14. UPPER MESENCEPHALIC RETICULOTOMY IN EPILEPSY AND BEHAVIOR DISORDERS

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This brief communication constitutes a link in the series of surgical interventions to the various parts of the limbic system. Results of those to the cingulate gyrus, to the temporal lobe and to the fornix were reported in the previous communications. In the last fifteen years, functions of the brain stem reticular system have been greatly elucidated by Magoun and his collaborators. The system is now widely known to modulate various kinds of neuronal activities through its ascending and descending projections. Not only the neocortex, but the limbic system comes under its influence. This report concerns the effects of lesions in the rostral brain stem reticular formation upon the pathological functional states of the cerebral cortex including the limbic system, namely, epileptic seizures and behavior disorders.

Technique

The most rostral part of the mesencephalic reticular formation around the aqueduct was chosen for the site of lesion. This area is situated rostral to the oculomotor nuclei and apart from the red nucleus, the substantia nigra, and the specific afferent and efferent systems (Figs. 1 and 2). The lesion of the area is
considered to exert bigger influences on the cerebral cortex and to yield less side
effects than those of any other regions of the brain stem. The periaqueductal
gray matter and the surrounding reticular formation are involved in the lesion.
The only structure that might cause untoward phenomena is the subcommissural
organ which recently was confirmed to exist in the human being\textsuperscript{1}) and injury of which will result in disturbances in water metabolism.

A needle insulated except for its tip was inserted into this area with the aid of a stereotaxic apparatus described elsewhere\textsuperscript{5}, under x-ray control (Figs. 3 and 4). The proposed area was easy to identify on the x-ray films, because the rostral part of the aqueduct was visible in the pneumoencephalograms. Electrocoagulation of the area was performed by means of direct current (10 V., 3 to 3.5 mA, 60 to 90 seconds) with the needle tip as the cathode. In experiments of the yolk of the egg, the direct current of the same parameters and the same polarity caused electrocoagulation lesions, 3 to 4 mm. in diameter.

Results

So far six cases, mostly of epilepsy with violent behavior, were submitted to the upper mesencephalic reticulotomy. These are summarized in Table 1. Postoperatively tendency to calmness or docility was more or less noted in most of the cases. The tendency was marked in the first few weeks, gradually attenuating thereafter, but in some cases (case T.S., H.I. and M.I.) lasted for the period
Table 1. Upper Mesencephalic Reticulotomy

<table>
<thead>
<tr>
<th>Cases</th>
<th>Age</th>
<th>Sex</th>
<th>Disease</th>
<th>Operation</th>
<th>Period of Observation</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. K.S.</td>
<td>31</td>
<td>♂</td>
<td>Epilepsy with violent behavior</td>
<td>Reticulotomy + Fornicotomy + Amygdalo-hippocampotomy</td>
<td>1 y. 2 m</td>
<td>Calm no seizure</td>
</tr>
<tr>
<td>2. H.O.</td>
<td>5</td>
<td>♂</td>
<td>Epilepsy with violent behavior, Idiocy</td>
<td>Reticulotomy</td>
<td>10 m.</td>
<td>no change</td>
</tr>
<tr>
<td>3. T.S.</td>
<td>8</td>
<td>♂</td>
<td>Epilepsy. Mental defective with violent behavior</td>
<td>Reticulotomy</td>
<td>7 m.</td>
<td>Calm no seizure</td>
</tr>
<tr>
<td>4. H.I.</td>
<td>26</td>
<td>♀</td>
<td>Epilepsy (Convulsive + psychomotor) with violent behavior</td>
<td>Reticulotomy</td>
<td>7 m.</td>
<td>Calm seizure persistent</td>
</tr>
<tr>
<td>5. M.I.</td>
<td>7</td>
<td>♀</td>
<td>Epilepsy with hemiplegia. Irritable</td>
<td>Reticulotomy</td>
<td>5 m.</td>
<td>Calm seizure persistent</td>
</tr>
<tr>
<td>6. H.S.</td>
<td>4</td>
<td>♀</td>
<td>Infantile autism with stereotyped movement</td>
<td>Reticulotomy + Thalamotomy</td>
<td>5 m.</td>
<td>Slightly improved</td>
</tr>
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</table>

of observation, though in a less degree. In the case K.S. of epilepsy and violent behavior reticulotomy not only could not relieve the behavior problems, but provoked spiking in the amygdaloid-hippocampal area and the temporal pole, so that fornicotomy and amygdalo-hippocampotomy had to be performed to alleviate violent behaviors and epileptic seizures.

There was only one case (case T.S.) whose seizures (convulsive seizures) were definitely relieved after the reticulotomy. This case was a 8-year-old boy who had generalized convulsive seizures since 3 years of age and developed violent behaviors since 5 years of age. Preoperatively spike-and-wave complex was noted in the bifrontal leads (Fig. 5). This pattern and the clinical attacks
disappeared after the reticulotomy and the behaviors were more or less ameliorated. Figure 6 was the EEG on the 9th day after the operation. Marked slow waves characteristic of EEG changes after the reticulotomy appeared in all the leads. The sleep record was normal, showing well-formed spindles, but on arousal, slow waves reappeared (Fig. 7).

The case H.I. was a 26-year-old woman who started convulsive seizures at the age of 5 and recently developed ictal automatism and violent behaviors.
Sporadic spikes are seen in the temporal and the frontal leads on the right side (Fig. 8). Figure 9 was the EEG on the first day after the reticulotomy. Slow waves, 3 to 6 c/s, were predominant in all the leads. Figure 10 was the EEG on the 26th postoperative day. Slow waves were still present, and yet desynchronization occurred on sensory stimulation. Figure 11 was the EEG on the 113th postoperative day. Slow waves were still dominating, although faster waves were overlapping on them. In spite of these slow waves, the patient has been quite conscious. The automatism has been essentially uninfluenced, while convulsive seizures tended to be minor ones. In this case gradually increasing dehydration was noted in the first three postoperative days, which might be ascribed to lesion of the subcommissural organ. The dehydration was relieved by prompt and adequate transfusion.

Table 2 summarizes changes after the upper mesencephalic reticulotomy.

<table>
<thead>
<tr>
<th>Table 2. Changes After Upper Mesencephalic Reticulotomy</th>
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<tbody>
<tr>
<td>Tendency to Calmness</td>
</tr>
<tr>
<td>Effects on Seizures</td>
</tr>
<tr>
<td>Effects on EEG—Slowing of EEG</td>
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<tr>
<td>(Temporary Dehydration—Lesion of the Subcommissural Organ?)</td>
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</table>

**Discussion**

The tendency to calmness or docility seen after the operation can be explained in the light of activating functions of the reticular system. The decrease in the “tonus” of the cerebral cortex will result in decrease of the emotional “tonus” and in docility. It is possible, however, that this procedure may injure some of the sympathetic outflows through the brain stem and thereby influences the patient’s attitude to the milieu.

Marked slowing of the EEG after the reticulotomy is a well established fact in animal experiments by Magoun and others, and here it is confirmed also in the human being. The lesion here made, however, is so small that desynchronization can be elicited upon external stimuli and there is no case who ever lost consciousness, although we are not certain about the consciousness at the moment of electrocoagulation of the proposed area, since general anesthesia was used in all cases.

Originally the procedure was expected to exert favorable influences upon various types of seizures by affecting firing of the foci. But the situation is not so simple. It seems, from the above data, that effects of the reticulotomy upon seizures originating from the limbic system are unfavorable; the seizures may remain unchanged or sometimes may increase after the procedure. No definite results have been obtained of the effects of the reticulotomy upon seizures involving the neocortex, but there is one favorable case.
These data are in accordance with the results of the experiments done by our colleague, Dr. Miyasaka\(^2\). He stimulated the various parts of the cerebral cortex in the cat, and concluded that the reticular formation exerted a facilitatory influence on the neocortical seizure discharges and an inhibitory influence upon those of the limbic system. The present data form the counterpart of the experiments.

**Conclusions**

If some conclusions may be drawn from these limited experiences of the stereotactically made, small lesion of the most rostral and periaqueductal part of the mesencephalic reticular formation, they will be as follows:

1. The reticulotomy may exert favorable influences upon behavior problems.
2. The effects of the reticulotomy on seizures of the limbic system are unfavorable; the seizures may sometimes increase after the procedure.
3. At the present stage, nothing definite can be stated about the effects of the reticulotomy on neocortical seizures, although there is one favorable case in the series.

**References**