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On the March of the Cerebellar Epi-leptic Convlsion in Dogs

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On the March of the Cerebellar Epi-leptic Convlsion in Dogs*

Dennosuke Jinnai and Futami Kosaka

Abstract

1) Cerebellar convulsion was identical with the cerebral cortical epileptic convulsion and the number of cases in which the march of spasm was observed were quite the same as that of cases in which convulsion occurred at the same time on the whole body. 2) No convulsion occurred by stimulation of the vermis cerebellaris and also convulsions occurred very rarely by that of the cerebellar nuclei. 3) In cases having the march of spasm caused by stimulation of the lobus lunatus anterior, spasm began in the fore limb, while by stimulation of the lobus lunatus inferior and lobus semilunaris spasm started mainly in the hind limb on the side of stimulation. 4) In the case of stimulation of cerebellum, the pathway of the impulse to the opposite side was considered to be the communication between both cerebellar hemispheres and both thalami and thus the march of spasm spread from one side of the body to the other side. 5) No march of cerebellar epileptic convulsion occurred without the cerebral motor cortex. 6) After the removal of both sides of the cerebral motor cortex no march occurred, but the general convulsion occurred. 7) No convulsion occurred by stimulation of the cerebellar hemisphere after the removal of both thalami or both nuclei lenticulares. 8) The march of convulsion occurs by close cooperation of the pyramidal and extrapyramidal tracts. It seems that for the impulse of the convulsion the extrapyramidal tract plays an important role, while for the start of the convulsion, that is, march of spasm pyramidal tract plays the main role.

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ON THE MARCH OF THE CEREBELLAR EPILEPTIC CONVULSION IN DOGS

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In 1863 JACKSON[1] observed the phenomenon that epileptic convulsions constantly originated from certain muscles and spread to other muscles in certain epilepsy and named this phenomenon the march of spasm. He reported that the march of spasm occurred by the arrangement in the rolandic area of the motor cortex. Since then FRITSCH and HITZIG[2] reported that movement occurred by electrical stimulation of the motor cortex, many important studies were conducted on this subject.

In 1664 THOMAS WILLIS[3] stated that the cerebellum might control involuntary muscles. Later, LUIGI ROLANDO[4] performed his experimental studies on the removal of cerebellum in many animals and noticed that these animals had disorders in their voluntary muscles. FERRIER[5] noticed that electrical stimulation to the cerebellum produced reaction on eyes, head and neck. LUCIANI[6] performed experimental studies by removing the cerebellum of monkeys, dogs and cats. He found that dogs and cats went into tetany in a week or ten days after the cerebellum was removed, chiefly showing tetanic spasm and tremor of the muscles of the whole body. SHERRINGTON[7] reported for the first time that tetany caused by decerebration is decreased during electrical stimulation of the anterior lobus of the cerebellum. Recently, CLARK[8], WARD, PAYEN and COWDEN[9] recognized that epileptic convulsions occurred by electrical stimulation of cerebral and cerebellar cortex and these men divided the type of march into 3 groups ("C", "S" and "U" types). They also stated that they found "S" type in the majority of cases when the cerebellum had been stimulated. But they made no investigation about their tract of impulse.

Recently in Japan, HAYASHI[10] and his coworkers performed experimental studies about epileptic convulsions caused by chemical stimulation (nicotin, metrazol etc.) and clarified the tract of impulse in epileptic convulsion. The characteristic of this chemical stimulation is to stimulate nerve cells only without stimulating nerve fibers in a certain concentration of these chemical substance (ISHIZUKA[11]). WATANABE[12] used this method (nicotinization) to stimulate the cerebellum. Since he was successful in making epileptic convulsion, he named it the cerebellar epileptic convulsion, which was induced by stimulation of the cerebellar hemisphere. No convulsions occurred by stimulating vermis cerebellaris and cerebellar nuclei. He has also stated that the impulse goes to the opposite side of the thalamus via the brachium conjunctivum from the cerebellar hemisphere. Then the subsequent course of impulse is of the same as in thalamic epileptic convulsion (OZAKI)[13]. We (JINNAI, YOSHIDA, SOUJI and KOSAKA)[14] performed experimental studies on the march of spasm in cerebral (cortical and subcortical) epileptic convulsion. The results are as follows: 1) Convulsions caused by stimulating the motor cortex, thalamus, nucleus lenticularis, nucleus caudatus and substantia nigra are accompanied by the march of spasm; 2) the pathway of impulse which goes from one side of the hemisphere to the opposite side runs between both thalami. The fibers connecting nucleus lenticularis and substantia nigra cross to the opposite side, but there are a few weak fibers connecting with each other on the same side.

We tried here an experimental study about the march of spasm on cerebellar epileptic convulsion in order to clarify its mechanism.

EXPERIMENTAL METHOD

Dogs weighing from 9 kg. to 15 kg. were used as experimental material. Three per cent morphine hydrochloride (0.5 c. c. /kg) was used for anesthesia and 10 per cent metrazol was injected as a local stimulant.

The purpose of our experimental study is not only to cause convulsions, but also to observe closely the march of spasm. If a large dose of metrazol is injected at one time, convulsions are apt to start at the same time throughout the whole body. Because of this reason, 0.07—0.08 c.c. of metrazol was used as a single dose. When there appeared no convulsion by this dose after 2 or 3 minutes, the same dose was repeated until the total of metrazol amounted to 0.2 c. c.

1) Method of exposing the cerebellar cortex:

In exposing the cerebellar cortex, the localization and the extent of craniectomy depend upon the cerebellar cortex which is to be stimulated, so as to prevent injury to the transverse sinus. With this point in mind, the exposure of the cerebellar cortex has been made by two methods; one by opening the upper, and the other by opening the lower part of linea nuchalis superior.

a) As the back of skull, i. e., planum nuchale, is thin and soft, it is easy to pierce and make a small hole with LUER's bone-forceps. This small hole is made large enough so that the upper edge reaches linea nuchalis superior and the lower edge reaches foramen occipitale magnum. We have succeeded in stimulating the declive, pyramis, uvula, lobus lunatus inferior, lobus semilunaris and cerebellar nuclei.

b) Parietal bone, a part of frontal bone and temporal bone are re moved with LUER's bone forceps. After the dura is opened the occipital lobe of the cerebrum is lifted with a metal retractor to find the tentorium cerebelli covering the upper part of the cerebellum. The upper part of the cerebellum is exposed after the tentorium cerebelli is removed. We have succeeded in stimulating the culmen and lobus lunatus anterior by this procedure.

2) Method of stimulating the cerebellar cortex and cerebellar nuclei:

Stimulation of the cerebellar cortex has been performed by injecting metrazol with tuberculin syringe 1 mm deep into the cerebellar cortex. Places where stimulation had been performed were the lobus lunatus anterior, lobus lunatus inferior, lobus semilunaris, culmen, declive, pyramis and uvula. The designation of the cerebellar cortex is described as Figure 1 (by ELLENBERGER and BOLK[15]). Namely lobus lunatus anterior, lobus

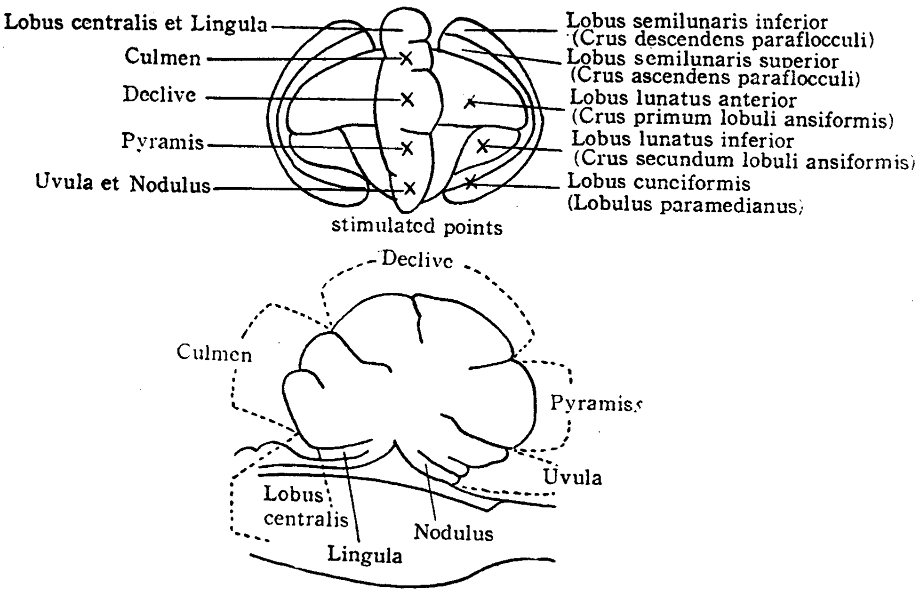

Fig. 1. Schema of Dog Cerebellum

lunatus inferior, lobus semilunaris superior, lobus semilunaris inferior and lobus cuneiformis by ELLENBERGER's designations, all of which correspond to what BOLK[15] called crus primum lobuli ansiformis (crus 1), crus secundum lobuli ansiformis (crus 2), crus ascendens paraflocculi, crus descendens paraflocculi and lobus paramedianus.

Stimulation of the cerebellar nuclei was made by WATANABE's[12] method. A needle was inserted forward and parallel with the upper surface of medulla oblongata at the mid point on the edge of the pyramis. Depth and direction of the needle differ according to each nucleus (Figure 2).

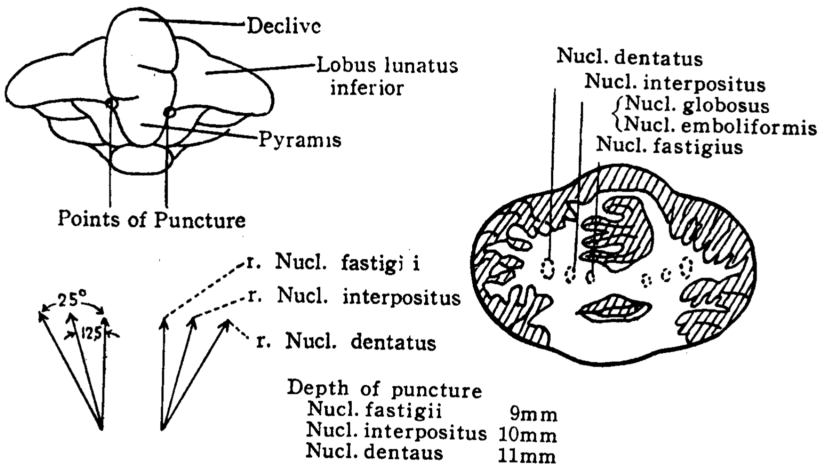

Fig. 2. Stimulating of the Cerebellar Nuclei

3) The method of removal of the thalamus :

Incision (about 3 cm.) was made along the gyrus entolateralis, reaching the lateral ventricle. The thalamus was removed with a curette.

4) The method of removal of the nucleus caudatus :

The lateral ventricle is opened in the same way as in removing the thalamus. The nucleus caudatus situated forward and lateral from the thalamus is removed with a curette.

5) The method of removal of the nucleus lenticularis :

The curette with a thin handle is inserted 11 mm. deep vertically from the surface of the brain at sulcus ectosylvius medius. Nucleus lenticularis is removed with the curette to scoop the sphere of an ellipse (anterior-posterior is 14 mm., superior-inferior is 11 mm.).

6) The method of transection of the corpus callosum and between both thalami :

The cerebrum is exposed and a thin plate is inserted between both cerebral hemispheres. The corpus callosum is cut by moving the plate from anterior to posterior.

By inserting the plate through the incision where the corpus callosum is cut, the midway between both thalami is transected.

7) The method of transecting brachium conjunctivum:

The front of the cerebellum is first exposed and then the brachium conjunctivum is cut with a small knife.

8) The method of removing the motor cortex :

The motor cortex is decided by a stimulator designed by MORI and NUMOTO[16] and is removed with a small spoon.

9) The method of observation on the march of spasm :

The order of the march of spasm is decided by electromyogram induced from the muscles of limbs.

EXPERIMENTAL RESULTS

1. March of spasm by stimulating the cerebellar cortex and cerebellar nuclei.

a) Stimulation of the lobus lunatus anterior :

When one side of the lobus lunatus anterior was stimulated, convulsion occurred in all cases (25 cases). About half of them (14 cases) had convulsion with the march of spasm, the rest (11 cases) did not have the march of spasm and convulsion started at the same time throughout the whole body. In the majority of cases having the march of spasm by stimulating the lobus lunatus anterior (9 cases out of 14), spasm began in the fore limb of the same side of stimulation and the march of spasm was a complete one.

b) Stimulation of the lobus lunatus inferior :

When one side of the lobus lunatus inferior was stimulated, convulsions occurred in all cases (26 cases) and half of them (13 cases) had convulsions with the march of spasm. The others did not have the march of spasm and convulsion started at the same time on the whole body. In 8 cases out of 13 having the march of spasm by stimulation of the lobus lunatus inferior, spasm began in the hind limb on the same side of stimulation and in 3 cases out of 13 spasm began in the fore limb on the same side of stimulation. These 11 cases out of 13 had complete march.

c) Stimulation of the lobus semilunaris :

When one side of the lobus semilunaris was stimulated, convulsions occurred in all cases (17 cases) and about half of them (8 cases) had convulsions with the march of spasm, the others (9 cases) did not have the march of spasm. In the majority of cases having the march of spasm (6 cases out of 8), the spasm began in the hind limb on the same side of stimulation and the march of spasm was a complete one.

d) Stimulation of the vermis cerebellaris :

No convulsion occurred by stimulation upon the vermis cerebellaris (culmen, declive, pyramis and uvula).

e) Stimulation of the cerebellar nuclei :

When the cerebellar nuclei (nucleus dentatus, nucleus interpositus and nucleus fastigii) were stimulated, the majority of cases had no convulsion, but when nucleus dentatus was stimulated, only 2 cases out of 20 had convulsions.

2. March of spasm by stimulating the cerebellar cortex after the removal of the thalamus.

a) Stimulating the lobus lunatus anterior after the removal of the thalamus of the same side :

In 9 cases out of 12, spasm began in the fore limb of the side of removal and the march of spasm was seen mainly on the side of removal. No march of spasm was seen on the opposite side of the removal. In 3 cases out of 12 convulsions started at the same time on the whole body.

b) Stimulating the lobus lunatus inferior, after removing the thalamus of the same side :

In 5 cases out of 7, spasm began in the hind limb of the side of removal and the march of spasm was seen on the side of removal. But no march of spasm was seen on the side opposite to the removal. In 2 cases out of 7, convulsions started at the same time on the whole body.

c) Stimulating the lobus lunatus anterior after removing the thalamus on the opposite side :

In the majority of cases (10cases out of 15) convulsion started at the same time on the whole body. In a few cases (5 cases out of 15) spasm began in the fore or hind limb of the same side of removal of the thalamus and no march of spasm was seen on the opposite side to the removal.

d) Stimulating the lobus lunatus inferior after removing the thalamus on the opposite side :

In the majority of cases (5 cases out of 7) convulsion started at the same time on the whole body. In a few cases (2 cases out of 7) spasm began in the hind limb of the side where thalamus was removed and no march of spasm was seen on the opposite side.

e) Stimulating the lobus lunatus anterior and inferior of one side after removing both thalami :

No convulsion occurred by stimulating the cerebellar hemisphere (lobus lunatus anterior and inferior) after the removal of the both thalami.

3. March of spasm by stimulating the cerebellar cortex after the removal of nucleus caudatus.

a) Stimulating the lobus lunatus anterior after removing nucleus caudatus on the same side :

In the majority of cases (8 cases out of 10) convulsions having the march of spasm were seen. Spasm began mainly in the fore limb of the side of removal. The march of spasm was mainly a complete one.

b) Stimulating the lobus lunatus inferior after removing nucleus caudatus on the same side :

The march of spasm were seen in the majority of cases (8 cases out of 10) with convulsions. In about a half of the cases having the march of spasm, spasm began in the hind limb of the side of removal and the march of spasm was mainly a complete one.

c) Stimulating the lobus lunatus anterior after removing the opposite nucleus caudatus :

Convulsions with the march of spasm were seen in 5 cases out of 10. In 3 cases out of 5 having the march of spasm they were complete march and spasm began in the fore limb or the hind limb of the side of the removal.

In 5 cases out of 10, convulsions started at the same time on the whole body.

d) Stimulating the lobus lunatus inferior after the removal of the opposite nucleus caudatus :

In 5 cases out of 10, convulsions having the march of spasm were seen and in the others (5 cases out of 10) convulsions began at the same time on the whole body. In 3 cases out of 5 having the march of spasm, the march was complete.

4. March of spasm by stimulation of the cerebellar cortex after the removal of nucleus lenticularis.

a) Stimulating lobus lunatus anterior after removing nucleus lenticularis on the same side :

Convulsions with the march of spasm were seen in the majority of cases (8 cases out of 10) and in a few cases (2 cases out of 10) convulsion occurred at the same time on the whole body. In 8 cases having the march of spasm, spasm began in the fore limb of the side of removal and was limited to that side.

b) Stimulating lobus lunatus inferior after removing nucleus lenticularis on the same side :

In the majority of cases (7 cases out of 9) convulsion with the march of spasm was seen. A few cases (2 cases out of 9) convulsion occurred at the same time on the whole body. In 4 cases out of 7 having the march of spasm, spasm began in the hind limb of the side of removal. In a few cases (2 cases out of 7) spasm began in the fore limb of the side of removal. The march of spasm was limited to that side of its removal.

c) Stimulating lobus lunatus anterior after the removal of the opposite nucleus lenticularis :

In 6 cases out of 10, convulsion occurred at the same time on the whole body and convulsion having the march of spasm was seen in 4 cases out of 10. In the majority of cases having the march of spasm (3 cases out of 4), spasm began in the fore limb on the same side of the removal of nucleus lenticularis and the march of spasm was seen on the same side, but no march of spasm was seen on the opposite side.

d) Stimulating lobus lunatus inferior after the removal of the opposite nucleus lenticularis :

In 6 cases out of 10, convulsions occurred at the same time on the whole body and convulsion having the march of spasm was seen in 4 cases out of 10. In 2 cases out of 4 having the march of spasm, spasm began in the hind limb of the same side of the removal. In one case out of the 4 having the march of spasm, spasm began in the fore limb of the side of removal. The march of spasm was limited to the side of removal.

e) Stimulating lobus lunatus anterior and inferior of one side after the removal of both nucleus lenticularis :

In the majority of cases no convulsion occurred by stimulating lobus lunatus anterior and inferior after the removal of both nucleus lenticularis. In only one case out of 20, convulsions occurred at the same time on the whole body.

5. March of spasm by stimulating the cerebellar cortex after transecting corpus callosum, between both thalami and brachium conjunctivum.

a) Stimulating lobus lunatus anterior and inferior of one side after transecting corpus callosum :

When lobus lunatus anterior was stimulated, convulsions with the march of spasm were seen in 7 cases out of 13. Spasm started mainly in the fore limb of the same side of stimulation and the march of spasm was complete. In others (6 cases out of 13) convulsions occurred at the same time on the whole body.

When lobus lunatus inferior was stimulated, convulsions with the march of spasm were seen in 3 cases out of 6. Spasm started mainly in the hind limb of the side of stimulation and the march of spasm was a complete march. In the others (3 cases out of 6) convulsions occurred at the same time on the whole body.

b) Stimulating lobus lunatus anterior and inferior of one side after transecting between both thalami :

When lobus lunatus anterior was stimulated, convulsion with the march of spasm was seen in the majority of cases (10 cases out of 13) and spasm began mainly in the fore limb of the same side of the stimulation. When lobus lunatus inferior was stimulated, convulsion with the march of spasm was seen in the majority of cases (7 cases out of 9) and spasm began in the fore limb or hind limb of the side of stimulation.

c) Stimulating the opposite lobus lunatus anterior and inferior after transecting one of the brachium conjunctivum :

When lobus lunatus anterior was stimulated, convulsions with the march of spasm occurred in all 7 cases. Spasm began mainly in the fore limb of the opposite side of transecting branchium conjunctivum and the march of spasm was a complete march. When lobus lunatus inferior was stimulated, convulsions with the march of spasm occurred in all 6 cases. Spasm began mainly in the hind limb or incidently in the fore limb of the opposite side of transecting brachium conjunctivum and the march of spasm was a complete march.

d) Stimulation on the lobus lunatus anterior and inferior after the transection of the homolateral brachium conjunctivum :

When lobus lunatus anterior was stimulated, convulsions with the march of spasm occurred in all 8 cases. Spasm began in the fore or hind limb of the opposite side of transecting brachium conjunctivum and the march of spasm was a complete march.

When lobus lunatus inferior was stimulated, convulsions with the march of spasm occurred in all 6 cases. Spasm began mainly in the hind limb of the opposite side of transecting the brachium and the march of spasm was a complete march.

e) Stimulating lobus lunatus anterior and lobus lunatus inferior after transecting the opposite brachium conjunctivum and between both thalami:

When lobus lunatus anterior was stimulated, spasm began in the fore limb of the opposite side of transecting brachium conjunctivum (in all 7 cases). The march of spasm was seen on the opposite side of transecting brachium conjunctivum and no march of spasm was seen on the same side. When lobus lunatus inferior was stimulated, spasm began in the hind limb of the opposite side of transecting brachium conjunctivum (in all 6 cases). The march of spasm was seen on the opposite side of transecting brachium conjunctivum and no march of spasm was seen on the same side.

f) Stimulating lobus lunatus anterior and inferior after transecting brachium conjunctivum of the same side and between both thalami :

In this case, convulsion without the march of spasm was seen in the majority of cases (10 cases out of 12).

6. March of spasm by stimulation of the cerebellar cortex after the removal of the motor cortex.

a) Stimulating lobus lunatus anterior after removing the motor cortex of the same side :

In the majority of cases (7 cases out of 8) spasm began in the fore limb of the removal of the motor cortex and the march of spasm was seen on the same side of the removal of the motor cortex, but no march of spasm was seen on the opposite side.

b) Stimulating lobus lunatus inferior after the removal of the motor cortex of the same side :

In this case, spasm began in the fore limb (in 3 cases out of 6) or in the hind limb (in 2 cases out of 6) of the same side of the removal of the motor cortex and the march of spasm was seen on the same side of the removal of the motor cortex, but no march of spasm was seen on the opposite side.

c) Stimulating lobus lunatus anterior after the removal of the opposite motor cortex :

In the majority of cases (5 cases out of 6) convulsion started at the same time on the whole body.

d) Stimulating lobus lunatus inferior after the removal of the opposite motor cortex :

In the majority of cases (6 cases out of 7) convulsion started at the same time on the whole body.

e) Stimulation of one side of the lobus lunatus anterior and inferior after the removal of both motor cortex :

In all cases convulsions started at the same time on the whole body.

SUMMARY AND DISCUSSION

In case of stimulation of the cerebellar cortex by metrazol, when the cerebellar hemisphere (lobus lunatus anterior, lobus lunatus inferior and lobus semilunaris) was stimulated, epileptic convulsion occurred, but no convulsion occurred upon stimulation of the vermis cerebellaris (culmen, declive, pyramis and uvula). It is believed that this is due to the functional and anatomical difference between the cerebellar hemisphere and the vermis cerebellaris. The cerebellum has been divided into the two parts, that is to say, neo-cerebellum which is a new part, and paleo-cerebellum which is an old part from the genetic point of view, since EDINGER[17], LARSELL[18], DOW[19], HIRAZAWA[20] and many other scholars. The cerebellar hemisphere belongs to the neo-cerebellum and the vermis to the paleo-cerebellum. In general, the fibers from the neo-cerebellum going to the midbrain pass through the nucleus dentatus, and the fibers from the paleo-cerebellum going to the medulla oblongata pass through the nucleus fastigii. When the cerebellar nuclei (nucleus dentatus, nucleus interpositus and nucleus fastigii) were stimulated, convulsion did not occur in the majority of cases. In the case of stimulation of the nucleus dentatus, convulsion occurred in 2 cases out of 20. Considering that the fibers from the cerebellar hemisphere pass through the nucleus dentatus, if the nucleus dentatus is stimulated, convulsion should occur, but as a matter of fact, it is very difficult to initiate convulsion by stimulation of the nucleus dentatus. This reason is unknown, but it is considered that the threshold value of chemical stimulation of the nucleus dentatus is high. Excitability of the cerebellar nuclei in monkey was investigated by SACHS and FINCHER[21], MAGOUN[22], HARE and RANSON[23] with electrodes. From these studies, it is evident that excitability of the nucleus dentatus is high, but when it is stimulated vigorously, movement of stretching and bending occurs in the fore limb and hind limb of the same side of stimulation.

Convulsions occurred in all of the 68 cases which were stimulated on the cerebellar hemisphere. In 35 cases out of 68, convulsion having the march of spasm occurred and in 33 cases out of 68, convulsion started at the same time on the whole body.

Convulsion with march of spasm was seen in all of the cases which were stimulated on the motor cortex or subcortical nuclei by JINNAI, YOSHIDA, SOUJI and KOSAKA[14].

In case of stimulation of the cerebellar cortex, the number of cases in which the march of spasm was observed were quite the same as that of cases in which convulsion occurred at the same time on the whole body.

But when the cerebellar hemisphere was stimulated after transecting one side of the brachium conjunctivum, convulsion with the march of spasm was seen in all cases and spasm began in the fore limb or hind limb of the opposite side. This is a very interesting result of the experiment and it is considered that there is connection of the fibers between both cerebellar hemispheres. There are two pathways of the impulses when the cerebellar hemisphere is stimulated. One of the pathways is to go to the thalamus of the opposite side, passing through the brachium conjunctivum of the same side of stimulation; another one is to go to the other side of the cerebellar hemisphere by these connecting fibers and to go to the thalamus of the same side as stimulated passing through the brachium conjunctivum of the opposite side. When one side of the cerebellar hemisphere is stimulated, the impulses passing through these two pathways, pile upon one another and march is disordered or abolished. In case of transecting one side of the brachium conjunctivum, the march of spasm is observed in all cases, because the pathways going to the thalamus become one. In case of stimulating the lobus lunatus anterior, in 12 cases out of 14, spasm began in the fore limb of the same side of stimulation. On stimulating lobus lunatus inferior, in 8 cases out of 13, spasm began in the hind limb of the same side of stimulation and in 3 cases out of 13, spasm began in the fore limb of the same side of stimulation. In case of stimulating lobus semilunaris, spasm began in the hind limb of the same side of stimulation in 7 cases out of 8.

The relationship between the place of stimulation and that of beginning of spasm is to be described. The problem of the functional localization of the cerebellum was investigated by BOLK[15] first. He designated the foundational figure of the cerebellar cortex from the results compared with many mammals and proposed the localization of the motor representation. That is, vermis cerebellaris controls the cooperative movement which is made by cooperation of both sides of the body, and the cerebellar hemisphere manages the movement which each half of body is able to do independently. He also stated that lobus lunatus anterior is the representation of the head; lobus simplex, of the neck; lobus paramedianus, of the trunk; lobus ansiformis (crus I), of the fore limb; and lobus ansiformis (crus II), of the hind limb.

Later, BOLK's[15] theory was examined by many scholars (Van RIJINBERK[24], ROTHMANN[25], ANDRÉ-THOMAS and DURUPT[26], INGVAR[27], TEN CATE[28], ADRIAN[29], NULSEN[30], SNIDER and STOWELL[31], HAMPSON[32] etc.). They affirmed that BOLK's[15] theory was generally correct. But in detail their opinions do not always agree with his.

There are some scholars who oppose BOLK's[15] theory (LUCIANI[6], SHERRINGTON[7], HOLMES[33] etc.).

To sum up, the localization of cerebellar function, that is, the representation of motor function, is not clarified at present, so that the opinions of many scholars do not necessarily agree with each other completely. But if the localization of cerebellar function exists so that many scholars recognize its existence, it is easy to understand that spasm begins in the part of the body corresponding to the part of the representation which is stimulated, the same as in case of stimulation of the cerebral motor cortex.

Relative to the localization of cerebellar function, according to the results of our experimental studies, the lobus lunatus anterior (crus I) is the representation of the fore limb and the lobus lunatus inferior (crus II) is probably that of the hind limb. These results agree with BOLK's[15] theory. The lobus semilunaris seems to be the representation of the hind limb, too. This fact does not agree with BOLK's[15] theory, but does with TEN CATE's[28].

The type of the march of spasm of the cerebellar epileptic convulsion is mainly of the march spreading to the other side from one side of the hind limb to the other side of the hind limb. This type of march was observed in 28 cases out of 35. The type of march spreading to the other side through the fore limb was seen in 5 cases out of 35.

CLARK[8], WARD, PAYEN and COWDEN[9] classified the types of march of spasm into the following three groups; "C" type, "S" type and "U" type. They found "S" type in the majority of cases when the cerebellum was stimulated. The "S" type is the march spreading in the order, from the fore limb of the same side of stimulation → the fore limb of the op posite side of stimulation → the hind limb of the same side of stimulation → the hind limb of the opposite side of stimulation. But convulsion which they initiated by stimulation of the cerebellum is slow seizure just like action seen in slow motion pictures. It is considered that the epileptic convulsion which occurred by chemical stimulation in our experimantal studies, is different in nature from the slow seizure which they caused by electrical stimulation.

When the cerebellar hemisphere is stimulated after transecting the corpus callosum, there is almost no difference from the case of simple stimulation of the cerebellar hemisphere.

When the cerebellar hemisphere was stimulated after transecting between both sides of the thalamus, spasm started in the fore limb or the hind limb of the same side of stimulation in the majority of cases.

When the opposite side of the cerebellar hemisphere was stimulated after transecting one side of the brachium conjunctivum and transecting between both sides of thalamus, spasm began in the fore limb or hind limb of the opposite side of the transected brachium conjunetivum and no march of spasm was seen on the same side of the transected brachium conjunctivum. From these results, the march of spasm of the cerebellar epileptic convulsion spread from one side of the body to the other side, passing through the communication between both thalamus and both cerebellar hemispheres.

From the experimental studies of the removal of the motor cortex, it is easy to understand that there is close relationship between the cerebellar cortex and cerebral cortex. That is, when the cerebellar hemisphere of the same side was stimulated after the removal of the motor cortex, no march of spasm was seen on the opposite side of the removal, but march of spasm appeared on the same side of the removal. When the contralateral cerebellar hemisphere was stimulated after the removal of the motor cortex, convulsions started at the same time on the whole body without march of spasm in the majority of the cases. No march of spasm occurred after the removal of both motor cortex, but convulsion started at the same time on the whole body. From these facts, in case of cerebellar epileptic convulsion, the motor cortex is necessary in order for convulsion to occur with the march of spasm.

There are some studies about the relationship between the cerebral cortex and the cerebellar cortex (ROSSI[34], WALKER[35], ADRIAN[29], MAGOUN[22], MASUDA[36] etc.). TOMINAGA[37] and we proposed that the impulse occurring by stimulation of the subcortical nuclei returned to the cerebral cortex once and spread according to the arrangement of the motor representation. From the results of our experimental studies of the removal of cerebral cortex, in which the cerebellum likewise was stimulated, it was considered that the impulse reached at the cerebral cortex once. In this case, the impulse of the epileptic convulsion is conducted through the extrapyramidal tracts which pass through cerebellum → brachium conjunctivum → thalamus → nucleus caudatus → nucleus lenticularis → substantia nigra. The initiation of the march of spasm is performed by the impulse which comes from the thalamus to the motor cortex and its impulses pass through the pyramidal tracts.

When one side of the thalamus or nucleus lenticularis was removed, no march of spasm was seen on the opposite side of the removal. The march of spasm is absent on the opposite side of the removal of the thalamus, because the impulse which goes to the motor cortex is intercepted by removing the thalamus. When one side of nucleus lenticularis was removed the result of the experiment was almost the same when the thalamus was removed. The reason for this is unknown.

After the removal of both thalami or nuclei lenticulares, no convulsion occurred by stimulating the cerebellar hemisphere. The removal of these nuclei seems to have intercepted the pathway. We stated the pathway of convulsion is the extrapyramidal tracts (cerebral cortex → thalamus → nucleus caudatus → nucleus lenticularis → substantia nigra) and also recognized the fact stated by FULTON[38] that there were the reverberating circuits as the connection between motor cortex and thalamus or motor cortex and nucleus lenticularis.

Now there arises a question. When the cerebellar hemisphere of the opposite side was stimulated after the removal of one side of the motor cortex, thalamus, nucleus caudatus and nucleus lenticularis, convulsion without having the march of spasm was seen in the majority of cases. We cannot find out the answer to explain this phenomenon.

Our experimental studies that have been discussed so far are summed up and shown diagrammatically in Figure 3. The impulses resulting

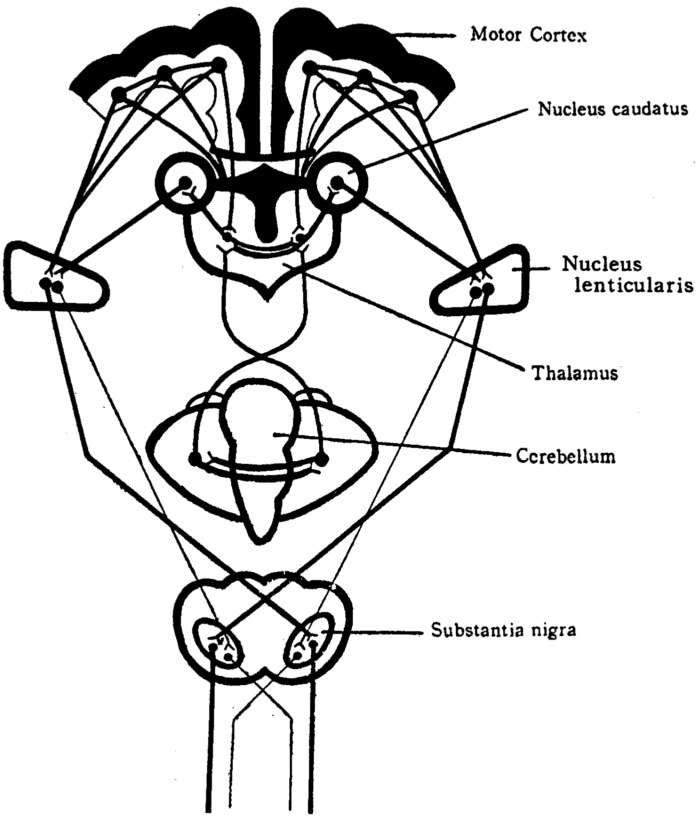

Fig. 3. Conduction Pathway of the Convulsive Impulses

from stimulation of the cerebellar hemisphere go to the thalamus of the opposite side of stimulation passing through the brachium conjunctivum of the same side of stimulation. On the other hand, the impulses go to the other side of the cerebellar hemisphere by the commissural fibers and reach the thalamus on the side of stimulation, passing through the brachium conjunctivum on the side opposite to stimulation. We understand that the impulse from the thalamus conducts the pathway that was described by JINNAI, YOSHIDA, SOUJI and KOSAKA[14] (thalamus → nucleus caudatus → nucleus lenticularis → the opposite side of substantia nigra chiefly, or the same side of substantia nigra partially).

CONCLUSIONS

1) Cerebellar convulsion was identical with the cerebral cortical epileptic convulsion and the number of cases in which the march of spasm was observed were quite the same as that of cases in which convulsion occurred at the same time on the whole body.

2) No convulsion occurred by stimulation of the vermis cerebellaris and also convulsions occurred very rarely by that of the cerebellar nuclei.

3) In cases having the march of spasm caused by stimulation of the lobus lunatus anterior, spasm began in the fore limb, while by stimulation of the lobus lunatus inferior and lobus semilunaris spasm started mainly in the hind limb on the side of stimulation.

4) In the case of stimulation of cerebellum, the pathway of the impulse to the opposite side was considered to be the communication between both cerebellar hemispheres and both thalami and thus the march of spasm spread from one side of the body to the other side.

5) No march of cerebellar epileptic convulsion occurred without the cerebral motor cortex.

6) After the removal of both sides of the cerebral motor cortex no march occurred, but the general convulsion occurred.

7) No convulsion occurred by stimulation of the cerebellar hemisphere after the removal of both thalami or both nuclei lenticulares.

8) The march of convulsion occurs by close cooperation of the pyramidal and extrapyramidal tracts. It seems that for the impulse of the convulsion the extrapyramidal tract plays an important rôle, while for the start of the convulsion, that is, march of spasm pyramidal tract plays the main rôle.

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