THE CHEST-HEAD PREPARATION USED TO STUDY CEREBRAL CIRCULATION

G. I. Mchedlishvili

Department of Pathological Physiology (Head – Honored Academician AN Georgian SSR V. V. Voronin) Institute of Physiology, Academy of Sciences of the Georgian SSR, Tbilisi
(Presented by Academician I. S. Beritashvili)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 53, No. 2, pp. 123-125, February, 1962
Original article received March 21, 1961

Cerebral circulatory changes are brought about both by vasomotor mechanisms and by changes in the general arterial pressure. In experiments, the latter are so intense that they mask the cerebral circulatory control mechanisms to the arteries of the brain itself. It is on this account that the idea has continued until now that nervous control over the cerebral arteries is very weak, and that the circulation within the brain is determined chiefly by the general arterial pressure [10, 11].

In studying the compensatory reactions of the cerebral circulatory system [1, 2] in recent years we have been able to demonstrate a number of local vascular mechanisms for controlling cerebral circulation, as follows: a) the mechanism of the regional cerebral arteries (internal carotid and vertebral arteries), which play an important part in compensating for certain circulatory disturbances arising through stasis of blood within the brain [2], in edema of the brain originating from a number of causes [6, 7] and in terminal conditions [5]; b) the mechanism of the pial arteries, which have principally a nutritive function; they are responsible for the cerebral circulatory changes associated with its blood supply demands [4, 6]; c) the mechanism for regulating the flow of blood from the cerebral sinuses, which is involved only in extreme conditions when there is gross interference with the supply of blood to the brain, as, for example, in terminal conditions [5], or when the aorta is temporarily occluded.

In a further study of nervous and humoral vascular control mechanisms we encountered the following serious difficulties: reflex influences and the action of drugs or physiologically active substances cause such great changes of the general arterial pressure that it becomes impossible to measure the influences on the cerebral vessels enumerated above. In many cases, a blood pressure compensator [3] is of no avail.

The object of the present investigation has been to find a more effective method of stabilizing the pressure in the aorta. After a number of experiments, we have been able to develop a chest-head preparation which satisfies our requirements.

All blood vessels of the peritioneal cavity and limbs are eliminated from the circulation, so that the animal becomes deprived of the greater part of the effector mechanisms by means of which the cerebral vasomotor centers are able to change the general blood pressure (these vascular regions contribute a considerable proportion of the peripheral resistance, as well as changes in the volume of the blood stream). In the operation, the subclavian arteries and veins on both sides are ligatured at their exit from the thorax. In addition, the abdominal aorta and caudal vena cava are ligatured immediately beneath the diaphragm. The only remaining functional system is that of the head and chest, and only the following effector mechanisms which could change the aortal pressure are retained: the heart (changes of the minute volume of the blood), and also the arteries of the head, neck, thoracic walls (changes of peripheral resistance). However, their activity is eliminated by a blood pressure compensator whose cannula is introduced into the abdominal aorta immediately beneath the diaphragm (Fig. 1).

We have used the chest-head preparation since 1959 to study cerebral circulation. We have already used more than 40 rabbits prepared in this way, and have shown that in most cases* the animals may survive in good condition for 2-4 hours. If the compensator operates normally, the pressure in the aorta remains constant even when, for example, 50-100 μg of adrenalin or of acetylcholine are injected into the blood stream, or when powerful electrical stimulation is applied to the sinocarotid receptor region.

*Except for a few weeks in spring and autumn, when the operations are not well tolerated.

The present shortcomings of the chest-head preparation can be eliminated. The absence of adrenal hormones in the blood can be made good by an adrenalin drip, or by introducing the cannula of the compensator into the abdominal aorta caudal to the adrenal arteries, after tying off the uterine, superior mesenteric, and renal arteries. Unwanted impulses from the receptors of the ischemic organs of the abdominal cavity may be blocked by spinal anesthesia at the corresponding level.

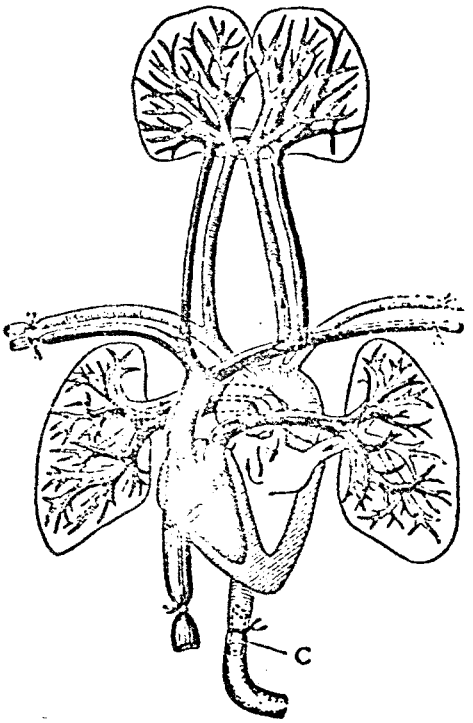

Fig. 1. Diagram of the chest-head preparation. C) Cannula of the blood pressure compensator.

Fig. 2. Change of resistance in the regional cerebral arteries caused by temporary occlusion of the trachea of the chest-head preparation. Curves, from above downwards; aortal pressure; blood pressure into the circle of Willis; zero pressure line; time of closure of the tracheotomy tube; time marker (5 seconds).

The chest-head preparation has been used in our laboratory to study reflex and other influences on certain parts of the cerebral vascular system (see p. 7 of this journal).

As an example, we will quote results obtained by means of this preparation in studying the effect of temporary occlusion of the trachea on the regional arteries of the brain (internal carotid and vertebral arteries). Previously [4], experiments we had undertaken suggested that the effect is to cause these arteries to contract; however, the effect had been difficult to demonstrate convincingly, because of the marked rise in general blood pressure which occurred simultaneously. Owing to the good stabilization of the aortal pressure in the chest-head preparation, the constriction of the carotid and vertebral arteries was made abundantly clear. As can be seen from Fig. 2, when the trachea was closed, and while the aortal pressure remained constant, the pressure in the circle of Willis fell steeply, a result which undoubtedly shows [3] that there was an increase in the resistance offered by the regional cerebral arteries. The difference in pressure between the aorta and the circle of Willis, which is an index of the resistance in these vessels, increased in various experiments by from 14 to 100%.* Despite the constriction of the regional cerebral arteries and the reduction of pressure in the circle of Willis, the venous pressure in the transverse sinus nevertheless rose, apparently because of a simulaneous dilatation of the pial arteries [4].

Long after the chest-head preparation had been used in our experiments, we came across the work of Dozio and others [9] recommending the heart-lung-head preparation. However, in our opinion, the latter is inferior to our preparation, on account of the following shortcomings: 1) the thorax has to be opened, and the large vessels it contains manipulated within it; 2) artificial respiration is necessary throughout the experiment; 3) the continuous circulation of blood through a system of glass and rubber tubes has an unfavorable effect on its properties; 4) there is no automatic stabilization of the aortal pressure.

*The effect was very weak in the presence of the "spontaneous" constriction of the regional cerebral arteries. When the trachea was closed repeatedly, the effect weakened, and sometimes did not appear at all.

The chest-head preparation which we have described has none of these disadvantages, and may be used successfully to study nervous and humoral control of the cerebral vessels, the influence on them of drugs, and to determine local cerebral circulatory regulatory mechanisms.

SUMMARY

A chest-head preparation is described in which circulation is maintained only in the area of the chest, neck, and head, and eliminated in the abdominal cavity and limbs. By means of a compensator, the systemic blood pressure may be well stabilized while various effects occur. The preparation may be successfully used for investigating the intrinsic mechanisms of cerebral circulation control. It has a number of advantages over the heart-lung-head preparation recently described by Dozio.

LITERATURE CITED

1. G. I. Mchedlishvili, Reports of the 17th Scientific Session of the Section of Biological and Medical Sciences AN Georgian SSR, Tbilsi, p. 9 (1957).
2. G. I. Mchedlishvili, Fiziol. zhurn. SSSR, No. 10, p. 1221 (1959).
3. G. I. Mchedlishvili, Byull. éksper. biol. i med., No. 5, p. 10 (1960).
4. G. I. Mchedlishvili, Byull. éksper. biol. i med., No. 6, p. 21 (1960).
5. G. I. Mchedlishvili, Fiziol. zhurn. SSSR, No. 10, p. 1210 (1960).
6. G. I. Mchedlishvili, Pat. fiziol. i éksper. ter., No. 4, p. 14 (1960).
7. G. I. Mchedlishvili and V. A. Akhobadze, Vopr. neirokhir., No. 2, p. 13 (1960).
8. V. M. Khayutin, Fiziol. zhurn. SSSR, No. 4, p. 440 (1959).
9. G. Dozio, B. Fumagalli, and S. Noli, Boll. Soc. ital. Biol. sper., Vol. 33, p. 1036 (1957).
10. S. Gurdjian, J. E. Webster, F. A. Martin, et al., Arch. Neurol. Psychiat, Vol. 80, p. 418 (1958).
11. S. F. Rothenberg and E. Corday, J. Am. Med. Assoc., Vol. 164, p. 2005 (1957).

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.
