EFFECT OF SEROTONIN ON TRANSCOMMISSURAL EVOKED POTENTIALS OF THE BASO-LATERAL PORTION OF THE AMYGDALA

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The effect of serotonin (5-HT) and 5-hydroxytryptophan (5-HTP) on evoked activity in the baso-lateral portion of the amygdala was studied in acute experiments on rats. The transcommissural evoked potential of the above portions of the amygdala was used as the index of bioelectrical activity. The experiments showed that 5-HT (2.5 and 5 mg/kg, intravenously) and 5-HTP (150 mg/kg, intraperitoneally) block the transcommissural potential. Semicarbazide (100 mg/kg, intraperitoneally, 2 h before 5-HTP) and reserpine (5 mg/kg, intraperitoneally, 24 h before 5-HTP) prevent the effect of 5-HTP on evoked responses of the amygdala. Reserpine (5 mg/kg), if injected 4 h before 5-HTP, did not modify the effect of the 5-HTP. It is concluded that the blocking effect of 5-HTP on the transcommissural potential of the baso-lateral amygdala is due to 5-HT formed from 5-HTP.

Considerable attention is now being paid to the investigation of the amygdalar complex (corpus amygdaloideum) of the limbic system. This is because injection of various mediators, including serotonin, into various zones of the amygdala, especially into the baso-lateral zone, induces definite changes in the behavior of the experimental animals [1-3]. Meanwhile there are few publications on the effect of serotonin on the serotoninergic structures of the amygdala [6, 11].

The object of this investigation was to study the action of serotonin and its precursor on the bioelectrical activity of the amygdala.

EXPERIMENTAL METHOD

Experiments were carried out on 55 albino rats weighing 150-160 g. After tracheotomy and insertion of the electrodes (under superficial ether anesthesia) 0.1 ml of a 2% solution of listhenon was injected subcutaneously, and the animal was artificially ventilated. The experiments began 1-1.5 h after recovery from the ether anesthesia. The animal's body temperature was maintained at 36-37°C.

Bipolar stimulating electrodes (nichrome, overall diameter 0.2 mm) were inserted into the baso-lateral nucleus of the amygdala using coordinates from the atlas of Konig and Klippel [8].

Square pulses (0.1-0.5 mA, 0.1-0.2 msec, 1 Hz) for stimulation were led from the generator through a high-frequency attachment. Evoked potentials were recorded on photographic film by the tenfold superposition method. After the end of the experiments a morphological control was set up.

Serotonin creatinine-sulfate was injected into the caudal vein; 5-hydroxytryptophan (5-HTP), semicarbazide, and reserpine were injected intraperitoneally. The doses of the substances used and the time of injection are given in Table 1 and in the captions to the figures. The character of the effect of the substances on the bioelectrical activity of the amygdala was judged from the change in amplitude of the transcommissural evoked potentials.

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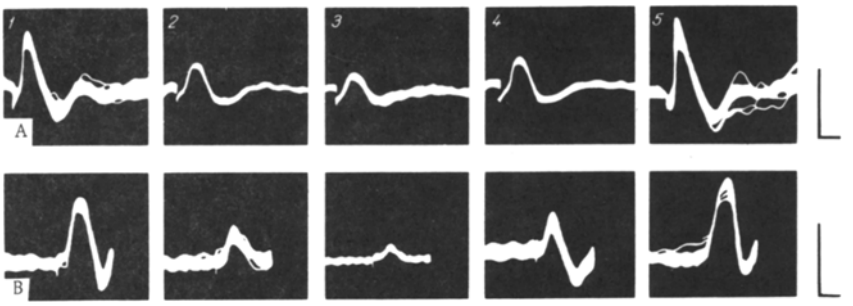

Fig. 1. Effect of serotonin on transcommissural evoked potentials in the baso-lateral nuclei of the amygdala in rats: 1) before injection of serotonin (initial response); 2, 3, 4, 5) amplitude of response 1, 3, 15, and 60 min, respectively, after injection of serotonin. A and B) serotonin intravenously in doses of 2.5 and 5 mg/kg, respectively. Calibration: 50 μV, 20 msec. Upward deflection corresponds to electrical negativity.

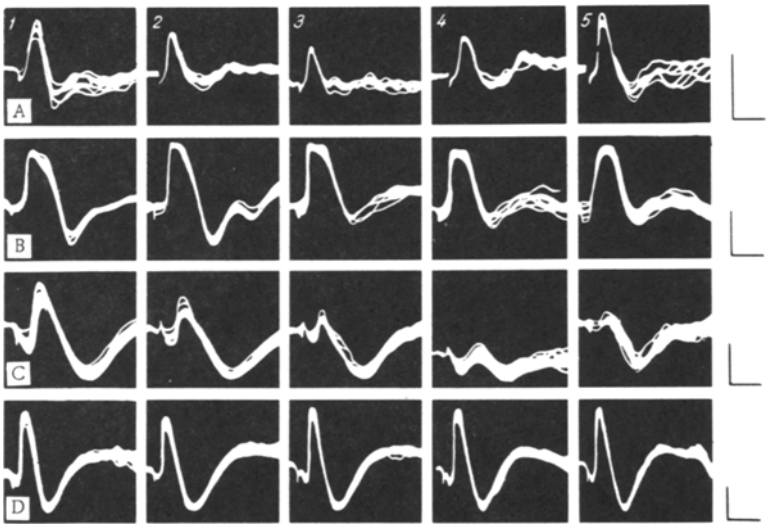

Fig. 2. Effect of semicarbazide and reserpine on ability of 5-HTP to inhibit transcommissural evoked potentials of baso-lateral nuclei of the amygdala in rats: A) 5-HTP (150 mg/kg); B) 5-HTP, 2 h after injection of semicarbazide (100 mg/kg); C) 5-HTP 4 h after injection of reserpine (5 mg/kg); D) 5-HTP 24 h after injection of reserpine; 1) initial level of potentials; 2, 3, 4, and 5) amplitude of responses 0.5, 1, 1.5, and 2.5 h, respectively, after injection of 5-HTP. Calibration: 50 μV, 20 msec. Upward deflection corresponds to electrical negativity.

EXPERIMENTAL RESULTS

In response to stimulation of the baso-lateral zone of the amygdala a characteristic response appeared in the contralateral zone; the response consisted of negative–positive waves with a latent period of 7-10 msec (Figs. 1 and 2).

Intravenous injection of serotonin in a dose of 2.5 mg/kg sharply reduced the amplitude of the transcommissural potentials (Fig. 1A). Depression of the evoked potentials 1 min after injection of serotonin amounted to 65.8 ± 12.3%, rising to 82.0 ± 13.8% after 3 min, and falling again to 71.8 ± 8.9% after 15 min. The amplitude of the potentials was restored after 60 min. Serotonin in a dose of 5 mg/kg (Fig. 1B) had a stronger effect.

TABLE 1. Effect of Semicarbazide and Reserpine on Ability of 5-HTP to Modify Transcommissural Evoked Potentials in the Baso-Lateral Part of the Amygdala

Substance used	Dose (in mg/kg)	Initial level of response (in μV) before injection of 5-HTP (control)	Amplitude of response (in μV) at various times (in h) after injection of 5-HTP					
			½	1	1½	2	2½	3
5-HTP	150	47,9±4,5	35,9±3,4*	20,0±4,5*	21,3±4,4*	20,2±5,8*	29,0±8,4	43,3±10,9
Semicarbazide	100	111,0±15,0	146,0±32,3	144,0±32,3	153,0±12,5	126,0±26,3	142,0±11,8	147,0±12,5
Reserpine (4 h beforehand)+5-HTP	5+150	117,0±9,7	104,0±9,9	92,0±7,5*	64,0±13,3*	71,0±10,9*	90,0±6,2*	—
Reserpine (24 h beforehand)+ 5-HTP	5+150	127,0±10,0	151,0±27,7	153,0±14,9	142,0±13,3	144,0±12,6	139,0±13,4	128,0±11,1

*Difference from control statistically significant ($P < 0.05$).

Some central effects of injected serotonin may be due to responses of peripheral functional systems [5-7]. In addition, the blood–brain barrier is a substantial obstacle for serotonin [5, 7]. In order, therefore, to show that serotonin influenced evoked potentials in the amygdala, its precursor 5-HTP was used in the subsequent experiments, for it passes relatively easily through the protective barriers into the CNS [5, 7].

After intraperitoneal injection of 5-HTP (150 mg/kg) there was a marked decrease in the amplitude of the evoked responses as early as 30 min after the injection (Fig. 2A). At this time the amplitude of the potentials was reduced by 23.4 ± 7.9%. In most of the experiments inhibition reached a maximum after 1, 1.5, and 2 h, when the responses were depressed by 53.6 ± 11.8, 51.6 ± 12.1, and 54.4 ± 13.1%, respectively. A tendency toward recovery was observed after 2.5-3 h (Table 1). In a few experiments recovery began sooner (Fig. 2A).

If 5-HTP is injected from an outside source, it penetrates into nerve cells, where it undergoes decarboxylation, and the serotonin thereby formed is transported to the nerve endings [10, 12]. With this in mind, it can be postulated that the depression of the transcommissural potentials of the amygdala by 5-HTP was in fact due to serotonin.

Support for this conclusion was obtained from the results of experiments with semicarbazide, an inhibitor of 5-HTP decarboxylase [4], and with reserpine.

These experiments showed that semicarbazide completely prevents the depriming effect of 5-HTP on the amygdalar evoked potentials (Fig. 2B; Table 1).

In the experiments with reserpine the action of 5-HTP on amygdalar bioelectrical activity persisted if the substance was injected 4 h after reserpine (Fig. 2C; Table 1). However, if reserpine was given 24 h before 5-HTP, its effect was completely prevented (Fig. 2D; Table 1).

The observations of Revzin et al. [9] showed that the serotinin level in the amygdala and the piriform cortex 4 h after injection of reserpine was reduced to one-third, and 8 h after injection to one eighth of the normal level. This may be why 24 h after the injection of reserpine 5-HTP did not exhibit its blocking action.

The baso-lateral zone of the amygdala is thus sensitive to the action of serotonin, and the biological activity of the structures of this zone is suppressed both by serotonin and by its precursor, 5-HTP.

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