Laser speckle-contrast imaging in the assessment of cerebral perfusion changes in rats with haemorrhagic shock

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Acute blood loss (ABL) is a critical illness, triggering a complex of general pathological responses with great variability depending on the rate and total volume of blood loss, functional reserves of the organism, etc. ABL with following cerebral ischaemia is particularly dangerous for the organism, and the study of mechanisms of cerebral microcirculatory flow regulation is a non-trivial task. However, it is possible to acquire information in preclinical studies on laboratory animals using non-invasive optical technologies such as laser speckle contrast imaging (LSCI). It allows not only to visualize the microcirculation in the study area, but also to extract quantitative information for further analysis.

The aim of the study was to evaluate cerebral perfusion in rats using LSCI method without and with craniotomy, as well as with ABL modelling while controlling physiological parameters of the laboratory animals.

One and a half months old Wistar rats were used in the experiment. Animals were divided into 2 groups - sham operated (craniotomy without blood loss, 4 animals), and with ABL (craniotomy with blood loss of 30% of estimated blood volume, 5 animals). The experimental setup that implements the LSCI technique was developed to obtain speckle images of the rat cortex. The images were captured for 90 frames per second and 11 ms exposure time for 5 minutes consistently in each phase of data recording, with total of 3 phases. During the experiment, the animal was subjected to catheterisation of the left carotid artery to monitor blood pressure and to perform blood loss and euthanasia. The animal was 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 stereotaxis, and exposure of the skull bones was performed. All manipulations with the animals are approved by the ethical committee of the Orel State University (protocol No. 27, 17 May 2023).

Blood flow maps in cerebral microvessels of animals were obtained using the algorithm developed in Matlab for processing LSCI data. The results showed that after craniotomy, there is an increase in the level of recorded perfusion in the craniotomy area (mean value 2542 perfusion units) compared to the similar intact area (mean value 2217 perfusion units), when both areas are recorded at the same time, with blood pressure monitoring for each rat. This allows recommending craniotomy in case of cerebral circulation studies in rats aged one and a half months and older to obtain data that are more comprehensive as it is more likely that these data are from the pial vessels, not the vessels in the skull bones.

In terms of physiological interpretation, there was a mixed response of perfusion level in rats with an ABL. The majority of animals exhibited either no changes of perfusion or decrease of perfusion while comparing the craniotomy area perfusion values before and after the blood loss. However, there were an increase of perfusion in some animals. This may indicate the complexity and individuality of compensatory mechanisms of the organism and requires further research.

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