Electroencephalographic Observation of Brain Tumors.

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In dealing with EEG of brain tumors, we are most interested in the localizations of the tumors. Since Walter1) (1936) first described the accurate localization of cerebral tumors by means of EEG, many similar studies have been introduced by Williams and Gibbs2) (1938), Kornmüller3) (1940) and others. Yeager and his coworker4) (1940), according to the study of 43 superficial lesions of which 36 were neoplastic, gave such result that 37 of them were localized by EEG and in some instances the EEG indicated the site of the lesion when other methods failed entirely. However, this study illuminates such questions as whether any kinds of brain tumors can be localized and any kinds of characteristics can be recognized by means of EEG, to say nothing of the localizations of the tumors.

Material.

This study is based on data concerning 50 consecutive patients who had tumors situated in various parts of the brain. Except for some cases, most of these were confirmed either by surgical operation or by necropsy and verified microscopically.

Technic.

Electroencephalographic tracings were made by a four-tube amplifier, the frequency character of which is constant to all frequencies between 1 and 35 cycles. In order to do monopolar recording, a silver electrode as a negative pole is attached to the lobe of each ear and the other as a positive pole is fastened to the surface of the cleansed scalp of the patient, with saline starch. The latter is movable on the parasagittal lines over the frontal, motor, parietal and occipital areas, according to the place selected for getting the record. On the temporal regions it is placed about
5 cm. directly above the external auditory meatus. Tracing time needs about 20 seconds for each area.

The conditions of recordings are standardized as nearly as possible. The patients are placed on an electrically shielded bed in a darkened room. They are instructed to lie as quietly as possible, with the eyes closed, but to remain in a waking state.

Judgement of Abnormalities of EEG.

The question has arisen whether there are any abnormalities of the waves gained from EEG of the brain tumors. Our answer to this problem will discuss 5 kinds as follows; (1) Base line fluctuation, (2) Decrease or absence of spontaneous waves, (3) Appearance of delta waves, (4) Low or high potentials, (5) Asymmetry of waves.

Results and Commentary.

The electroencephalographic findings in 50 cases of brain tumors can be classified as follows;

(1) Normal records in 6 cases.
(2) Abnormal records in 44 cases.

(1) The group of normal records.

This group contains 6 cases. The results of the EEG were normal in the presence of tumors. Most of them were found to be in the surrounding portions of sellar tubercle (3 hypophysial tumors, 1 craniopharyngioma and 1 retrobulbous granuloma) and too small to increase the intracranial pressure. Moreover, the case of pontine tumor confirmed by necropsy and verified microscopically as a granuloma was not so large as to give rise to the stenosis of ventricle.

These facts may indicate that the small deep midline brain tumors not increasing intracranial pressure are indifferent to the abnormal electroencephalographic waves.

(2) The group of abnormal records.

They were divided into three main groups.
a) The first group.

This group involves 13 cases. 5 of them were found to be in the near portions of sellar tubercle (1 hypophysial tumor, 3 craniopharyngiomas and 1 cyst of optic chiams), 3 in the surrounding parts of the third ventricle (2 ependymomas of the wall and 1 pinealoma), 2 in the brain basis (2 pontine gliomas) and 2 in cerebellum (1 medulloblastoma and 1 Lindau's disease). Each of them existed either in the deeper brain centre or in the posterior fossa lying near the ventricle and gave rise to the intracranial hypertension.
Their electroencephalographic changes were distributed uniformly over every area of the brain and were not circumscribed on focus, and they closely resembled each other on every area. The figure of the waves showed that the beta waves were vastly increased and superimposed on the generalized delta waves with the alpha waves remaining unaffected. These waves are due to the raised intracranial pressure incurred by the existing tumors.

After all, the tumors of this group were not localized by the EEG because of the generalized changes, as well as the study of Kuwahara\(^5\) (1942).

b) The second group.

15 cases belong to this group. The tumors contained in this group showed some common features as follows;

(i) They were situated pressing on the cerebral cortex from the outside or invading the cortex. Sometimes they were found to be in the subcortical portions adjacent to the cortex.

(ii) They were most frequently found in cerebrum, except for 3 in cerebellum and limited to one hemisphere.

(iii) Although their extents were considerably wide, the intracranial pressure was not generally so high as to be seen in the stenosis of ventricle.

The electroencephalographic changes of this group were manifested in a single area as a rather circumscribed focus and they distinctly designated the locations. When generalized changes were present, they were usually intensified on the focus.

The electroencephalographic changes appearing on focus are as followings;

(i) The delta waves obtained from the foci of 3 meningiomas, 1 tuberculoma of cerebellum, 1 medulloblastoma and 1 skull bone tumor were of distinguishably low potentials and slow in frequency of from 1 to 3 cycles per second, rather seemed to be a random and slow base line with reduced potentials. Consulting the references, Foerster and Altenburger\(^6\) (1935) have shown that the tumor tissue was electrically inactive. Kornmuller (1940) and Kuwahara (1942) demonstrated the instances, the localizations of which were possible because of the reduced or abolished electric activities of the local cerebral cortex. Thus, in our cases, it is supposed that the tumors occupied such extents that the electrodes were placed easily above the locales.

(ii) In 6 cases of gliomas (5 in cerebrum and 1 in cerebellum) the delta waves, moderately slow in frequency (from 3 to 5 cycles per second) and apparently high in amplitude, were prevalent in the absence of the spontaneous alpha and beta waves.

This evidence indicates that such a electroencephalographic change
appears when the cerebral cortex invaded by a tumor maintains partially, however, its electric activity not completely damaged.

(iii) 2 cases of skull bone tumors showed such delta waves that their potentials were moderately slow and high with almost unaffected alpha and beta waves superimposed on them. These waves may be associated with the cortical changes produced by slight pressure.

(iv) In the case of inflammation by which the cerebral cortex was less influenced, such as subcortical abscess, the changes were not so pronounced as were seen in other cases. The delta waves were somewhat slow in frequency. The spontaneous alpha and beta waves remained unaffected and free from delta waves.

(v) On the hemisphere opposite to that of cerebellum involving tuberculoma, the delta waves were remarkably high in amplitude with the beta waves of high potentials superimposed on them.

This fact illustrated that while tumor tissue is electrically inactive, the effect of tumor on the surrounding cortical tissue is the basis of the production of high potentials, as described by Foerster and Altenburger (1935).

c) The third group.

This group includes 16 cases. This group was characterized by the electroencephalographic complexity and those records were less easily analysed, so that at times it was fairly difficult to determine the locations of the tumors without reference to the pneumoencephalographic and the neurologic examinations. A few of those records were reanalysed in reference to the locations of the tumors confirmed by the surgical intervention. Although the electroencephalographic changes of this group were generally present, the intensities of the changes were most pronounced on the foci in such cases as 1 glioma, 1 acoustic tumor, 1 meningioma, 1 medulloblastoma and 1 tumor of cerebellopontine angle, and on the hemispheres involving lesions, such as 1 abscess and 1 brain metastasis of lung carcinoma. Case and Bucy (1938) experienced the same cases by the study of 11 brain tumors.

In 1 pinealoma and 1 craniopharyngioma, the changes were lateralized on the site to which the tumor extended.

Another case of pinealoma and 1 neurinoma showed only base line fluctuation as a representative change on the focus.

In the case of glioma of the right hemisphere of cerebellum, its location was mistaken because of the intensity of the changes on the opposite hemisphere.

The most interesting and complicated changes are exhibited by the following cases.

Another case of craniopharyngioma, according to the pressing on the parietal cerebral cortex to the skull bone adjacent to it, showed the cha-
Fig. 1 Case of craniopharyngioma
a. left frontal, a'. right frontal
b. left temporal, b'. right temporal
c. left parietal, c'. right parietal
d. left occipital, d'. right occipital

characteristic waves of exceedingly reduced potentials on that area. (Fig. 1)

The case of ependymoma of the third ventricle which developed within both sides of the second ventricle, especially the left side, through the Monrow's foramen showed on the frontal and the left occipital areas of the brain a similar change.

In the case of meningioma of the right side of the anterior fossa, any areas of the left hemisphere were not changed, whereas on the right hemisphere the frontal area showed the delta waves of high potentials associated
with the edema of the surrounding tissue of the tumor and the occipital area showed the waves of reduced potentials appearing remote from the tumor mass.

The case of meningioma of the left olfactory groove which was widespread and extended to the left side of the forehead showed the most remarkably complicated records possible to be found in a single case. (Fig. 2) That is to say, the left side of the forehead where the tumor seemed to be situated showed the waves of most reduced potentials because of the inactiv-
ity of the tumor tissue. On the contrary, the right side of the forehead and the left frontal area adjacent to the tumor showed the delta waves of high potentials because of the edema of the surrounding tissue occasioned by the tumor. In addition, on both sides of the parietal area remote from the tumor mass appeared the reduced electric activities which were related to the inactivities of the cerebral cortex of that area caused by the pressing on it to the skull bone.

In this way, according to the information of those records, one can ascertain that the abnormal waves of high potentials on the surrounding tissue of the tumor are to be noted as a near local electroencephalographic change and the abnormal waves of low potentials on the distant part of the tumor as a far local electroencephalographic change, just as there is neurologically a near local and a far local symptom.

Tumors of this group showed generally such features that they existed either in the subcortical portions or in the deep centres of the brains and raised the intracranial pressure. A few of them were localized by means of the synthetetic judgments of the changes of each area.

Many works attributed EEG to be unvaluable in the localizations of the deep lying tumors, whereas Lemere\(^8\) (1937) has noticed in the study of the subcortical tumors that the electroencephalographic changes were intensified on the side of the tumors more than on the opposite side. Smith, Walter and Laidlaw\(^8\) (1940) found the delta waves, which showed phase reversal over the focus, from 8 cases of the tumors in the posterior fossa. Walter and Dovey\(^10\) (1944) and Cobb\(^11\) (1944) accounted for the appearance of the theta waves obtained by the study of subcortical brain tumors.

After all, the abnormal waves reviewed in EEG of 44 cases are classified into 4 types and interpreted as such. (Fig. 3)

(i) The first type shows a random and slow base line with reduced potentials.

This type appears either on the tumor tissue or on the nearly destroyed cerebral cortex.

(ii) The second type shows delta waves of high potentials in the absence of the spontaneous alpha and beta waves.

This type predominates in glioma. The cerebral cortex may be supposed to retain with difficulty its electric activities.

(iii) The third type shows delta waves of high potentials with the spontaneous alpha and the increased beta waves superimposed on them.

This type is related either to the edema of the brain or to the intracranial hypertension, and the cerebral cortex may be considered to be less damaged than that of the second type. This type embraces the majority of all cases.
Fig. 3 4-types of the abnormal waves in EEG of brain tumors
A. 1st type
B. 2nd type
C. 3rd type
D. 4th type

(iv) The forth type shows only base line fluctuation with the spontaneous alpha and beta waves.

This type appears on the cerebral cortex being slightly influenced by the tumor. This type is most unchangeable as a whole.

According to the study of Charles Le Vant Yeager and Sarah Luse\textsuperscript{12)} (1945), the wave similar to our second type was identified with glioma and
that similar to our third type with meningioma, so that they concluded in the report that a clue to the pathologic nature of the underlying lesion may be obtained by utilizing the information gained from EEG, in addition to the localization. In contrast, according to our study meningiomas were frequently found to be in the first type. As to the difference between their result and ours, that will depend in part on the extent of the tumor.

**Summary.**

As a result of the electroencephalographic observation of our fifty cases, it was recognized to be valuable in the localization of superficial tumors of the convexity of the brain. In evaluating the EEG of the deeply underlying tumors, it should be emphasized that there is a near local and a far local electroencephalographic change. Therefore one should always endeavour to understand the abnormal waves recorded in EEG, with caution.

**References.**

8) Lemere, F., Brain, 1937, 60, 118–125.

* Written in Japanese.