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Pathophysiological and Morphofunctional Reaction of A Dental Pulp under Inflammation.

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ABSTRACT

The scientific works of recent years indicate the possibility of obtaining objective data on the structural and functional changes occurring in the dental pulp under various forms of inflammation developed therein by using ultrasound. This paper deals with the results of the experimental study of the effectiveness of ultrasonic diagnostic methods for pathophysiological and morphofunctional reactions of a dental pulp at different stages of the inflammatory process. The results of pathophysiological and morphofunctional study have shown that acute and exacerbated inflammation in the pulp is accompanied by pronounced changes in vascular bed microcirculation, the leading of which is a reduced vascular tone and venous wave. We have established a strong correlation (r=1.89, p<0.05) between the intensity of exudative and purulent-infiltrative changes in the pulp in the acute and chronic inflammation phases and the nature of the duplex sonography, which allows us to recommend this method of study for differential diagnosis of the clinical form of pulpitis.
Keywords: pulpit, ultrasound scanning, inflammation, experiment, microcirculation, vessel, tooth injury

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INTRODUCTION

The research on the development and improvement of the pulpitis treatment methods has been carried out in dentistry for a long time [1,2]. Modern standards of care for patients with this pathology require the preservation of the pulp both in viable and in functioning state [3,4]. Meanwhile, successful treatment is impossible without an accurate diagnosis of the pulp state [5,6,7]. The arsenal of dentists is still short on objective intravital research methods that allow assessing the functional state of a pulp [8,9,10]. The scientific works of recent years indicate the possibility of obtaining objective data on the structural and functional changes occurring in the dental pulp under various forms of inflammation developed therein by using ultrasound [11,12].

Objective of Research

To study both pathophysiological and morphofunctional reactions of a dental pulp at different stages of the inflammatory process, and their correlation with ultrasonic diagnostic methods.

MATERIALS AND RESEARCH METHODS

6-year-old rams of 20-25 kg under thiopental anesthesia (0.1 mg per 3 kg body weight) underwent trepanation of the mandibular incisor crowns (central incisors) from the buccal surface to the visualized pulp, with opening the latter with the help of a dental probe. The teeth were left in this state throughout the experiment and extracted in 1 hour, and in 1, 3, 10, 20, 30 and 40 days. After after extraction under thiopental anesthesia, the teeth were fixed in 10% buffered formalin solution and decalcified in 25% Trilon-B solution. The specimen after its processing with alcohols of increasing density were embedded in the paraffin. Histological sections were stained with hematoxylin and eosin, by Mallory's, and Van-Gieson's method.

All experimental studies on animals were conducted with the permission of the ethics committee of the Stavropol State Medical University No.302 of 04.14.2013.

The blood flow indices were determined with the help of ultrasonic scanning - color duplex scanning (CDS) or duplex sonography (DS), which ensures to simultaneously assess the condition of the vessel walls and the blood flow distribution.

The result of computer processing of the Doppler shift was obtained in the form of a Dopplerogram with spectral analysis of blood flow high-speed components, or a color two-dimensional cartogram of intravessel flows distribution. For results processing we used a rheographic index (RI) and a vascular tone indicator (VTI). The studies were conducted on the expert ultrasound scanner Philips iE33 with a linear sensor Philips L11-3.

RESULTS

According to our histologic examination of the animal pulp specimens, 1 hour after injuring the horn area there was detected a limited focus of tissue necrosis surrounded by leukocyte torus and perifocal serous exudation against sharp dilatation and blood vessels hyperemia. The inflammatory infiltrate beyond the leukocyte torus had diffuse nature, and contained some impurities of macrophages and lymphocytes against a decrease in the number of leukocytes. The described preferably exudative and to a lesser degree infiltrative reactions to injury were revealed in the core layer of the distal crown pulp; their intensity was decreasing gradually toward the root pulp where they quickly disappeared. This morphological pattern is typical of acute focal serous pulpitis (Figure 1 - 1, 2). According to the ultrasonic scanning, there was a sharp drop in pulp DS and VTI amplitude as compared to initial values 1 hour after the injury. The DS visual assessment allowed identifying the venous wave and a number of additional waves on its descending part (Figure 2 - 1), which, apparently, is due to the sharp dilatation of vessels in reaction to injury and to the difficult blood outflow on the background of developing exudative phenomena.

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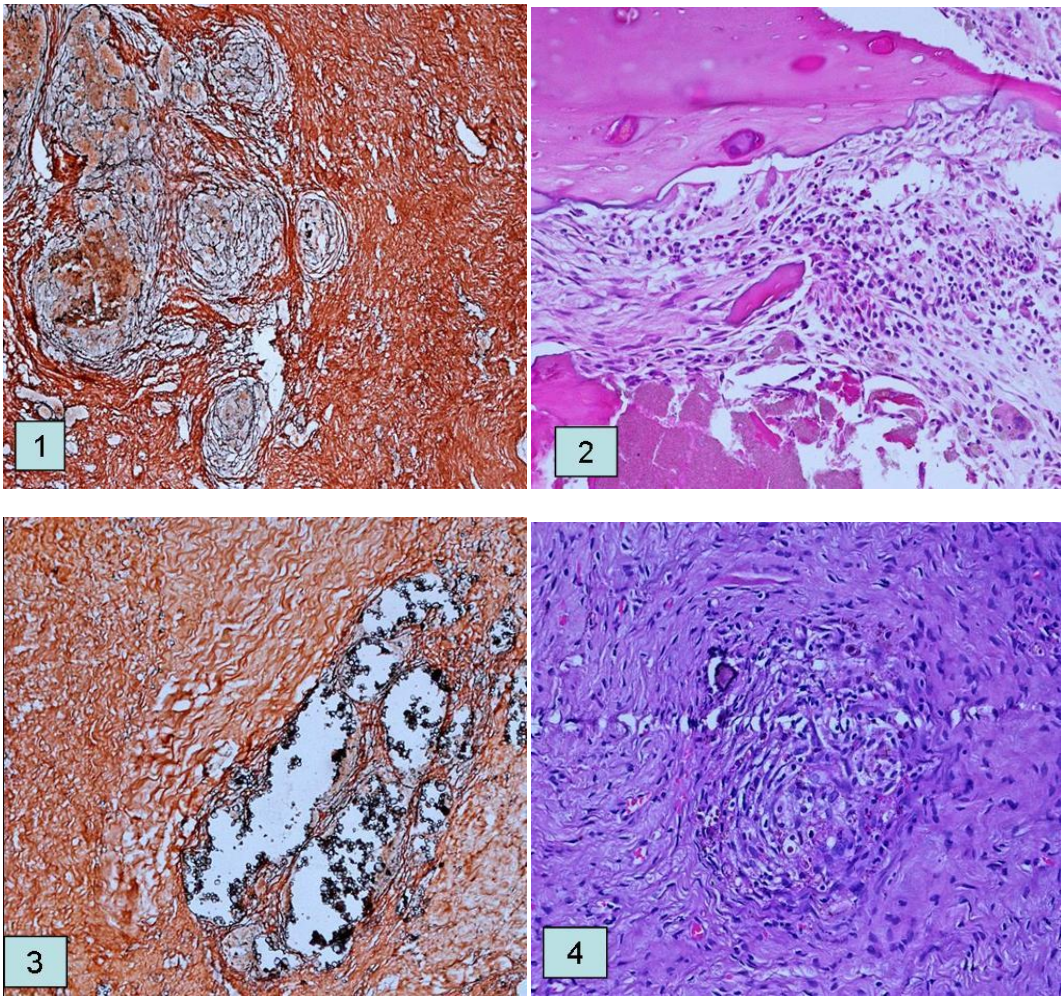

Figure 1: Morphological pattern of acute pulpitis 1 day (1, 2) and 3 days (3, 4) after the start of the experiment. 1 – acute focal pulpitis. Van Gieson's stain. Ocular 10, Objective 20; 2 – perifocal hyperemic reactions in the crown pulp beyond the injured area. Hematoxylin and eosin stain. Ocular 10, Objective 20; 3 – acute seropurulent pulpitis, a necrosis focus with severe leukocyte infiltration. Van Gieson's stain. Ocular 10, Objective 20; 4 – confluent lesions of leukocyte infiltration in the crown pulp. Malory's stain. Ocular 10, Objective 20

1 day after the start of the pulpitis simulation, a pattern of diffuse seropurulent pulpitis was determined. There was the formation of an extensive zone of seropurulent exudation with its epicenter close to the pulp destruction lesion near the dentin defect (Figure 1 - 3, 4). Away from this defect, there are the pronounced vessel hyperemia and serous exudative phenomena. At the same time, there was leukocyte infiltration in the form of small foci and confluent zones observed in the crown pulp, and at some distance from the injured area (Figure 1 - 4). A characteristic feature was spreading of leukocyte infiltration in the pulp in the form of stripes along the peripheral layer. Intensity of hyperemic, exudative, and infiltrative reactions was decreasing in proximal direction, however, the signs of swelling remained pronounced. Vessels remained dilated, with smudged wall pattern; both leukocyte margination and their partial migration beyond the vascular wall were observed. According to ultrasonic scanning, his period was characterized by a significant reduction in the DS amplitude (20% of the initial level) and a decreased VTI (67%). There was a pronounced venous wave detected visually in DS (Figure 2 - 2). We may suggest that a further drop in the DS amplitude and the presence of venous wave in this period are due to the progressive development of edema.

3 days after, there was an extensive zone of necrosis observed in the injured area, with the severe leukocyte infiltration around loosing gradually its density in the proximal direction. Extensive hemorrhage, serous exudation areas, as well as the egress of leukocytes into the perivascular spaces were observed somewhere in the crown pulp. Exudative hyperemic reactions were gradually fading toward the root pulp, with the remaining vascular congestion. Further decrease in DS amplitude and a significant relaxation of vascular tone were still observed (Figure 2 - 3). Slight expression of venous wave.

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At the same period during the development of diffuse purulent process in the pulp, there was a purulent melting of vast crown areas with sharp hyperemic phenomena, vessel stasis, and exudative hyperemic changes, reaching the root pulp and its tissue swelling. As a rule, no DS was recorded in such cases. No DS, however, was on day 20-40 of the acute pulpitis phase characterized by sharply pronounced vascular stasis and total spreading of exudative-infiltrative process up to the root pulp.

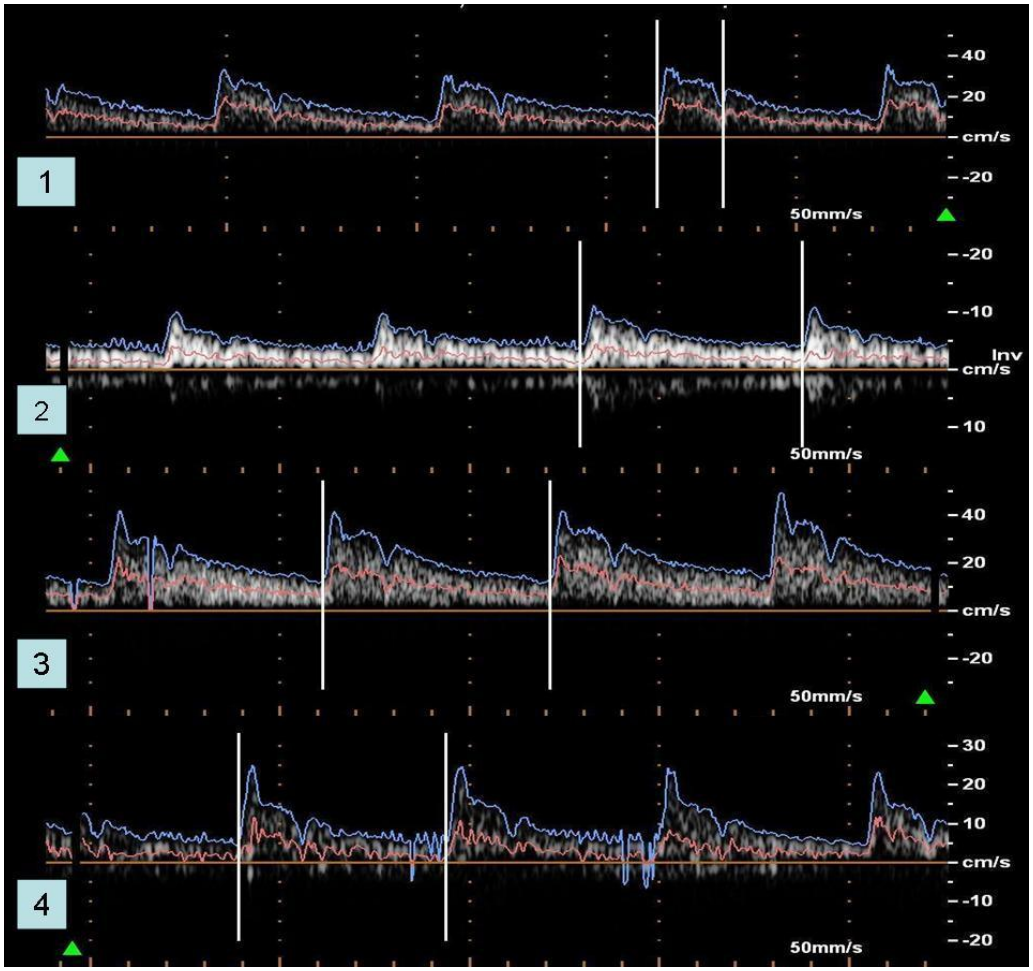

Figure 2: Duplex sonography of tooth pulp 1 hour (1), 1 day (2,) 3 days (3), and 20 days (4) after the start of the experiment. 1 – an expressed venous wave on the descending curve; 2 – a reduced amplitude, an increased vessel tone, and a weak venous wave; 3 - increase in amplitude, a slightly expressed venous wave; 4 - a reduced amplitude, a sharply increased vascular tone

On day 20-30, in addition to the said phenomena, there were observed other variants of the process flow, in particular the pattern of both chronic fibrous pulpitis in the "cold" phase, and moderately pronounced exacerbation. The first is characterized by a smoldering process with a limited destruction focus forming in the injured zone surrounded by the torus of lympho-macrophage elements with an area of concentrically oriented collagen fibrils. Lympho-macrophage infiltrate was quickly diminishing in proximal direction, and congestive reactions of swollen vessel were detected only in the crown pulp; generally, its sclerotic changes were prevailing.

Mild infiltrative congestive effects were observed in the long-term period in the exacerbation phase, with lesser severity than in the acute phase. The ultrasound parameters at the same time were characterized by a noticeable increase in VTI and decrease in the DS amplitude (Figure 2 - 4). As a rule, no pulp DS was recorded during a diffuse purulent, and gangrenous pulpitis (day 20, 30, and 40), accompanied by extensive pulp destruction.

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SUMMARY

During the study, we have established a strong correlation between the intensity of purulent-infiltrative changes in the pulp in the acute and chronic inflammation phases and the nature of the duplex sonography. The acute phase, against the focal serous-purulent pulpitis, is characterized by a decrease in VTI and in the DS amplitude, which is apparently due to the sharp dilatation of blood vessels, bradyhemarrhea therein, as well as the development of edema, which increases the interstitial pressure, thereby deteriorating drastically the microcirculation. This was confirmed by the venous and other waves detected in the DS. Further, the DS remained reduced after process transition to chronic phase (day 10 and 20), however, the VTI increased. This dynamics of the DS characteristics can be explained by the late development of pulp sclerosis and sclerotic changes in the vascular walls. Worsening of processes associated with the spreading of purulent infiltration in the vast area of the pulp, leading sometimes to pulp necrosis, was shown on DS as the absence of vessel pulses. It is remarkable that the similar phenomena were also observed in the case of the root pulp preservation when it was not completely destructed. As a rule, such changes in the DS took place against exacerbation of chronic pulpitis, while the root pulp had exudative effects, hyperemia, and the pronounced swelling detected.

CONCLUSION

Thus, the results of pathophysiological and morphofunctional study have shown that acute and exacerbated inflammation in the pulp is accompanied by pronounced changes in vascular bed microcirculation, the leading of which is a reduced vascular tone and venous wave. We have established a strong correlation (r=1.89, p<0.05) between the intensity of exudative-hyperemic and purulent-infiltrative changes in the pulp in the acute and chronic inflammation phases and the nature of the duplex sonography, which allows us to recommend this method of study for differential diagnosis of the clinical form of pulpitis.

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