REACTIONS OF CEREBRAL AND PERIPHERAL VESSELS OF NEUROSURGICAL PATIENTS TO CEREBRAL ANGIOGRAPHY

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Responses of cerebral and peripheral vessels during cerebral angiography were studied in 29 patients with local brain lesions by means of a combined technique which included recording the rheoencephalogram, the rheoencephaloplethysmogram, the photoplethysmogram, electrocardiogram, and electroencephalogram. Seven patients received injections of physiological saline as the control. Injection of urotrast into the carotid artery was followed initially by transient changes in the cerebral hemodynamics associated with infusion of an additional volume of fluid into the blood stream, but later a more marked and persistent dilatation of the cerebral arteries was observed, probably as a result of the action of the contrast material on the chemoreceptors of the blood vessels. In response to the injection of physiological saline no such dilatation of the cerebral vessels was observed.

An important problem arising during cerebral angiography is the effect of the contrast substance on the cerebral vessels. Investigations into this problem have been comparatively few in number and their results are mainly contradictory. Some workers found no changes in the cerebral hemodynamics under the influence of the contrast substance either experimentally [12] or clinically [9] if the blood vessels were not first irritated. Other workers observed changes in the tone of the cerebral vessels [11, 14], a decrease in pressure in the ophthalmic artery [6], and an increase in the cerebrospinal fluid pressure [15]. In rheoencephalographic investigations one observer found increased vascular tone and a reduced blood flow in the brain after injection of contrast material [4] while two other observers described directly opposite changes [2,5]. Similar data have been obtained for changes in cardiac activity and the peripheral circulation: tachycardia and elevation of the peripheral arterial pressure were discovered after injection of contrast material into the vertebral artery [8] and into the ascending aorta [3]. It is difficult to compare these observations for they were obtained by the use of different contrast materials and of different techniques.

The object of the investigation described below was to study the responses of cerebral and peripheral vessels, changes in cardiac activity, and changes in the electrical activity of the brain simultaneously at all stages of carotid angiography and during the 15-30 min after injection of the contrast material. To determine any effects of the contrast material itself on the cardiovascular system, the results were compared with those of injection of physiological saline into the carotid artery (under identical technical conditions).

EXPERIMENTAL METHOD

In this combined investigation the EEG, ECG, rheoencephalogram (REG), rheoencephaloplethysmogram (REPG), and the digital photoplethysmogram (PPG) were recorded on the side of injection of the contrast material. The Japanese PM-150 polygraph was used for the recordings. Special brass foil "x-ray transparent" electrodes were used. Angiography was performed under local anesthesia; 10-15 ml of 60% urotrast solution was injected by an automatic syringe in the course of 1.5 sec.

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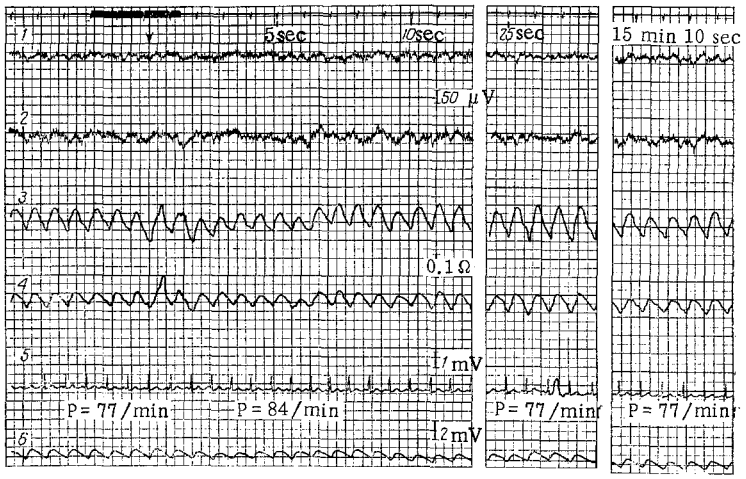

Fig. 1. Vascular responses to injection of 15 ml urotrast into right carotid artery (Patient Sh. with arterio-venous aneurysm of the right fronto-parieto-temporal region). Top record is time marker (1 sec) and marker of injection of urotrast. Numbers show times after injection. 1,2) Right and left fronto-parieto EEG leads; 3,4) right and left fronto-mastoid REG leads; 5) ECG (lead II); 6) PPG of right middle finger. Increase in amplitude of three REG waves can be seen at the moment of injection (first phase) and this is followed by a decrease in amplitude of the REG waves to 75% on the right and 80% on the left (second phase). During the next 6 sec it again increases to the original level (third phase). After 25 sec the amplitude of the REG waves reaches a maximum: 160% on the right, 132% on the left (fourth phase). Immediately after injection of urotrast a small increase in the pulse rate and slight decrease in amplitude of the pulse waves on the PPG are recorded.

Altogether 29 patients (11 women and 18 men aged 16-45 years) with various local brain diseases (tumors, aneurysms, carotid-cavernous shunts) were investigated. Angiography on 21 patients was performed through a catheter introduced through the femoral artery into the carotid artery. Eleven direct carotid angiograms were obtained on the other eight patients by puncture of the carotid artery. In seven control observations 10-15 ml physiological saline was injected in the course of 1.5 sec into the same artery 5-10 min before injection of the contrast material.

EXPERIMENTAL RESULTS

Analysis of the results showed that the anesthesia, puncture of the artery, introduction of the catheter or tube, and the noise of the x-ray apparatus had a detectable but transient action on the cardiovascular system. In the overwhelming majority of patients investigated (24 of 29) the vascular responses associated with these manipulations were of short duration, and a stable and comparatively quiet background was established usually by the time of injection of the urotrast.

Actually during injection of the contrast material and taking the serial photographs clearly marked and successive changes in the cerebral hemodynamics were recorded in 16 patients. The following four phases were distinguished. In the first phase during injection of the urotrast an increase in amplitude of the REG waves was recorded for 2-3 sec (more marked on the side of injection), reflecting mechanical stretching of the arteries as a result of injection of an additional volume of fluid into the arterial blood flow. In the second phase, lasting 5-7 sec, the amplitude of the REG waves fell rapidly below its initial level as a result of an increase in vascular tone which developed in response to transient stretching of the walls of the carotid artery. In the third phase the amplitude of the REG waves gradually increased for the next 5-10 sec and returned to its initial level. In some observations the amplitude and shape of the REG waves were unstable during this phase. In all probability the vasoconstrictor response to injection of an additional volume of fluid had disappeared in this phase and the vasodilator action of the urotrast had begun to appear. In the fourth phase the amplitude of the REG waves increased above its initial level on the side of injection to 146% (mean value), reaching the maximum after 20-40 sec. The signs of a decrease of the peripheral vascular resistance (shortening of the rise time of the wave) were less constant and distinct.

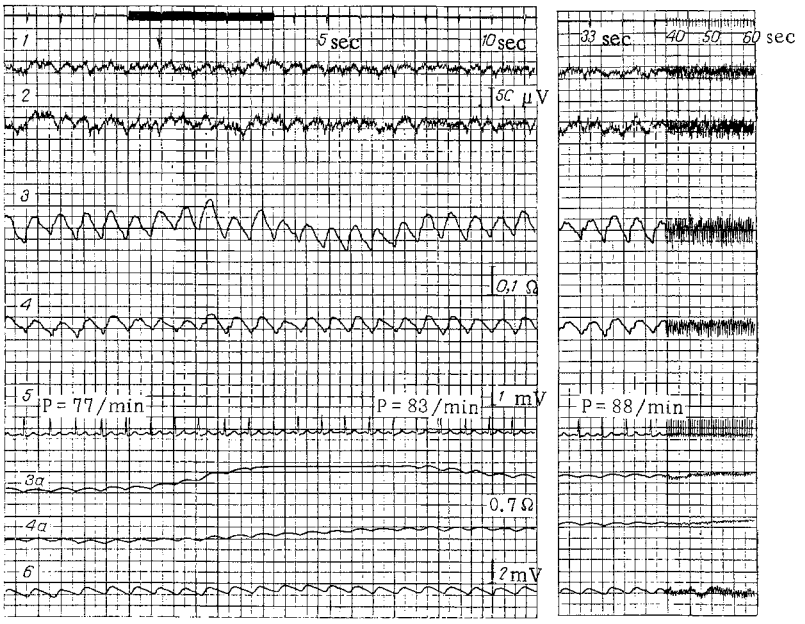

Fig. 2. Vascular responses to injection of 15 ml physiological saline into the right carotid artery (the same patient). Top record is time marker (1 sec) and marker of injection of saline. Numbers represent times after injection. 3a,4a) right and left fronto-mastoid leads of REPG. Remainder of legend as in Fig. 1. During injection of the solution an increase in amplitude of the three REG waves is observed (first phase) and this is followed by a decrease in amplitude of the REG waves to 75% on the right and 93% on the left (second phase), followed by a return to the initial level at 8-9 sec (third phase). No significant or persistent increase in the cerebral blood flow was observed after injection of physiological saline (fourth phase).

The subsequent restoration to normal occurred gradually over a period of 10-30 min (Fig. 1). The phases detected were similar to those described by other workers when investigating the effect of injection of Diodrast into monkeys [11].

The increase in the cerebral blood flow after injection of urotrast was also observed on the REPG, with the recording of a bilateral rise of the curve, more marked on the side of injection. In 12 patients the amplitude of the PPG was reduced and in eight patients it was unchanged. The changes in the pulse rate after injection of the contrast material were slight in these investigations: it was increased (by 5-10 beats) in 15 patients, reduced by the same small amount in five, and unchanged in the rest.

In about half of the patients (14) clear depression of the α-rhythm was observed for 3-4 sec during the injection of urotrast, and after a further 10-15 sec the fast desynchronized rhythm described previously in such cases [1] appeared. The coincidence between the time of appearance and disappearance of these EEG changes and the increase in the cerebral blood flow and restoration of its normal level suggests that these changes share the same genesis and are due to the action of the contrast material on the blood vessels.

Comparison of these observations with the results of the control tests in which physiological saline was injected into the carotid artery (Fig. 2) showed that the first phases virtually coincided in both cases, but the third and fourth phases were observed only after the injection of urotrast. By contrast with the first two phases (caused by the rapid injection of an additional volume of fluid), the third and fourth phases observed later and for a comparatively long time and detected only after the injection of the contrast material, evidently reflect its action on the chemoreceptors of the vessels. This hypothesis is confirmed by experiments which showed that other substances besides contrast materials (in particular, sodium chloride solution) in the same molecular concentration give rise to similar changes in the cerebral circulation [7, 13, 16]. The authors cited are of the opinion that the changes observed in the hemodynamics are not the result of the specific action of the contrast material but are caused by stimulation of the vascular chemoreceptors (in the carotid artery). The same opinion is held by Arutyunov and co-workers [1] who investigated changes in the EEG during cerebral angiography.

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