REFLEX CONTROL OF VASCULAR TONE IN ANAPHYLACTIC SHOCK

Communication I. The State of the Pressor Reflexes During Hypotension Due to Anaphylactic Shock

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The study of the nervous reflex control of the vascular tone in a state of shock may help to explain the role of the nervous system in circulatory disorders and to find effective methods of dealing with the low arterial pressure in shock. In particular, an investigation of the pressor vascular reflexes will give some information on the value of certain methods of stimulation of afferent pressor mechanisms during the hypotension associated with shock.

There are few reports in the literature dealing with the reflex control of vascular tone in anaphylactic shocks. The only information [3, 6, 12] is of a considerable depression of the pressor vascular reflexes after the injection of an assaulting dose of antigen into the animal.

Many researchers [5,7-10] are inclined to believe that the state of shock, and the disorders which are then observed, are connected with the development of a parabiotic state in the central nervous system.

In view of this hypothesis, corresponding changes might have been expected to take place in the character of the vascular reflexes in anaphylactic shock.

The present investigation is devoted to the study of the pressor vascular reflexes after the injection of an assaulting dose of antigen into an animal, both at the onset of the fall in arterial pressure and during its recovery.

The capacity of the arterial pressure to be gradually, although slowly, restored, indicates that the experimental results considered below relate to a moderately severe state of shock.

METHOD

Experiments were carried out on 32 rabbits and 6 dogs under nembutal anesthesia. The animals were sensitized by two subcutaneous injections of horse serum in a dose of 1 ml/kg body weight for the rabbits and 0.5 ml/kg body weight for the dogs. On the ocassion of the second injection of serum, after an interval of one day, the sensitizing dose was doubled. The assaulting dose of serum, which for the rabbits was 0.2 ml/kg body weight, and for the dogs 0.25 ml/kg body weight, was injected intravenously on the 15th-18th day of sensitization.

The arterial pressure was recorded in the common carotid artery by a mercury manometer on a smoked drum, and respiration by means of a Mary's capsule connected to a tracheotomy cannula. The pressor vascular reflexes were elicted by stimulation of the central end of the vagus (rabbit) or sciatic (dog) nerve with rectangular impulses from a generator, and also by acute asphyxia from closure of the tracheotomy tube.

RESULTS

In normal conditions the average arterial pressure of the rabbits was 108 mm Hg. After the intravenous injection of the assaulting dose of serum, in nearly every case a transient increase in the arterial pressure was observed, followed by a fall to 40-50 mm Hg. The arterial pressure was then gradually restored, and after 35-40 minutes its level was 75-80 mm Hg.

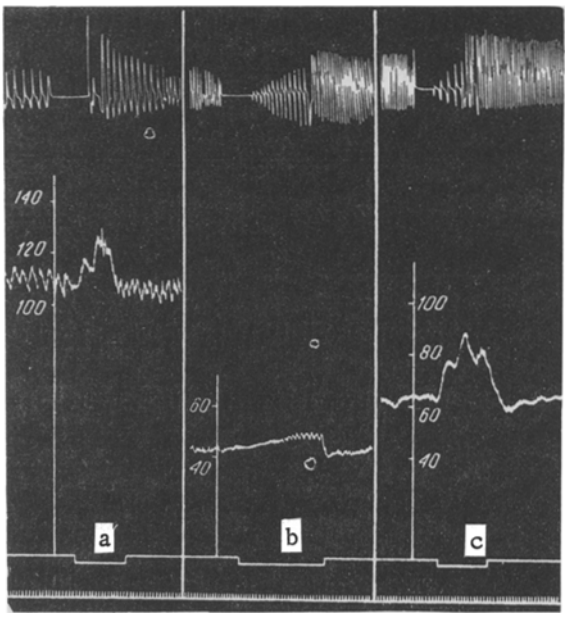

Fig. 1. Changes in the pressor vascular reflex during stimulation of the central end of the vagus nerve in the rabbit. a) Normal; b) 5 minutes after injection of the assaulting dose of serum; c) 30 minutes after. Significance of the curves (from above down): Respiration, arterial pressure; stimulation marker; time marker (1 second).

In the first minutes of the fall in the arterial pressure, the pressor reflexes caused by stimulation of the central end of the vagus nerve were considerably depressed. Whereas the magnitude of the normal pressor reflexes was on the average 14 mm Hg, immediately after the fall in pressure the magnitude of these reflexes did not exceed 10 mm Hg (Fig. 1, a, b). Subsequently, despite the lowered arterial pressure, stimulation of the central end of the vagus nerve was accompanied by an even greater pressor effect (Fig. 1, c). In the majority of experiments the magnitude of the pressor reflex was equal to that of the normal reflex, or even exceeded it, after only 20-30 minutes. This increase in the strength of the reflexes over that normally observed was especially obvious at the 35th-40th minute of lowered arterial pressure.

The same changes in the pressor reflexes were found also in experiments on dogs during stimulation of the central end of the sciatic nerve. It should be mentioned that although the injection of the assaulting dose of antigen was accompanied by a larger fall in pressure than during the experiments on the rabbits, the pressor reflexes were not merely restored but even strengthened by comparison with normal (Fig. 2). Moreover, in the control animals at the end of the period of stimulation of the sciatic nerve a depressor vascular reaction often appeared, which was almost absent in shock. We may mention that F. G. Akhmedov [1] observed strengthening of the depressor, and not the pressor, phase of the reflex under consideration. In this opinion, the cause of such a change in the pressor reflex is pessimal inhibition of the vasoconstrictor centers with simultaneous concomitant pessimal exaltation of the vasodilator centers. The author does not explain what is meant by the term "pessimal exaltation".

Investigation of the pressor reflexes caused by acute asphyxia showed that changes caused therein during lowering of the arterial pressure were similar to those in the pressor reflexes just examined. The results of one of these experiments are shown in Fig. 3.

The changes which we have described in the pressor vascular reflexes demonstrate that the capacity of the vasomotor center to respond to pressor stimuli is not merely restored when the arterial pressure is lowered, but is even increased by comparison with normal.

Attention is also directed to the fact that the rate of restoration of the magnitude of the pressor reflexes was considerably greater than the rate of restoration of the arterial pressure level. This means that the restoration of arterial pressure in anaphylactic shock is brought about, not by a passive increase in the mass of circulating blood, but by the active influence of the regulating mechanisms of the central nervous system. Under these circumstances, in view of the increased capacity of the vasomotor center to respond to pressor stimuli, favorable conditions are created for such restoration to take place.

It must also be mentioned that we were unable to observe any phasic parabiotic changes in the pressor vascular reflexes, whether in the initial period of lowering of the arterial pressure or during its restoration. Using stimulation of the vagus nerve of different intensities, in all cases we observed that the "rules of force" were obeyed.

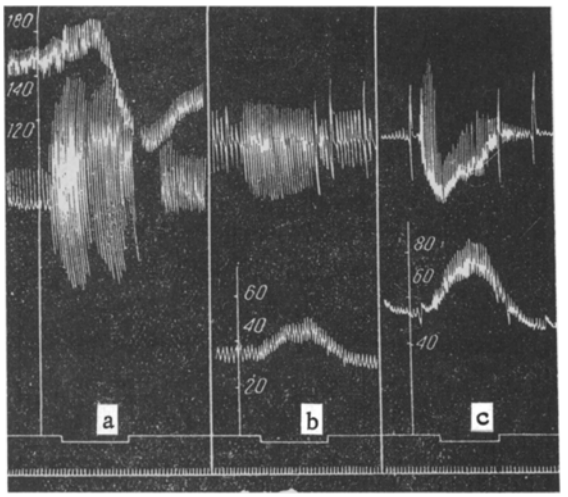

Fig. 2. Vascular reflex in response to stimulation of the central end of the sciatic nerve of a dog. a) In normal conditions; b) 20 minutes after injection of the assaulting dose of serum; c)30 minutes after. Legend as in Fig. 1, with the exception of a, in which respiration is traced below the arterial pressure.

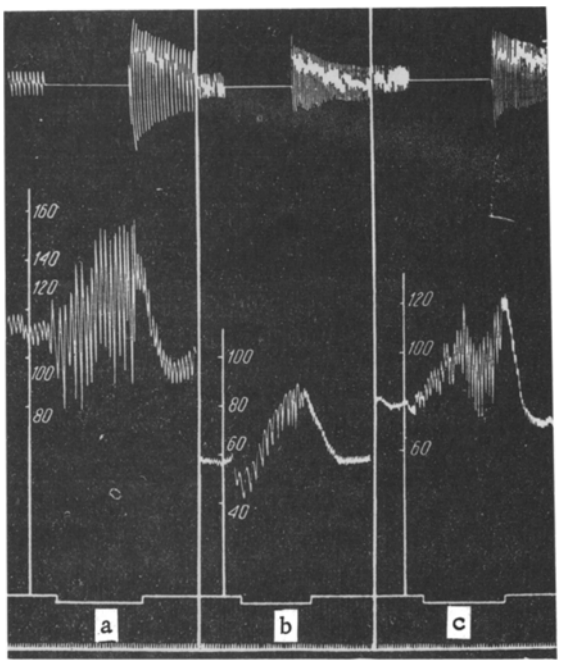

Fig. 3. Vascular reflex in response to acute asphyxia in a rabbit. a) In normal conditions; b) 15 minutes after injection of the assaulting dose of serum; c) 25 minutes after. Legend as in Fig. 1.

In consequence of this, it is difficult to agree with the opinion of V. S. Kiselev [7-10] and of other workers that, in anaphylactic shock, a parabiotic state develops in the central nervous system. Should it happen that when an animal is in a state of shock and parabiosis develops in the central nervous system, then, according to the teaching of N. E. Vvedenskii [2], any additional, intensive stimulation must of necessity deepen this state and lead to still further disturbance of the circulation. The results of our experiments, and certain reports in the literature, including those of V. S. Kiselev, do not, however, support this hypothesis. V. S. Kiselev [7], for instance, who regards shock as the development of a parabiotic state in the central nervous system, used the occipital injection of warm Ringer-Locke solution, stimulating the vasomotor and respiratory centers, to extricate animals from their state of shock.

The favorable influence of intraarterial fusion of blood or blood-substitutes, when used in the treatment of shock or hemorrhage [11], is due mainly to the reflex excitation of the vasomotor center in consequence of the intensive stimulation of the vascular receptors.

Finally, it must be stated that evidence has recently appeared [4, 13, 14] showing that an increase in the excitation of the central nervous system by some means or other may result in the extrication of an animal from a state of shock.

Reports in the literature and our own investigations thus show that in anaphylactic shock the vasomotor center does not lose its capacity to respond to pressor stimuli. This helps to explain the effectiveness of intraarterial infusion of blood or blood substitutes under pulsating pressure in conjunction with the use of stimulants in overcoming the low arterial pressure associated with moderately severe shock.

SUMMARY

Experiments were conducted on rabbits and dogs under conditions of anaphylactic shock of medium intensity. The pressor reflexes inhibited at the beginning of the arterial hypotension not only recover their function but even become intensified, in comparison with the normal condition. This indicated that in the given state the ability of the vasomotor center to respond to the pressor stimuli is not only restored, but even intensified. Phasic parabiotic changes of the pressor reflexes were not observed either at the beginning of the reduced arterial pressure nor during its restoration. The stimulation of the corresponding efferent nerve by impulses of different intensity demonstrated that the so-called "rule of force" remained undisturbed.

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