Cerebral Blood Flow Dynamics in Rats with Blood Loss

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Abstract — This paper presents the results of investigating the blood flow dynamics using the laser speckle contrast imaging method in rats with blood loss and without it. The results indicate that under such conditions, there was no significant decrease in speckle perfusion values.

Keywords — laser speckle contrast imaging, cerebral blood flow dynamics, blood loss, intensive care medicine, animal study.

I. Introduction

The study of central hemodynamic parameters during blood loss, as well as their evaluation in clinical practice, are of great importance. Microcirculation, perfusion and oxygenation disorders are the key pathogenetic factors in the development of organ dysfunction in hemorrhagic and other types of shock[1].

Laser speckle contrast imaging (LSCI) has been actively used to visualize blood flow in biological tissues[2]. The ability to assess microcirculation makes this method applicable to the study of microhemodynamics in various medical and scientific applications, including intensive care medicine and rehabilitology[3].

Thus, the aim of the study was to evaluate changes in cerebral blood flow by means of LSCI in two groups of rats, one of them was subjected to blood loss in the amount of 30% of the estimated blood volume.

II. Materials and Methods

To detect speckles, the experimental setup was assembled. Raw monochrome images were obtained with such parameters as 90 frames per second and 11 ms exposure time via a high-speed UI-3360CP-NIR-GL CMOS camera (IDS, Germany) coupled with the MVL25TM23 objective (Thorlabs, USA) with a NIR linear polarizer (Thorlabs, USA) in front of it. To illuminate the area of interest, the LDM785 laser source (Thorlabs, USA) with a wavelength of 785 nm was used, and the set of diffusers (Thorlabs, USA) was placed in front of it to disperse the collimated laser beam.

During the experiment, animals were anaesthetized and subjected to catheterization of the left carotid artery to monitor blood pressure and perform blood loss. Animals were placed on the table of the Rodent Surgical Monitor+ surgical system to maintain stable body temperature and to control heart rate. The animal's head was fixed in a holding device. Exposure of the skull bones with the following left-sided skull thinning was performed. Two groups of laboratory rats (1.5 months old, 120-140 g) were studied: the control one (n1=4) and the one with the blood loss in the amount of 30% of estimated blood volume (n2=5). Speckle data were recorded before and after performing the blood loss. All manipulations with the animals were approved by the ethical committee of the Orel State University (protocol No. 27, 17 May 2023).

III. Experimental Results And Discussion

Analysis of the obtained blood pressure values showed that there was a significant difference ($p < 0,05$) between the control group of animals (71,0 [67,0; 72,0]) and the group of animals with blood loss (48,0 [43,0; 58,0]). That indicates that blood loss was performed appropriately, and the hemodynamic characteristics of the animals have changed. However, according to the processed LSCI data, there was no significant difference in speckle perfusion values between two groups of animals.

It is known that microhemocirculatory disorders, despite the common manifestations in different organs, still have their specificity depending on the vascular region of the body. This specificity is determined by both features of the blood supply of a particular organ and the nature of local vascular reactions arising in response to blood loss. The blood supply of vital organs (brain, heart) for some time can be maintained due to the good autoregulation of blood flow and the phenomenon of centralization of blood circulation[4]. That is probably what we have observed. Nevertheless, to confirm the conclusion, the number of animals studied needs to be increased.

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