RESISTOGRAPHY OF THE ISOLATED INTERNAL CAROTID ARTERY

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The active role of the main arterial trunks of the brain (internal carotid and vetebral arteries)* in regulation of the cerebral circulation has begun to attract attention only comparatively recently [6]. Subsequently the functional behavior of these arterial systems has been studied in various conditions [8, 9, 11] and the conclusions have been confirmed by other investigators [2, 4, 5, 16].

However, a considerable part of the internal carotid and vertebral arteries is difficult of access for direct investigations during life. For instance, the pressure gradient in these arteries (pressure measured in the aorta and circle of Willis) could be used to assess their state only if the general arterial pressure remained stable and allowance was made for the resistance of the peripheral parts of the cerebral arter- [7, 10]. The volume velocity of the blood flow in the internal carotid arteries could provide evidence of their lumen only if allowance was made for changes in the general arterial pressure and the state of the smaller cerebral vessels, and also if the blood flow in the contralateral internal carotid artery remained unchanged [12, 13]. The relative complexity of interpretation of the experimental data could arouse doubt of its validity, so that further attempts were needed to seek more reliable methods of recording the functional state of the main arterial trunks of the brain.

Pursuing research in this direction, the authors have recently developed a technique of resistography of the isolated internal carotid artery.

EXPERIMENTAL METHOD AND RESULTS

A constant volume of blood was injected from a perfusion pump into the internal carotid artery, which remained in situ but which was deprived of all its connections with the extracerebral vessels of the head, and inside the skull the blood drained from it through a thin polyethylene tube directly into the jugular vein, by-passing the vascular system of the brain. In this way the changes in perfusion pressure in these experiments reflected the vascular resistance in the internal carotid artery only.†

Experiments were carried out on 14 dogs weighing 15-30 kg, anesthetized with Nembutal (mean dose 35 mg/kg body weight), aiming at obtaining a superficial level of anesthesia after the end of the operation. The cannula of the perfusion pump was tied into the cranial end of the divided (usually right) common carotid artery. All its branches except the internal carotid artery were ligated and the carotid sinus in some experiments was denervated. The large anastomoses between the internal carotid and external orbital and middle meningeal arteries, which are branches of the external carotid artery, had also to be ligated. After ligation of the external carotid artery, a relatively large part of the blood begins to flow from the internal carotid artery through these anastomoses [14].

Several investigators have described operative approaches to the anastomoses connecting the internal carotid artery with the external orbital artery (a branch of the internal maxillary artery) [1, 17, 18]. In the present experiments the skin incision was made along the sagittal line beneath the lower jaw, and taken deep between the digastric and mylohyoid muscles to the pterygoid muscle. This latter was separated

*In previous papers these arteries have been described as regional (as arteries of medium caliber entering a given organ), but the term has since been abandoned, because many writers use it to describe the internal arteries of organs in general.

†When the same experimental technique is used, instead of recording the perfusion pressure, continuous measurements can be made of the volume velocity of the blood flow by means of any suitable flowmeter, but if this is done a constant level of the general arterial pressure is essential.

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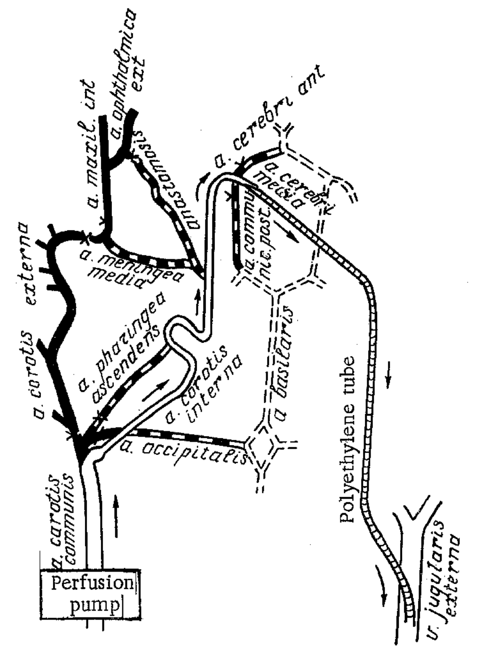

Fig. 1. Scheme of isolation of internal carotid artery in a dog. Explanation in text.

from the bone with the diathermy knife, retracted laterally, and in this way access was gained to the internal maxillary artery. This vessel was carefully mobilized toward the periphery, as far as the external orbital artery, and the anastomosis was isolated. A ligature was passed around it, or if this could not be done, it was coagulated and destroyed. Since the middle meningeal artery leaves the internal maxillary within the pterygoid canal, ligatures were applied at both the beginning and end of the canal, thus blocking the middle meningeal artery (Fig. 1). A control injection of ink into the internal carotid artery after the experiment verified that all its branches had been blocked. The whole operation as described was carried out with great care and with minimal trauma to the tissues, Novocaine being injected every time into the region where the manipulations were being performed.

The operative approach to the base of the brain for introducing the cannula into the internal carotid artery within the skull was made through the temporal bone. The skin incision was made vertically, using the middle of the zygomatic bone as a guide, after which this bone and the coronary process of the mandible were nibbled away. The muscles were removed and the temporal bone exposed. A wide burr hole was made in the skull, the dura opened, and the brain was gradually pushed away with a spatula in a supero-caudal direction until the circle of Willis was reached. The anterior cerebral and posterior communicating arteries were ligated at their origin. A polyethylene (more rarely, glass) cannula was introduced into the middle cerebral artery, and its end taken as far as the mouth of the internal carotid artery. The cannula was connected by a polyethylene tube to the animal's external jugular vein. In this way it was possible to perfuse only the internal carotid artery, from which the blood was drained directly into the venous system, by-passing the small cerebral vessels (Fig. 1).

When the experiments were carried out in this way the reactions of the internal carotid arteries could be studied in isolation, the vessel continuously perfused with blood remained in situ, and all its nervous connections remained intact. The experimental conditions were thus close to natural. Under relatively superficial anesthesia the walls of the internal carotid arteries reacted to small doses of physiologically active substances and other procedures; the resistance in the vessel changed within wide limits, and sometimes the lumen of the vessel was completely closed for varying periods. In this paper, devoted mainly to a description of the technique, only a few consistently observed reactions of the internal carotid arteries will be given as examples.

Intraarterial injection of noradrenalin, and also of adrenalin, in doses of 0.1-1 μg (the sensitivity of the vessel walls varied in different experiments) consistently caused an increase in the perfusion pressure in the isolated internal carotid artery, indicating an increase in tone of its wall (Fig. 2A). The increase in perfusion pressure was usually preceded by a brief decrease, amounting on the average to one-quarter of the increase. This effect disappeared after intraarterial injection of adrenolytic preparations suchas dihydroergotoxin, etc. A consistent decrease in the tone of the internal carotid artery took place after injection of acetylcholine in doses of 0.1-1 μg (Fig. 2B). This effect was completely abolished or considerably weakened under the influence of cholinolytic preparations. A considerable increase in perfusion pressure of the isolated internal carotid artery was observed after intraarterial injection of serotonin (Fig. 2C). Comparison of the magnitude of the effect in response to equal doses of the injected drugs demonstrated clearly that the sensitivity of the internal carotid artery to serotonin is many times greater than to noradrenalin.

The results of these experiments thus confirmed previous data showing high activity of the walls of the internal carotid arteries and the possible participation of these vessels in regulation of the blood flow to the cerebral hemispheres [3, 13]. The absence of reactions of these arteries observed by some investigators in dogs both to direct application of physiologically active substances [15] and to changes in the level of the intraarterial pressure [17] after blocking all anastomoses with the extracerebral vessels may be dependent either on the deep anesthesia or on the animal's serious condition after the operation.

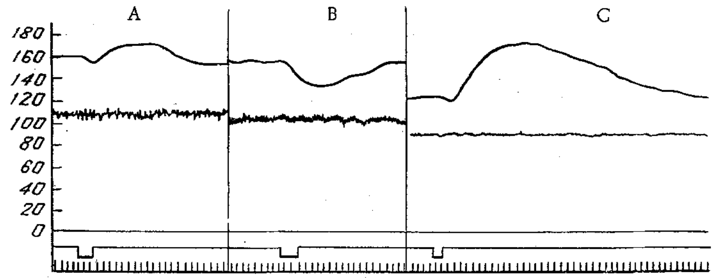

Fig. 2. Changes in resistance of the isolated internal carotid artery of a dog following injection of 0.5 μg noradrenalin (A), 0.5 μg acetylcholine (B), and 0.1 μg serotonin (C) into the vessel. From top to bottom: perfusion pressure, general arterial pressure (scale on the left), zero line, marker of injection of drugs, time marker (5 sec).

If certain conditions are observed, resistography of the internal carotid artery can also be carried out leaving the vessels of the circle of Willis intact. This can be done because the four main trunk arteries of the brain are connected together at their origin (the arota) and end (the circle of Willis), and wide arterial anastomoses in the region of the circle of Willis ensure equalization of pressure in all its parts. The perfusion pressure in the internal carotid artery thus reliably reflects the resistance of this vessel only in the following conditions: first, when the level of the general arterial pressure and, consequently, pressure in the circle of Willis remains stable throughout the experiment (for example, if minimal doses of physiologically active substances of noradrenalin or acetylcholine type are injected into the test artery); second, the increase of perfusion pressure reflects the increase in resistance in the internal carotid artery, when the pressure in the circle of Willis is lowered because of the lowered general arterial pressure or for other reasons (for example, in terminal states or in the last stages of asphyxia). In this modification of measurement of the perfusion pressure in the internal carotid artery, just as in the method described above, all anastomoses connecting this vessel to the extracerebral arteries must be blocked. The results of the authors' experiments showed that characteristic reactions of the internal carotid arteries could be found in various conditions—after local administration of physiologically active substances, in terminal states, in asphyxia, and so on.

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