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REACTION OF INTRACRANIAL AND EXTRACRANIAL VESSELS TO NORADRENALIN IN EXPERIMENTAL CARDIOGENIC SHOCK

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Weakening of the constrictor response of the intracranial and extracranial vessels to noradrenalin in animals with cardiogenic shock was established by resistography and rheoencephalography in acute experiments on anesthetized cats. Under these conditions elevation of the systemic arterial pressure by noradrenalin leads to passive dilatation of the brain vessels and to an increase in the volume of blood in them.

KEY WORDS: noradrenalin; cerebral circulation; cardiogenic shock.

Pressor substances used in clinical practice to restore the systemic arterial pressure to normal in cardiogenic shock can at the same time potentiate the already well marked constriction of the regional vessels [5, 7, 8]. According to some investigators [3] the response of the cerebral vessels to injection of noradrenalin (NA) in these patients depends on the severity of the cardiogenic shock. It was shown previously [1, 4, 6] that NA in intact animals as a rule evokes a constrictor response of both intracranial and extracranial vessels.

It was appropriate to study the response of the cranial vessels to noradrenalin in experimental cardiogenic shock.

EXPERIMENTAL METHOD

Acute experiments were carried out on 47 cats weighing 2.5-3.5 kg under urethane anesthesia (1 g/kg). A two-channel resistograph was connected to the common carotid arteries for parallel recording of the tone of the intracranial and extracranial vessels. To disconnect the intracranial circulation from the extracranial, the corresponding vessels were ligated [1]. After the resistograph had been connected the vertebral arteries were tied, so that the effect of the systemic arterial pressure on cerebral vascular tone could be excluded. The arterial pressure was recorded by a mercury manometer in the central end of the carotid artery. To prevent the blood from clotting heparin was given. In some experiments the method of rheoencephalography was used. The 4RG-1A attachment was connected to an Élkar four-channel electrocardiograph. The electrodes were arranged for orbital-occipital and orbital-lingual derivations, to characterize the tone and the blood volume of the intracranial and extracranial vessels [2]. Parallel with the rheoencephalogram (REG), the ECG was recorded in standard lead I. The experiments were carried out under controlled respiration. Cardiogenic shock was induced by chemical necrosis of the myocardium, by injecting 0.25 ml of a 25% solution of sulfuric acid into the wall of the left ventricle (under ECG control without thoracotomy). NA was injected intravenously in doses of 5 and 10 μg/kg and into the carotid artery in a dose of 0.5-1 μg/kg 30-45 min after the beginning of myocardial necrosis. In the course of this time interval the systemic arterial pressure in most cases fell by more than 30%.

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TABLE 1. Effect of NA on Resistance of Intracranial and Extracranial Vessels and on Systemic Arterial Pressure (in % of initial level)

Experimental Conditions	Dose, μg/kg	Mode of injection of preparation	Change in vascular resistance		Change in arterial pressure
			intracranial	extracranial	
Control	5	Intravenously	−34±8,9 $P<0,001$	—	−78±15,3 $P<0,001$
	10	"	−39±10,0 $P<0,001$	−55±12,8 $P<0,001$	−81±13,1 $P<0,001$
	0,5–1	Into carotid artery	−36±8,1 $P<0,001$	−44±6,2 $P<0,001$	−26±3,8 $P<0,001$
Cardiogenic shock	5	Intravenously	−20±4,0 $P<0,001$	−23±5,2 $P<0,001$	−73±9,1 $P<0,001$
	10	"	−23±3,1 $P<0,001$	−35±3,7 $P<0,001$	−66±6,3 $P<0,001$
	0,5	Into carotid artery	−19±2,7 $P<0,001$	−22±4,3 $P<0,001$	−14±3,9 $P<0,001$

EXPERIMENTAL RESULTS

As Table 1 shows, when injected intravenously and into the carotid artery, in all cases NA produced a vasoconstrictor effect, which began immediately after injection of the preparation and lasted 3-4 min.

Meanwhile the changes in the perfusion pressure and systemic arterial pressure differed in the control and experimental series. The constrictor response of the intracranial vessels to intravenous injection of NA in a dose of 5 μg/kg in the animals with cardiogenic shock was 14% weaker than in the control cats. With an increase in the dose of NA injected intravenously to 10 μg/kg (Fig. 1) the difference between the vascular responses in the control and experimental animals was even greater, and for the cerebral vessels, the extracranial vessels, and the arterial pressure it amounted to 16, 20, and 15% respectively. After injection of NA (0.5-1 μg/kg) directly into the perfused vessels (Fig. 2) weakening of the constrictor response of the intracranial and extracranial vessels also was observed (by 16 and 22% respectively) in the animals with cardiogenic shock.

During cardiogenic shock the sensitivity of the cranial vessels to NA is thus reduced. An increase in its dose is not followed by any significant increase in the intensity of the constrictor response of the intracranial vessels, whereas the pressor response of the systemic arterial pressure is actually reduced a little.

These results were obtained in experiments in which there was no possibility of the brain receiving a blood supply from the systemic arterial pressure. It was important to study if changes took place in the cerebral circulation under the influence of NA with the participation of the arterial pressure.

In control experiments the REG data showed that intravenous injection of NA in a dose of 10 μg/kg reduced the delay time of the pulse wave in the intracranial vessels by 29 ± 6.6% ($P < 0.001$) and of the extracranial vessels by 27 ± 9.5% ($P < 0.01$) relative to the original data. The same decrease in the time of spread of the pulse wave also was observed during cardiogenic shock (Fig. 3). Consequently, under normal conditions and during cardiogenic shock NA reduces the elasticity of these vessels equally.

The time of the systolic rise of the pulse wave in the control was unchanged by NA. When the arterial pressure is raised, the vasoconstrictor effect of NA evidently is not exhibited. This is also confirmed by the absence of change in amplitude of the rheographic wave.

In cardiogenic shock NA slightly reduced the time of systolic rise of the pulse wave of the intracranial (by 19 ± 11.4%) and extracranial (by 15 ± 9.1%) vessels. This change in the modulus of elasticity of the vessel walls can be explained by their passive stretching under the influence of the increased intracranial pressure.

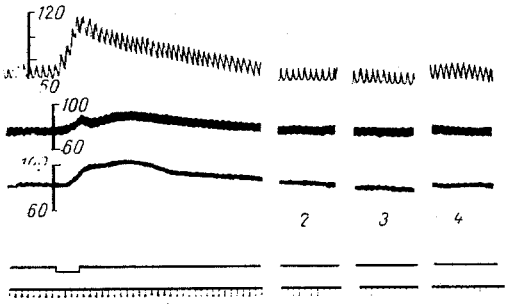

Fig. 1

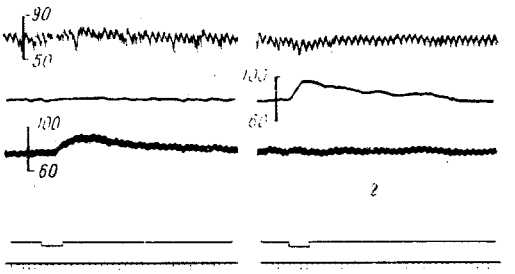

Fig. 2

Fig. 1. Response of intracranial and extracranial vessels of cats after injection of NA (10 μg/kg, intravenously) during cardiogenic shock. From top to bottom: systemic arterial pressure; resistograms of intracranial and extracranial vessels; time of injection of noradrenalin; time marker (5 sec). 1) Before and immediately after injection; 2, 3, 4) 3, 5, and 10 min, respectively after injection of NA.

Fig. 2. Responses of intracranial and extracranial vessels of cats after injection of NA (1 μg/kg, intra-arterially) during cardiogenic shock. 1) Injection of NA into system of intracranial vessels; 2) injection into system of extracranial vessels. Remainder of legend as in Fig. 1.

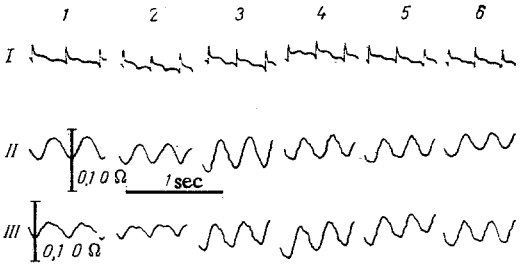

Fig. 3. Response of intracranial and extracranial vessels after injection of NA (10 μg/kg, intravenously) during cardiogenic shock. I) ECG (standard lead I); II) REG of intracranial vessels; III) REG of extracranial vessels. 1) Before injection; 2, 3, 4, 5, 6) 15 sec and 1, 3, 5, and 10 min respectively after injection of NA.

Other evidence in support of this view is given by the increase of 14.2% in the amplitude of the rheographic wave of the cerebral vessels.

In cardiogenic shock NA thus promotes passive dilatation of the cerebral vessels, for the comparatively high intravascular pressure cannot be counteracted by the weak constriction of the cerebral vessels.

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