Neuronal Activity of the Human Pretectal Area (Preliminary Report)

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Recently, the extracellular recording of unit discharge in human cases is an usual technique, however, the data of unit activities in human extra-thalamic structures has not reported in literature. During stereotaxic operations for intractable pain, spasmodic torticollis and see-saw nystagmus, unit activities were recorded in the thalamus and the pretecal area including the interstitial nucleus of Cajal. In this paper, the authors will deal with unit recording in the pretecal area in man. The results of stimulation and destruction of the interstitial nucleus of Cajal in cases of spasmodic torticollis were reported elsewhere⁷⁾⁸⁾.

In 11 operations of 2 cases of spasmodic torticollis, 1 case of see-saw nystagmus and 4 cases of intractable pain, the recording of unit discharges were performed. The coordinates of the target points for spasmodic torticollis and see-saw nystagmus⁷⁾⁸⁾ were as follows: 7 to 9 mm posterior to the midpoint of the intercommissural line, 2 to 3 mm inferior to the intercommissural line and 2 mm lateral to the mid-sagittal plane. In cases of intractable pain, the coordinates of the target points were 5 to 7 mm posterior to the midpoint of the intercommissural line, zero to 1 mm superior to the intercommissural line and 4 to 5 mm lateral to the lateral wall to the third ventricle. According to Schaltenbrand-Bailey's atlas, the former coordinates indicates the pretecal area including the interstitial nucleus of Cajal and the latter coordinates is the CM-Pf complex. The operations were performed under local anesthesia using 1.0% solution of procain. The head of the patient was freely movable. Through a precentral burr hole, electrode was introduced to the target point. In all cases, the tracks of the electrodes passed through the two points represented by the coordinates mentioned above. Before insertion of the ordinary bipolar concentric electrode for stimulation and destruction, a microelectrode was put into the target point through a coated stainless steel tube, 1.0 mm in outer diameter. The guide tube was stereotaxically inserted and was fixed 5 to 10 mm above the target point. The microelectrode consisted of a 0.1 to 0.2 mm coated tungsten wire, the tip being 1 to 2 μ in diameter, which was held on a 0.8 mm coated stainless steel tube. The resistance of the microelectrode was 5 to 15 M Ω . The cathode follower amplifier, NIHON KODEN MZ-4, and the data recorder, TEAC R-401 were used for recording.

As shown in Table 1, 192 units were successfully recorded in the thalamus and in the pretecal area. The all needle tracks were shown in Fig. 1. 35 units out of 192 were picked up in the pretecal area. When the microelectrode passed out the thalamus, the background activity changed and the amplitude of units was at-

Table 1 Classification of response patterns recorded in the human thalamus and pretectal area.

Total	192
(7 cases, 11 operations)	
DM	75
CM-Pf	82
pin prick	18
heat & pin prick	2
none	62
Pretectal	35
neck movements	12
eye movements	7*
none	17

*: 1 out of 7 units had responses to neck and eye movements

Fig. 1: Microelectrodes tracks

pc: posterior commissure, ac: anterior commissure, 0: midpoint of the inter-commissural line 5 and 10: 5 and 10 mm from the mid-sagittal plain

Table 2 Response Patterns of pretectal units

Rotation		Flexion		No. of Units	
Ipsi.	Contra.	Post.	Ant.		
—	↑	—	—	3	} 6
—	↑	↑	—	2	
—	↑	—	↑	1	
↑	—	—	—	3	} 3
↑	—	↑	—	0	
↑	—	—	↑	0	
—	—	↑	—	1	} 3
—	—	—	↑	2	
Response to Eye Movements				7*	
No Response				17	
Total				35	

Ipsi. & Contra.: the head rotation to the ipsilateral and to the contralateral side of the recording electrode, respectively.

Post. & Ant.: posterior and anterior flexion of the head, respectively.

*: the same in Table 1.

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Fig. 2 Pretectal neuron and neck movement
 — duration of the voluntary head movement

Fig. 3 Pretectal neuron and eye movements duration of the voluntary eye movements.

tenuated. Then it was able to determine that the microelectrode was in the pretectal area. Sometimes, the site of the tip of the electrode was checked on X-ray films. After the units were stably recorded, the patient was asked to move his head or eyes.

Out of 35 units, 17 units had no response to the voluntary head or eye movements. 12 units were correlated with neck movements and 7 units increased their discharge with movements of eyes. The classification of the response patterns of those 12 neurons correlated with neck movements is shown on Table 2. Electromyography of the bi-

lateral sternocleidomastoid muscles and the bilateral trapezius muscles were recorded. Rotation of the head caused the EMG discharges of the sternocleidomastoid muscle on the side contralateral to the direction of head rotation and of the trapezius muscle on the ipsilateral side. The bilateral trapezius muscles contracted during posterior flexion of the head and the bilateral sternocleidomastoid muscles contracted during anterior flexion of the head. Increase of discharges of 6 units was induced by the head turning toward the contralateral side. In 2 units out of 6, discharges increased during posterior flexion of the head. As the muscle which takes part with both rotation and posterior flexion of the head, is the trapezius muscle on the same side of rotation, these two units should be correlated with contraction of the contralateral trapezius muscle or relaxation of the ipsilateral sternocleidomastoid muscle. At the ipsilateral turning of the head, 3 units increased in firing rate, as shown in Fig. 2. Units which had a relation with the flexion of the head were 3; 1 unit in posterior flexion and 2 units in anterior flexion, respectively. Apparent suppression of unit discharges at the movement in the opposite direction was not observed, however, some neurons seemed to decrease in number of discharges by rotation toward the opposite side.

7 units showed a response to eye movements, as one of them was shown in Fig. 3.

As mentioned in our previous papers⁶⁾⁷⁾⁸⁾, the authors have stimulated various points in the human brain stem. Upon stimulation, the subthalamus, the postero-medial hypothalamus, the red nucleus, the central tegmental tract and the inferior olive all caused lateral flexion of the head to the side ipsilateral to stimulation. Electrical stimulation of the pretectal area including of the interstitial nucleus of Cajal in man elicited EMG discharges and contraction of the bilateral posterior neck muscles, dominantly on the side of stimulation accompanied by retroflexion of the head and sometimes accompanied by eye movements. As described in those previous papers, rotatory movement of the head and neck was not observed upon electrical stimulation of the human brain stem. Based on the studies of Hess²⁾ on cats, Hassler¹⁾ described that upon stimulation of the interstitial nucleus the rotatory movement of the head around the longitudinal axis toward the side of stimulation was elicited, the raising of the head occurred by stimulation of the pretectal nucleus and the bending of the head was produced by stimulation of the nucleus of Darkshewitsch. Mabuchi³⁾ confirmed that stimulation of the area in and around the interstitial nucleus elicited rotatory movement of the head and eyes to the stimulation side and ablation of this area caused the head rotation to the opposite side, in cats. In chronic implant human cases, Nashold⁴⁾⁵⁾ said that the contralateral turning of the head and eyes was produced upon stimulation of the subthalamus and the dorsal midbrain as caudal as the inferior colliculus. According to the results of the present study, it is obvious that the neurons which have some relation with the movements of the head and neck, especially with rotatory movement, scatter in the pretectal area including the interstitial nucleus of Cajal. It seems that each neuron corresponds to each muscle. It is not clear whether these neurons are centrifugal or centripetal.

In present study, number of units was not enough to further examination. Mechanism of neck movements and mechanism of spasmodic torticollis are very complicated and further studies will be necessary to elucidate these mechanisms.

Summary

During stereotaxic operations for spasmodic torticollis, see-saw nystagmus and intractable pain, 192 units were recorded in the human thalamus and the pretectal area including the interstitial nucleus of Cajal. In this paper, the authors discussed the relation between the pretectal neurons and the movements of head and eyes. The pretectal neurons have some relation with the movements of the head and neck, especially with rotatory movement. It seems that each neuron corresponds to each neck muscle. It is not clear whether these neurons are centrifugal or centripetal.

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