THE RHOMBENCEPHALON AND VASOMOTOR REFLEXES TO IMPULSES IN SOMATIC A-FIBERS

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Cats were decerebrated so that the medulla preserved its connections with a greater or lesser part of the pons, after which they were immobilized with flaxedil or succinylcholine and the response of their arterial blood pressure (BP) to volleys of impulses in various subgroups of fibers of the tibial nerve (frequency of volleys 10 sec^{-1}) was investigated. Impulses in $A\beta$ + $A\delta_1$-afferents and the most excitable fraction of $A\delta_2$-afferents lowered BP in all animals. Application of impulses in all $A\delta_2$-afferents potentiated the fall in BP in 79% of the experiments and led to a rise in BP in only 21% of the experiments. The addition of impulses in $A\delta_3$-fibers to the afferent flow either did not change the mean decrease in BP or led to a small or sometimes more considerable increase in BP. The critical factor producing a sharp reduction in the pressor reflexes or their replacement by depressor reflexes was the integrity of the structures of the pontobulbar junction and the most rostral part of the medulla. This region of the hindbrain thus contains formations causing tonic depression of the excitatory action of impulses in somatic A-afferents on vasoconstrictor neurons and which thereby unmask the existence of an inhibitory component of their action on these neurons. In unanesthetized cats this action of hindbrain structures is depressed tonically by the mesencephalon.
KEY WORDS: *decerebration; somatic afferents; blood pressure reflexes.*

Stimulation of A + C-afferents of the sciatic nerve raises the arterial blood pressure (BP) in cats whose medulla is separated from higher levels [4, 6]. If, however, the medulla remains connected to the other parts of the rhombencephalon, the same stimulation causes a significantly smaller increase in BP [4] or may even lower it. According to some observations, a fall in BP is observed only in response to stimulation at frequencies not exceeding 4 sec^{-1} [4], but according to others, it is observed in response to a very high frequency also [6]. Consequently, certain formations of the rhombencephalon, if disconnected from higher levels of the brain, can depress excitation of vasoconstrictor neurons by impulses in spinal afferents and can even alter the response of these neurons to inhibition. The mechanisms of these phenomena, like those caused by general anesthetics [5], have not been explained. In particular, it is not yet clear whether the intensity and character of the action of impulses in A- or C-afferents on vasoconstrictor neurons are modified in "rhombencephalic" animals, for in the investigations cited above [4, 6] only combined stimulation of A- and C-afferents was used.

The object of this investigation was detailed study of reflex responses of BP to impulses in different subgroups of A-afferents of the tibial nerve (TN) after destruction of connections between the rhombencephalon and mesencephalon, and also to locate zones of the rhombencephalon whose influence reduces pressor reflexes or leads to the appearance of depressor reflexes.

EXPERIMENTAL METHOD

Cats were anesthetized with ether. The animal's head was fixed in the SEZh-3 stereotaxic apparatus. Eight holes (diameter 1 mm, step 2 mm) were drilled in the skull in the

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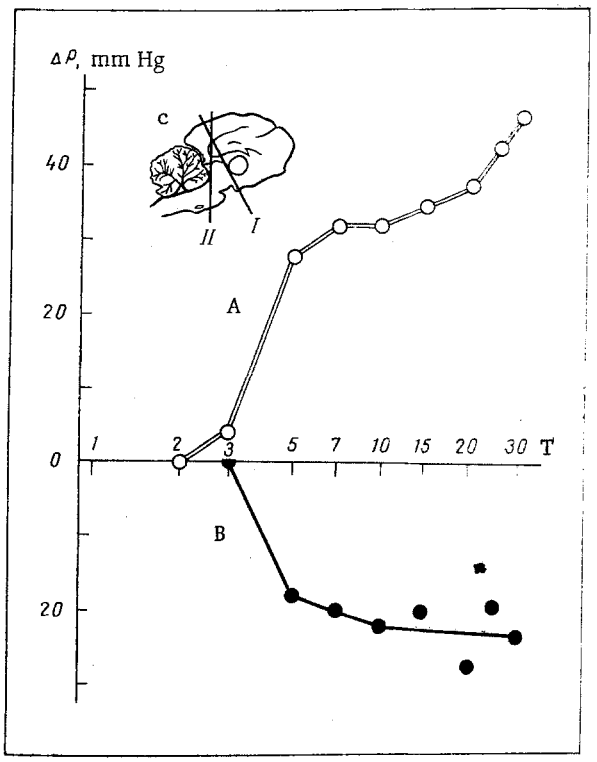

Fig. 1. Magnitude of reflex changes in BP as a function of intensity of stimulation of tibial nerve after transection of brain stem of same animal at two different levels. Curve A obtained after precollicular decerebration (I in Fig. 1c). Abscissa, amplitude of electrical stimuli (0.1 msec, 10 sec^{-1}) measured relative to threshold (T) of most excitable fibers of tibial nerve; ordinate, magnitude of reflex change in BP (in mm Hg).

frontal plane for insertion of electrodes and for thermocoagulation of the tissues of the brain stem by a high-frequency current [1, 2]. The position of the holes and the angle of inclination of the electrode were chosen to allow for a zone of coagulation of about 3 mm in diameter. When decerebration was complete the administration of ether was stopped. The rectal temperature was maintained by a heater at 36-38°C. Flaxedil or succinylcholine was injected intravenously 2-4 h later and artificial ventilation applied at a rate corresponding to the animal's body weight [8] and the study of reflex responses of BP began. For this purpose the left TN was stimulated by square pulses (duration 0.1 msec, amplitude 0.1-3.0 V). The frequency of the impulses was 10 sec^{-1}, i.e., the same as in experiments on "bulbar" and "mesencephalic" animals [1]. The unit of strength (amplitude) of the stimuli was the threshold of excitation (1 T) of the A_β-fibers of TN, determined from the compound action potential of that nerve [3]. BP was measured in the right femoral artery or in the carotid artery by an electromanometer and recorded on the KSP-4 ink-writing apparatus.

At the end of the experiment the brain was removed and fixed in 10% formalin solution. Completeness of transection of the brain stem was then verified and the level of transection determined accurately from sagittal sections. The results of only those experiments in which transection of the brain stem was complete were taken into account. In six experiments in which the electrode was introduced through the cerebellum the brain stem was divided close to the pontobulbar junction. The coordinates of the most caudal transection of the brain stem were: ventrally P 3.0, dorsally P 4.5; the coordinates of the most rostral transection were ventrally A 1.0, dorsally P 2.0. In 13 experiments the electrode was introduced through the cerebral hemispheres parallel to the vertical axis of the Horsley—Clarke coordinate system so that the ventral boundary of the plane of transections of the brain stem in some experiments passed through the caudal third of the pons, and in others more caudally still, as far as the pontobulbar junction.

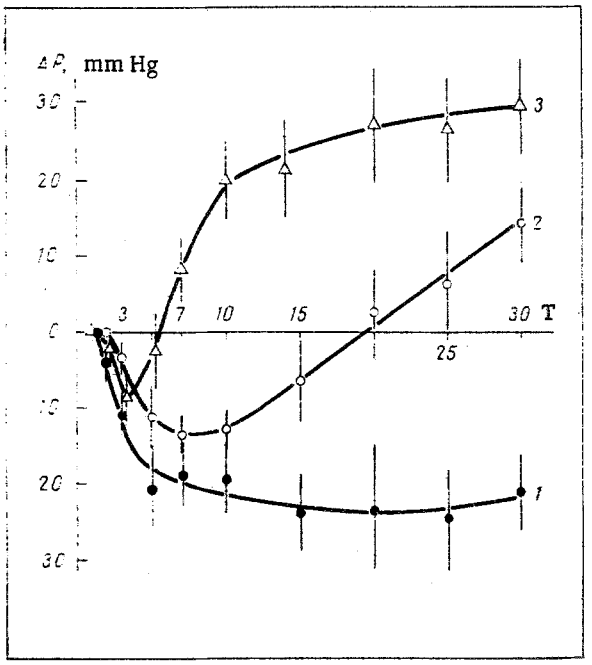

Fig. 2. Magnitude of reflex changes in BP as a function of intensity of tibial nerve stimulation in "rhombencephalic" animals, averaged for groups of experiments. 1) Group of experiments (eight animals) in which only depressor reflexes appeared in response to stimulation of all strengths used; 2) group of experiments (seven animals) in which excitation of $A_{\delta 3}$-fibers was accompanied by pressor reflexes; 3) group of experiments (four animals) in which pressor reflexes appeared in response to stimulation of $A_{\delta 2}$-fibers. Abscissa and ordinate, as in Fig. 1.

EXPERIMENTAL RESULTS

Curves showing how the reflex changes in BP depended in magnitude on the strength of stimulation of TN in an animal after preliminary precollicular decerebration (Fig. 1c, I), followed by more caudal decerebration (Fig. 1c, II), are illustrated in Fig. 1. After disconnection of the mesencephalon impulses from A-afferents began to induce depressor reflexes (Fig. 1b) instead of pressor (Fig. 1a). This qualitative change in the responses of BP to impulses from all subgroups of A-afferents, i.e., the appearance of depressor reflexes only, was discovered in eight animals (Fig. 2: curve 1).

According to previous findings [3], stimulation of TN with a strength of 2-2.5 T excites not only Aβ-afferents, but also $A_{\delta 1}$-afferents (conduction velocity over 20 m/sec). The strength of stimulation of 3-7 T is sufficient to excite $A_{\delta 2}$-afferents (conduction velocity 15-22 m/sec), whereas to excite $A_{\delta 3}$-afferents (conduction velocity under 15 m/sec) the stimulus amplitude must be increased to 15-30 T. Hence it follows that in experiments such as those examined above (see Fig. 1 and Fig 2: curve 1) disconnection of the mesencephalon gave rise to a state in which the inhibitory component of the action of all subgroups of A-afferents of the vasomotor system predominated over the excitatory component.

Depression of the excitatory component of the action of the higher-threshold A-afferents was not always so complete. Seven animals could still develop pressor reflexes to impulses from $A_{\delta 3}$-afferents (Fig. 2: curve 2). Admittedly the mean amplitude of these reflexes in response to stimulation with a strength of 30 T reached only 15.4 ± 5.3 mm Hg. This is only 32.6% of the mean amplitude of the pressor reflexes to stimulation of TN at the same strength in cats with precollicular decerebration and 40.4% of the mean amplitude of the pressor reflexes recorded in 12 "bulbar" animals [1]. Consequently, the presence of connections between the medulla and pons (which also implies integrity of the most rostral portions of the medulla itself) can lead to very considerable weakening of the excitatory action of impulses from $A_{\delta 3}$-afferents on the vasoconstrictor system and can block the corresponding action of

lower-threshold afferents (Fig. 2: curve 2). In the experiments of this group, stimulation on TN with a strength of 7 T, sufficient to excite $A_{\delta 2}$-afferents, in fact evoked only depressor reflexes, whereas all "bulbar" cats stimulated at the same strength developed pressor reflexes [1].

Only in a few animals (4 of 19) did preservation of connections between the medulla and pons have a weak effect on excitation of the vasoconstrictor system by impulses from relatively high-threshold A-afferents. In response to stimulation of TN with strengths of up to 3-5 T inclusive, i.e., to impulses from $A\beta$ + $A_{\delta 1}$-afferents and the most excitable $A_{\delta 2}$-afferents, these animals responded, like all the rest, with a fall in BP (Fig. 2: curve 3). However, in response to excitation of a larger number of $A_{\delta 2}$-afferents (7-10 T) they developed pressor reflexes. It is essential to note, however, that the number of such experiments was small.

The main results of these experiments, namely that considerable widening of the range of strengths of stimulation within which depressor reflexes arise instead of pressor, is independent of whether the medulla was connected to a relatively large part of the pons or only to a relatively small part. Consequently, for depressor reflexes to arise instead of pressor, the critical factor is preservation of certain formations located near the pontomedullary junction. Transection of the brain stem through this region or a little caudally to it in fact either limits the range of strengths of stimulation in response to which depressor reflexes arise to 3-5 T or prevents their appearance altogether [1]. Recording potentials of the vasoconstrictor fibers, which was done in the experiments described above, showed that the appearance of depressor reflexes instead of pressor is due mainly to inhibition of activity of the system generating the so-called very late A-response [7, 9]. Fuller details of these observations will be given elsewhere.

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