CHANGES IN THE TISSUE BLOOD FLOW IN THE RABBIT BRAIN AFTER BURN, ACUTE RADIATION, AND COMBINED INJURIES

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The tissue blood flow of the brain was determined in experiments on rabbits with the aid of xenon-133 after severe burns affecting 20% of the body surface, whole-body x-ray irradiation in a dose of 900 rad, and combined exposure to both factors. The cerebral blood flow was found to be reduced by a lesser degree in burns than the minute volume of the heart (on the average by 20-30% and 50%, respectively). In combined trauma the decrease in the cerebral blood flow was the same as with isolated burns or radiation injury. The authors suggest that a greater decrease in the cerebral blood flow is incompatible with life. The results are evidence of the existence of compensatory mechanisms aimed at maintaining the cerebral blood flow despite a fall in the minute volume of the heart.

KEY WORDS: brain tissue blood flow; burns and combined radiation and burn injury.

A few investigations have been carried out to study the cerebral hemodynamics in burn shock [1, 6] and acute radiation injury [4, 5]. No attempt has evidently been made to study the cerebral circulation in combined burn and radiation injuries.

Radioactive xenon-133 was used in the present investigation to study changes in the tissue bloodflow of the brain in burn, acute radiation, and combined injuries.

EXPERIMENTAL METHOD

Experiments were carried out on 33 rabbits weighing 2.5-3.1 kg. A burn of the dorsal region, graded as degree IIIB-IV (20% of the body surface), was produced by a special electric heater with an exposed heating element. Irradiation in a dose of 900 rad was given by two RUM-3 x-ray therapeutic applicances. In the case of combined injury, the burn was inflicted immediately after irradiation.

Xenon-133 in a dose of 50 μCi was injected through a catheter into the right atrium. Curves showing removal of the isotope from the tissues of the head by the bloodstream were recorded with a type URU-64 radiometer. The pick-up with a collimator 3 cm wide was located in the parietal region. The tissue blood flow in the white and gray matter of the brain [7, 8] was calculated by the equation:

$$f = \frac{0.693 \cdot 100 \cdot \lambda}{T_{1/2}} \text{ ml/min/100 g tissue},$$

where $T_{1/2}$ is the half-elimination time for the fast (for the gray matter of the brain) and the slow (for the white matter of the brain) component of the elimination of xenon-133 from the tissue of the head, and λ the tissue/blood partition coefficient of xenon, which is 0.8 for the gray matter and 1.5 for the white matter [9].

The total cerebral blood flow was calculated [10, 11] by the equation:

$$f = \frac{H_{\max} \cdot 1.08 \cdot 100}{A + \frac{h \cdot T_{1/2}}{0.693}},$$

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where H_{max} is the highest point on the curve of elimination of xenon-133 from the tissues of the head, h the height of the elimination curve at the 10th minute; A the area bounded by the portion of the xenon-133 elimination curve between the points H_{max} and h.

The curves were analyzed in the Cybernetics Laboratory (Head, Professor M. L. Bykhovskii) on the M-20 computer. The original curve was resolved into the fast and slow exponents composing it by means of the equation $R = Q + \sum_{i=1}^{2} \cdot A : \exp \cdot (-\alpha : t)$. Under these circumstances the background level (the constant component Q) was automatically deducted and counting fluctuations were smoothed out.

The brain tissue blood flow was determined before injury and again 30 min and 4 h after injury.

EXPERIMENTAL RESULTS AND DISCUSSION

Before injury the total brain tissue blood flow in the different groups of rabbits varied from 35.3 ± 2.2 to 40.1 ± 2.3 ml/min/100 g weight of tissue. The blood flow in the gray matter varied from 50.7 ± 3.2 to 56.6 ± 2.1 ml/min/100 g and in the white matter from 3.4 ± 0.2 to 12.3 ± 0.08 ml/min/100 g. After burning the brain tissue blood flow was reduced within 30 min: the total blood flow to 30.3 ± 2.5 ml/min/100 g, in the gray matter to 37.7 ± 3.1 ml/min/100 g, and in the white matter to 2.4 ± 0.1 ml/min/100 g (in all cases $P < 0.05$). The blood flow was reduced still further 4 h after injury: the total to 79.0%, in the gray matter to 64.0%, and in the white matter to 79.5% of its initial level. These measurements confirmed the data obtained by indirect methods [1, 6] indicating a decrease in the cerebral blood flow after burns.

Comparison of the decrease in the cerebral blood flow with the changes in the minute volume of the heart, measured by radiocardiography, showed that the minute volume of the heart 30 min after burning had fallen to 65% of its initial level, and 4 h after burning to 40%, whereas the cerebral blood flow was reduced only to 85 and 79% respectively of the initial values.

In burn shock the cerebral blood flow is thus reduced by a lesser degree than the minute volume of the heart; this is evidence of the role of compensatory mechanisms maintaining the cerebral blood flow despite a fall in the minute volume of the heart. However, even a moderate decrease in the blood flow through the brain is reflected in its function, as shown by the results of a study of the EEG and responses of the nervous system [2, 3].

After whole-body acute radiation injury (dose 900 rad) a marked decrease in the brain tissue blood flow also was observed ($P < 0.05$). In this case, however, the blood flow in the white matter was actually increased ($P < 0.05$). The changes were more marked 30 min than 4 h after injury. The results agreed with those of determination of the cerebral blood flow in rabbits after irradiation in a dose of 1000 R by means of heat-exchange pulse transmitters [4].

After combined radiation and burn injuries the total brain tissue blood flow and the blood flow in the white and gray matter were all reduced. The total blood flow after 30 min was reduced on the average to 37.7 ± 2.4 ml/min/100 g ($P < 0.05$) and after 4 h to 33.2 ± 0.9 ml/min/100 g ($P < 0.05$).

The fact will be noted that after combined injury the decrease in the cerebral blood flow in the rabbits was approximately the same as that after burn or radiation injury only, although the mortality among the animals after combined injury was twice as high as after burn injury alone.

Severe burn or radiation injury presumably reduces the brain tissue blood flow to critical levels. In these experiments the blood flow in the gray matter of the brain after each of these injuries fell to 60% of its initial level.

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