# REFLEX INFLUENCES FROM THE VENOUS SINUSES ON THE REGIONAL CEREBRAL ARTERIES

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 53, No. 2, pp. 9-13, February, 1962
Original article submitted March 21, 1961

Since the important demonstration [5-10] of the part played by the regional cerebral arteries (internal carotid and vertebral arteries) in the regulation of the circulation, it now becomes necessary to study those reflex mechanisms by means of which the lumen of these vessels changes in response to various physiological and pathological conditions.

From an examination of the experimental results [5], the view may be advanced that constriction of the regional cerebral arteries following impairment of the flow of blood from the intracranial venous system occurs as a result of a reflex initiated from the baroreceptors of the cerebral sinuses. The next problem is to make a detailed study of this reflex influence.

## METHOD

The experiments were carried out under urethane anesthesia (up to 1 g per kg) on 16 large rabbits weighing 3.5-5 kg. Stimulation of the baroreceptors of the cerebral venous sinuses was effected by infusing into them under pressure a fluid consisting of isotonic sodium chloride, polyglucin, and blood warmed to body temperature. First the external jugular veins were very carefully dissected, and all their branches tied off except for the temporal connections to the transverse cerebral sinuses (Fig. 1). Infusion of fluid into the latter was made through a polyethylene cannula directed cranially into the jugular vein; a similar cannula connected on the opposite side enabled changes of venous pressure in the cerebral sinuses to be recorded. A third polythene cannula introduced through the external jugular vein and directed towards the thorax as far as the anterior vena cava enabled the blood pressure in the latter to be recorded. In some experiments a pressure compensator was used in the cranial vena cava; the principle of its operation was described in [6], and it prevents the accumulation of blood and increase of pressure while the venous sinuses are infused. The blood removed was returned again into the venous system.

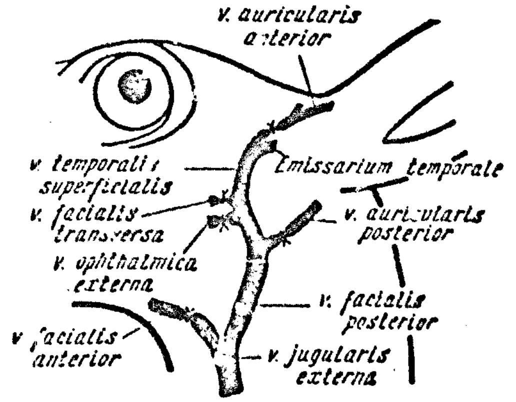


Fig. 1. Diagram of the operation on the branches of the external jugular vein of a rabbit to introduce fluid into the transverse venous sinuses and to measure their pressure without trepanning the skull.

The change in the lumen of the regional arteries (internal carotid and vertebral arteries) was measured in terms of the resistance to blood flow in these vessels as determined by simultaneous recording of the blood pressure in the aorta and in the circle of Willis. The pressure difference can be taken as a certain indication of the condition of the regional arteries only when it is known that the pressure in the aorta remained constant [6]. However, because the latter has been shown to fall steeply on stimulation of the baroreceptors of the cerebral sinuses,* it was not possible to prevent this change by means of the ordinary type of compensator [6], and therefore the present experiments were carried out on a chest-head preparation, which has been described in detail in another article in this journal [9].

*In dogs such a fall of pressure in the cerebral sinuses has been demonstrated by N. Ya. Vasin [3].

## RESULTS

When fluid is infused into the transverse sinus, it is quite difficult to increase the pressure in the whole cerebral venous system, despite the fact that in our experiments the external jugular veins were ligatured on both sides. It is well known that in rabbits the latter are important in draining the blood from the brain. The explanation of the difficulty is that apparently the well-developed collateral flow of blood passes chiefly through the venous system of the vertebrae. However, when fluid was injected comparatively rapidly (at a rate of 0.13-0.73 ml per second, according to the weight of the rabbit), the venous pressure in the contralateral transverse sinus rose by 0.5-3.5 cm water.

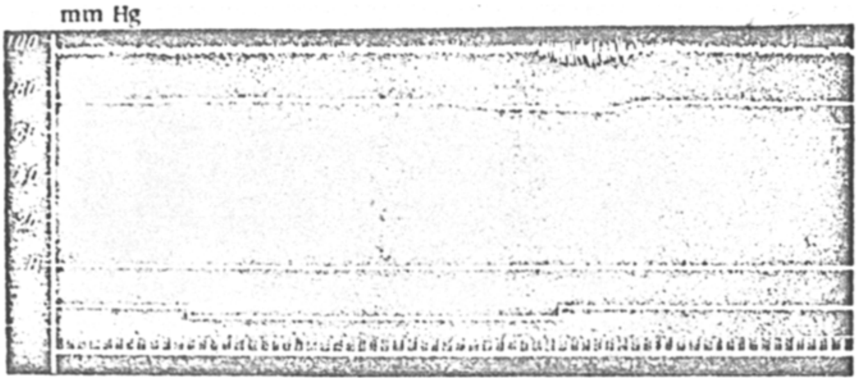


Fig. 2. Constriction of the regional cerebral arteries (internal carotid and vertebral arteries) in response to the injection of fluid into the transverse cerebral thymus at a rate of 0.13 ml per second. Ordinates – pressure (in mm mercury). Curves, from above downwards: arterial pressure in aorta; arterial pressure in the circle of Willis; datum line; time at which fluid was introduced into the transverse sinus; time marker (5 seconds). Experiment made on a chest-head preparation.

At the same time as the pressure in the venous cerebral sinuses rose the blood pressure in the circle of Willis fell, while the general arterial pressure remained unchanged (Fig. 2). This result indicated a constriction of the regional cerebral arteries. Usually, while the venous pressure in the cerebral sinuses remained at the original level, the condition of the arteries was unchanged (Fig. 3a), but as soon as the pressure began to rise there was an immediate increase in the pressure difference between the aorta and the circle of Willis, indicating a constriction of the internal carotid and vertebral arteries (Fig. 3b). It is known that the walls of the venous sinuses are rich in receptors [1], and it is natural to suppose that the influence just demonstrated on the regional arteries is reflex in nature.

It may also be supposed that the increase of pressure in the venous cerebral sinuses occurs partly as a result of the mechanical pressure exerted by the regional arteries, as was observed in the experiments by Staudacher – Dalle Aste [15]. He perfused a human head through the internal carotid artery, and found that when the pressure in the cavernous sinus through which this artery passes was increased, the rate of perfusion was somewhat reduced. The following facts however are evidence against such a mechanism for the effect we have described: firstly, in our experiments the increase in venous pressure was small, and usually not greater than 2.5-3.5 cm water, and it would not be able to evoke any noticeable pressure on the arteries; secondly, the possibility of a mechanical pressure from the arteries is excluded by the anatomical arrangements in the rabbit, in which the internal carotid and vertebral arteries do not pass through the venous sinuses; thirdly and lastly, there was no precise parallelism between the increase of pressure in the cerebral sinuses and the extent of the constriction of the regional arteries. The changes occurred almost simultaneously, but at the end of the infusion, and after the venous pressure had fallen, the constriction of the internal carotid and vertebral arteries might continue for some time. On this account we have concluded that when there is some increase of pressure in the venous sinuses a reflex constriction of the internal carotid and vertebral arteries occurs, with the result that the arterial pressure in the circle of Willis is reduced.

It is precisely when the baroreceptors of the intracranial venous system are stimulated that this reflex influence on the internal carotid and vetebral arteries is observed; in control experiments, when the pressure in the extracranial veins of the head was increased, this reaction of the regional cerebral arteries failed to occur. The general arterial pressure then showed a tendency to rise, whereas when the baroreceptors of the cerebral sinuses were stimulated it usually fell.

The reflex constriction observed in the regional cerebral arteries showed the same features as did constriction of the vessels of the pia mater on stimulation of the superior cervical sympathetic ganglion [4, 14]: usually it occurred with a relatively greater latent period, developed comparatively slowly, and still continued for some time after the venous pressure in the cerebral sinuses had already fallen.*


Fig. 3. Relationship between the condition of the regional cerebral arteries and the pressure in the venous sinuses. Ordinate, upper scale – pressure in cm water, and the lower scale, ditto in mm mercury. I) Venous pressure in transverse cerebral sinus; II) pressure in cranial vena cava (pressure compensator introduced into the latter); III) arterial pressure in the aorta; IV) ditto in the circle of Willis. Below, above the 5-second time marker – moment of introduction of fluid into the transverse sinus (a) 0.23 ml per second, and b) 0.32 ml per second), at moment of recording the venous pressures. Experiment made on a chest-head preparation.

At present it is not clear along what nervous pathways the reflex from the cerebral venous pathways onto the regional arteries, as just described, is completed. The internal carotid and vertebral arteries are known to be supplied with vasoconstrictor sympathetic nerve fibers from the cervical sympathetic ganglia [11, 12, 13].** However, in our experiments bilateral extirpation of the superior and inferior (stellate) cervical ganglia and sympathetic trunk did not eliminate the reflex contraction of the regional cerebral arteries induced by stimulation of the baroreceptors of the venous sinuses. Consequently, the reflex path must be completed (always, or at any rate after cervical sympathectomy) through the cervical sympathetic chain; the possibility exists that this reflex reaction involves those sympathetic ganglion cells which are scattered either singly or in groups among the nerve plexuses of the major cerebral arteries [11, 12, 13]; the reaction may be a true reflex, or alternatively a pseudoreflex at the level of the pre- or postganglionic fibers [2].

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*At first sight it is difficult to understand why such a constriction of the regional cerebral arteries, which is a compensatory reaction, is maintained for some time even after the venous pressure in the cerebral sinuses had fallen. Apparently when this occurs there is a transient edema of the brain, for which the constriction of these arteries is also characteristic [8, 10].

**In the experiments of G. Mchedlishvili, T. Garbulinskii, and A. Gosk, when the cervical sympathetic ganglion was stimulated there was a marked constriction of the internal carotid artery of the same side.

The reflex constriction of the regional arteries, as we have described it, caused by increase of pressure in the cerebral venous sinuses represents a particular instance of "veno-vasomotor" reflexes. The effect is to protect the brain, enclosed within the rigid cranium, from its vessels being over-filled with blood, when flow from the latter into the venous system would be impaired.


## SUMMARY

In experiments on rabbits the baroceptors of the venous cerebral sinuses were stimulated by the infusion of fluid under pressure which caused a reflex constriction of the regional arteries of the brain (internal carotid and vertebral arteries). It is still uncertain along which nerve path this reflex is conducted. The effect is a veno-vasomotor reflex, and prevents the brain from being overfilled with blood when the outflow into the venous system would be blocked.


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**All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal.** ***Some or all of this periodical literature may well be available in English translation.*** **A complete list of the cover-to-cover English translations appears at the back of this issue.**