity in rat’s blood serum for different periods of experimental periodontitis (M ± m)

<table>
<thead>
<tr>
<th>The form of experiment</th>
<th>Experiment duration (days)</th>
<th>Number of animals</th>
<th>SOD, conditioned units/ml</th>
<th>CT, mcat/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group, intact animals</td>
<td>7</td>
<td>10</td>
<td>2.294±0.066</td>
<td>0.118±0.001</td>
</tr>
<tr>
<td>Animals with periodontitis</td>
<td>7</td>
<td>8</td>
<td>1.292±0.048 p&lt;0.01</td>
<td>0.521±0.008 p&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>8</td>
<td>1.840±0.040 p&lt;0.01, p&lt;0.01</td>
<td>0.382±0.008 p&lt;0.01, p&lt;0.01</td>
</tr>
</tbody>
</table>

Notes: 
1. p1 - significance of differences in relation to intact animals; 
2. p2 - significance of differences in relation to animals with experimental periodontitis on the 7th day of the study.

At the early stage of experimental periodontitis, that is on the 7th day, SOD activity in serum decreased (by 1.78 times; p<0.01), but later, on the 14th day, this index changed in the opposite direction – it increased (by 1.42 times; p<0.01), as compared to the indexes of animals on the 7th day of the experiment. However, its change was less relative to the intact animals (by 1.25 times; p<0.01). This gives ground to believe that it is a decompensatory response to stimulating SOD activity with elevated levels of oxygen radicals in inflammation (Figure 2).

The study of one of the key AOS enzymes in blood serum – catalase – in different periods of experimental periodontitis development showed an opposite trend of change as compared to the values of the SOD activity. In addition, the degree of expression was somewhat higher. In particular, in the early stage of experimental periodontitis, which included the 7th day of the experiment, increased activity of CT in serum was observed as compared to the control group (by 4.42 times; p<0.01).

In next stage of inflammation in the periodontal tissue complex (14th day), the activity of CT in serum decreased (by 1.36 times; p<0.01), as compared to the group of animals on the 7th day of the experiment, but remained at a high level in relation to this index in the control group (by 3.24 times; p<0.01). That proves a large pool of use of that enzyme and maintained reserve capacity for antioxidant protection. With the suppression of its activity, it is likely that the antioxidant protection are insufficient for full neutralization of lipid peroxidation products that are over-

Notes: * - significance of differences in relation to the intact animals (p<0.01); # - significance of differences in relation to the animals with periodontitis on the 7th day of the experiment (p<0.01).

Figure 1. Changes of lipid peroxidation indexes in the rats’ serum with experimental periodontitis (% of the control group)
produced in periodontal tissues during the inflammatory process and enter the bloodstream, which ultimately leads to the development of oxidative stress as an additional factor of an alteration and formation of prolonged inflammation with possible complications on the systemic level.

Figure 2. Changes in antioxidant parameters of rats’ blood serum with experimental periodontitis (% of the control group)

IV. CONCLUSION

In the dynamics of inflammation with a bacterial-immune component in the area of periodontal complex, lipid peroxidation products accumulate, stressing the antioxidant protection system and being one of the pathogenic links that determines the character of the course and the outcome of the inflammatory process.

V. REFERENCES