EFFECT OF HIGH BLOOD PRESSURE ON CEREBRAL BLOOD FLOW IN NORMAL ANIMALS AND ANIMALS WITH EXPERIMENTAL RENAL HYPERTENSION

I. V. Gannushkina, V. P. Shafranova, and L. N. Dadiani

UDC 616.12-008.331.1-02:616.61]-092.9-07:616.831-005-07

Changes in the cerebral blood flow were studied by the hydrogen clearance method in acute experiments on control rabbits and on rabbits with experimental renal hypertension during elevation of the systemic arterial pressure by intravenous injection of 10 ml 0.2% noradrenalin solution over a period of 2-3 min. Raising the pressure in control rabbits above 160-180 mm led to an increase in the cerebral blood flow; in the rabbits with experimental renal hypertension this increase in blood flow began at higher levels of the arterial pressure and was quickly followed by a decrease to 40-50% of the initial blood flow.

Investigations [4, 6, 8, 9] have shown that in normocapnia and if the intracranial pressure is unchanged, elevation of the mean arterial pressure to 150-200 mm Hg need not necessarily be accompanied by a disturbance of autoregulation of the cerebral blood flow.

In persons with hypertension crises accompanied by a sharp rise of blood pressure are frequently observed. It is usually assumed that the presence of neurological symptoms and damage to vessels and tissues of the brain during such crises are the result of spasm of the cerebral vessels. Nevertheless, experiments on animals have shown that there is no direct correlation between constriction of the brain vessels and the height and duration of the hypertension or between the site of constriction of the vessels and the location of ischemic damage to the brain tissue [3]. Experiments on cats and monkeys have shown that dilatation of the brain vessels may precede their constriction in monkeys with hypertension, the permeability of the blood-brain barrier is increased, and swelling of the brain tissue may develop [5, 7].

The state of the cerebral blood flow was studied in normal animals and in animals with experimental renal hypertension in response to an acute rise of blood pressure.

EXPERIMENTAL METHOD

Acute experiments were carried out on 10 control rabbits (arterial pressure 90-120 mm Hg) and 12 rabbits with experimental renal hypertension produced by constricting both renal arteries 8-10 weeks before the experiment (blood pressure 180-200 mm Hg). The weight of the animals varied from 2.8 to 3 kg. To measure the volume velocity of the cerebral blood flow by the hydrogen clearance method [1, 2], platinum electrodes 0.3 mm in diameter were inserted symmetrically into the cortex and white matter of the parietal lobes of all the animals. During the acute experiment noradrenalin was injected intravenously (10 ml of a 0.02% solution over a period of 2-3 min), and the changes in the cerebral blood flow and the pressure in the femoral artery were recorded. The animals were decapitated after the experiment, and a histological investigation was carried out in the usual way. An acute rise of blood pressure in the control rabbits gave rise to the usual response of the cerebral vessels. On a rise of pressure to 160-180 mm Hg the cerebral blood flow remained stable (32-108 ml/100 g/min) through activation of the mechanisms of autoregula-

Research Institute of Neurology, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR E. V. Shmidt.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 76, No. 11, pp. 33-35, November, 1973. Original article submitted March 30, 1973.

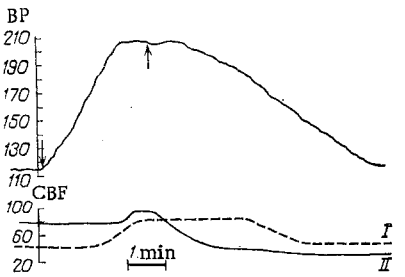

Fig. 1

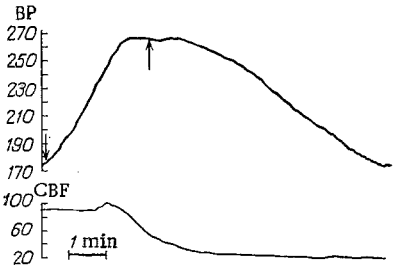

Fig. 2

Fig. 1. Changes in cerebral blood flow (CBF) during a rise in systemic blood pressure (BP) caused by intravenous injection of noradrenalin in a normal rabbit and a rabbit with experimental renal hypertension after preliminary blood loss. Here and in Fig. 2: top curve—BP (in mm Hg); bottom curve – CBF (in ml/100 g/min): I) in a normal rabbit; II) in rabbit with experimental renal hypertension and after blood loss; arrows mark beginning and end of injection of noradrenalin.

Fig. 2. Changes in CBF in a rabbit with experimental renal hypertension in response to a rise of blood pressure caused by intravenous injection of noradrenalin.

tion. A further rise of pressure led to a passive increase in the cerebral blood flow (47-138 ml/100 g/min; $P < 0.01$). In the experiment illustrated in Fig. 1, for instance, a rise of blood pressure to 180 mm was not accompanied by any increase in the cerebral blood flow (curve 1). A further increase in pressure to 205 mm caused an increase in the cerebral blood flow from 42 to 81 ml/100 g/min. After the injection of noradrenalin had ceased, the blood pressure began to fall, and the cerebral blood flow returned to its initial level when the blood pressure was about 150 mm Hg.

In the animals with experimental renal hypertension the initial values of the cerebral blood flow (26-150 ml/100 g/min) were indistinguishable from those in the group of control rabbits. After the beginning of noradrenalin injection the extreme values of the blood pressure which still did not cause changes in the cerebral blood flow were higher in these animals than in the controls, and approached 240 mm Hg. A rise of pressure beyond that level was accompanied by some increase in the cerebral blood flow (34-182 ml/100 g/min; $P < 0.01$), which then fell sharply (to 40-50% of its initial value; $P < 0.01$) although the blood pressure continued to rise (Fig. 2). The cerebral blood flow remained low even after the blood pressure had returned to its initial level. The results of the macroscopic and microscopic investigations of animals with experimental renal hypertension confirmed the prolonged hypertension; in every case marked hypertrophy of the left ventricle and contraction of both kidneys were present. Hypertrophy and hyperplasia of the media of the arteries and arterioles were found in the brain. In some cases, in addition, plasmorrhagia and hemorrhages of varied size were discovered.

In two rabbits with experimental renal hypertension the blood pressure was lowered by preliminary blood loss to 110-120 mm Hg. Injection of noradrenalin produced the same rise of pressure in these animals as in the controls, but the cerebral blood flow changed in the same way in response to this rise of pressure as in the animals with experimental renal hypertension. Raising the blood pressure from 115 to 200-210 mm led to a transient increase in the cerebral blood flow followed by a lasting decrease (Fig. 1, curve II).

Considering that the walls of the blood vessels in rabbits with experimental renal hypertension are hypertrophied, the decrease in the cerebral blood flow in them can be explained either by increased sensitivity of the vessel wall to the direct action of catecholamines or by excessive vasoconstriction (overregulation) in response to the rise of blood pressure. The role of external compression of the microcirculation of the brain on account of filtration edema of the brain tissue likewise cannot be ruled out.

LITERATURE CITED

1. L. N. Dadiani and L. S. Andreeva, Pat. Fiziol., No. 3, 91 (1972).
2. K. Aukland, Acta Neurol. Scand., 41, Suppl. 14, 42 (1965).

3. H. B. Dinsdale and D. M. Robertson, Minerva Med., 13, 160 (1971).
4. J. B. Ekström, E. Häggendal, et al., Minerva Med., 13, 158 (1971).
5. E. Häggendal and B. Johansson, Minerva Med., 13, 160 (1971).
6. A. M. Harper, J. Neurol. Neurosurg. Psychiat., 26, 341 (1963).
7. J. S. Meyer, A. G. Waltz, and F. Gotoh, Neurology (Minneapolis), 10, 735 (1960).
8. A. G. Waltz, Neurology (Minneapolis), 18, 613 (1968).
9. N. N. Zwetnow, Scand. J. Clin. Lab. Invest., Suppl. 102 (1968).