EXTRA-PYRAMIDAL MOTOR DISTURBANCES. A
REPORT OF A CASE WITH AUTOPSY. LENTICULO-RUBRO-CEREBELLO-OLIVARY
DEGENERATION*

By JOHN H. W. RHEIN, M.D.

PROFESSOR OF DISEASES OF THE MIND AND NERVOUS SYSTEM AT THE PHILADELPHIA POLYCLINIC AND COLLEGE FOR GRADUATES IN MEDICINE, NEUROLOGIST TO THE HOWARD HOSPITAL.

The following case is cited as illustrating some previously undescribed anatomical conditions which may be looked upon as the probable underlying pathological basis for the extra-pyramidal motor disturbances.

M. D., æt. 43, was admitted to the Philadelphia Home for Incurables April 7, 1913, the chief complaint being partial paralysis of the right arm and leg.

Family History.—Mother died of consumption at the age of 44. Father's whereabouts unknown. One brother died of consumption, one sister of croup at the age of 1 year, and one sister of diphtheria at the age of 8. Three brothers were living and well. One sister was living and well. None of patient's relatives has any condition similar to hers. One aunt died of a paralytic stroke.

Previous Medical History.—She had measles and chicken-pox when a little girl but had never been sick otherwise with exception of a sore on the leg.

H. P. I.—Up to age of eight or nine years the patient was well in every way. She played with the other children and went to school. At the age of nine years she had a convulsion. She was lying on a sofa when she suddenly called out with pain. She thinks her father told her that she had been acting queerly for a week or two previous. She does not remember whether she was unconscious or not. The left arm was paralyzed. She never recovered the use of her arm. She was not sure to what extent the face and leg were affected.

She was admitted to the Philadelphia Hospital on March 8,

* Read by title at the forty-first annual meeting of the American Neurological Association, May 6, 7, and 8, 1915.

From the Home for Incurables and the Laboratory of Neuropathology of the University of Pennsylvania.

1905, at which time her condition was as follows: Patient was small in stature and well nourished. The occipito-frontalis muscle was held in contraction most of the time causing the brow to be wrinkled. She could frown and open and shut her eyes well. Pupils were equal and reacted to light sluggishly and in accommodation. There was an opacity on the left cornea due to an old ulceration. The movements of the extra-ocular muscles were good. On attempted convergence the left eye diverged.

She could not close her lips completely because the upper jaw protruded and the upper lip receded from the teeth. The lower jaw was small and did not approximate with the upper. When the mouth was closed the front teeth on the lower jaw were about half an inch posterior to the front teeth on the upper jaw. The tongue was protruded in the median line when the mouth was opened. When the patient talked she opened the mouth widely and "mouthed" her words. Her speech was difficult to understand. Her articulation was poor especially for labials. Her mentality was good.

Muscular power in the right arm and both legs was good. In the left arm the power in the biceps and triceps was fair. The left forearm was held in a position of semi-flexion on the arm. The wrist was flexed on the forearm. The third, fourth and fifth fingers were greatly flexed; the tips lying on the thenar eminence. The forefinger and thumb were also flexed so that the tip of the thumb touched the end of the forefinger. The muscles of the left forearm and hand were contracted. The fingers and hand on the left side were small as if they had not developed. The forearm could be fully flexed on the arm but could not be fully extended because of the contracture of the biceps tendon. Motion of the left shoulder was slightly restricted in all directions but this was not very marked. The fingers and wrist on the left could be moved only slightly. The left foot was held in position of talipes equinus.

The great toe was held markedly extended while the other toes seemed to be flexed. The musculature of the leg was good.

Reflexes: The biceps jerk and triceps jerk on the right side were normal. On the left the triceps jerk was normal; the biceps jerk could not be elicited because of the contracture. The right knee jerk was quick and somewhat increased. The left knee jerk was increased but not as much as the right. Stroking either sole caused flexion of all the toes. Ankle clonus was not present.

When the patient attempted to move either member of the paralyzed side regular clonic contractions of the muscles developed. In the arm the biceps was sometimes involved, causing the forearm to move back and forth. More often the hand alone was involved. The fingers shook and the forefingers and thumb executed the pill-rolling movement seen in paralysis agitans.

When the leg was held up and the patient told to flex it at the knee the leg moved up and down. These involuntary movements were increased when the patient attempted to move the part. They were often but not always present when the member was still.

Coördination: In the right arm this was good. While lying in bed coördination with right leg was good. When the patient attempted to put the left heel to the right knee the movements described above commenced and made the act difficult. When the

FIG. 1. A, Degenerated left nucleus dentatus. B, Normal right nucleus dentatus. C, D, Degenerated olives.

patient stood with feet together with the eyes open or closed she fell backward. Her gait was not ataxic. In walking she kept the great toe on left side extended. She limped on right side. This was due to a painful leg ulcer, now almost healed, on the right leg. She had a scar of an old ulcer on the left leg. Sensation to touch and pain was normal.

The chest was well formed. No adventitious sounds were heard in the lungs or the heart. The liver and spleen were normal. The abdomen showed no abnormalities.

The examination a month before she died, May 3, 1914, at the Philadelphia Home for Incurables resulted as follows: The lower jaw was retracted, all of the upper teeth showing, and the mouth was held open. She could not entirely close the mouth on account of the retraction of the lower jaw. The tongue was protruded in the median line. The speech was somewhat indistinct and spastic. It was not noted whether there was any difficulty in swallowing.

There was a rhythmical contraction of the masseter muscles and also the muscles about the mouth. There was no facial paralysis. The pupils were equal and reacted to light and in accommodation.

The left arm was in a state of contracture. The forearm was flexed upon the arm, the hand flexed upon the forearm with the fingers partially flexed. The left leg was held in an extended position, the foot in talipes equinus position, there being contracture of the tendo Achillis. There was some rigidity also at the knee joint. The big toe was hyperextended.

The right arm and leg were moved freely and showed no spasticity or contractures.

There was present a tremor in the left arm. In the hand the tremor was characteristic of the pill-rolling tremor of paralysis agitans. It was rhythmical and it temporarily disappeared when the fingers were extended by the examiner. There was a constant to and fro tremor of the left foot which was also temporarily quieted by extension of the foot.

Measurements of the arms and legs on both sides showed a moderate degree of atrophy of the arms, forearm, thigh and calf on the left side. The circumference of the upper arm on the right side was 18½ cm., on the left side 16 cm. The circumference of the right forearm was 19½ cm., the left side 19 cm. The circumference of the right thigh was 38 cm., of the left 35 cm. The circumference of the right calf was 29 cm., of the left calf 27 cm.

The knee jerks were increased on both sides but more so on the left. There was neither ankle clonus nor Babinski on either side. The biceps jerk on the left was increased in the arm, on the right side was present but not exaggerated. She was able to walk with a hemiplegic gait until general weakness from a malignant growth in the pelvis sent her to bed a month before her death.

At the autopsy a large mass occupied the pelvis involving the uterus, rectum and intestines. The tumor appeared to be a cancer. The brain and spinal cord were hardened in formaline and the basal ganglia, pons and medulla oblongata were cut in serial sections. Sections were also made from the paracentral regions and the spinal cord.

On section the brain showed no gross lesion except in the lower portion of the lenticular nucleus on the right side—which was the seat of space formation. The area was small and occupied the posterior portion of the inferior levels of the putamen.

At a level corresponding to Fig. No. 230 in Dejerine the red nucleus was normal on the left side. The lenticular nucleus, the internal capsule, the anterior pillars of the trigone and the anterior commissure appeared to be normal. On the right side the red nucleus was ill-defined and approximately $\frac{1}{3}$ to $\frac{1}{2}$ smaller than the left red nucleus. Microscopically there was partial de-

FIG. 2. A, Normal right nucleus dentatus. B, Atrophied left nucleus dentatus.

generation of the fibers. The ansa lenticularis stained less well on the right side. On the outer side of this, a small tract of degeneration could be traced as far as the capsule of the red nucleus. The right retro-lenticular segment of the internal capsule stained less well than on the left side. The fibers which surrounded the red nucleus stained poorly especially on the inner surface. The left corpus Luysii was a little smaller than on the right side.

A little lower several lacunæ were observed in both lenticular nuclei but otherwise nothing abnormal was observed in the basal ganglia. The thalamostriate fibers stained well on both sides.

The ansa lenticularis on the right side stained better than in the section above but still less well than on the left side. The right red nucleus was smaller than the left, and the fibers around it still stained poorly. The caudate nucleus was normal and the anterior commissure stained normally.

Still lower on the right side numerous lacunæ were observed in the first and second divisions of the lenticular nucleus, these consisted of perivascular spaces but they did not give rise to any degeneration of the neighboring fibers.

In the section corresponding to No. 231 in Dejerine, the ansa lenticularis stained poorly still. The right red nucleus was still smaller than the left. There was nothing abnormal otherwise.

In the section still lower on the right side the internal and external layers of the lenticular nucleus stained poorly and were very vascular. The space formation was quite apparent on both sides but only on the right side was the staining poor.

At a level still lower the third segment of the lenticular nucleus on the right side was much smaller than on the opposite side and presented in its posterior aspect, space formation. Under the microscope this consisted of perivascular distention in which were several blood vessels and also space formation. In these spaces there were contained some compound granular cells and these were present also in the adjoining tissue and in the walls of the cavity. There was some blood pigment observed in the spaces. There were also several blood vessels. In places by the Weigert stain were observed some degenerated fibers. This area was situated just externally to the anterior commissure.

At the lowest level this area in the lenticular nucleus appeared to be smaller in extent and was still limited to the posterior portion of the third division of the lenticular nucleus. It was only present on the right side and began first to be observed at the level corresponding to where the second nerve begins to make its appearance in horizontal sections.

Cerebellum: The left dentate nucleus was much smaller than the right and microscopically showed great diminution of fibers. On the right side the dentate nucleus stained well. In the medulla oblongata the right olive was completely degenerated in this section. There was some degeneration also in the left olive but much less than on the right side. The left restiform body was much smaller than the right.

The left dentate nucleus measured 7 mm. in length and the right measured 12 mm. in length. The left dentate nucleus was much smaller therefore. Under the microscope there was an absence or diminution of nerve cells and the fibers within the nucleus were very sparse. The atrophy however was apparent at all levels. Higher up the atrophy was less apparent but there still the nerve cells were fewer and the fibers not so numerous as on the opposite side.

The nucleus emboliformis was about equal in size on both sides. The corpus justa-restiforme stained less well on the left side than on the right. The internal semicircular fibers were atrophied or took the stain poorly on the left side. The left median lemniscus was a little larger than the right.

The pyramids were normal in size in the pons. The fasciculus longitudinalis posterior stained well on both sides but was smaller on the right side. The superior cerebellar peduncle stained less well on the left side and was smaller than on the right. The tegmentum was degenerated on the right side.

FIG. 3. A, Normal left nucleus ruber. B, Atrophied and degenerated right nucleus ruber. C, Normal tract to be compared with corresponding area on opposite side. D, Degenerated tract going to nucleus ruber and connecting with degeneration of ansa lenticularis.

At a lower level the right olive showed an entire absence of fibers. There was also some degeneration in the inferior part of the left olive. Both pyramids stained well. The left restiform body was still smaller than the right.

At a level higher up, the left dentate nucleus stained with difficulty especially the fibers around it, mainly externally, and internally to a less degree. This was in marked contrast to the right side which stained in a sharp cut manner. These fibers it will be remembered connect with the opposite lower olive and are termed "Vlies." The cortex of the cerebellum showed intact Purkinje cells and in normal numbers.

The nucleus tecti appeared to be equal in size on each side.

At a little higher level the superior cerebellar peduncle was smaller on the left than on the right. The right red nucleus was still much smaller than the left. The median lemniscus was of the same size on the two sides.

At a still higher level the superior cerebellar peduncle before its transition into the red nucleus was still much smaller on the right side.

In the left paracentral region the several layers of cells stained well. In the right paracentral region some of the cells showed yellow pigmentation. The Betz cells stained normally. The other cells could be defined clearly and stained well. The same findings were observed in the right paracentral region.

The pia was somewhat thickened but nowhere can be seen any round-cell infiltration.

The spinal cord at all levels stained well and showed no degeneration in any of the tracts. The cells in the anterior horns stained by Nissl method showed in places increase in yellow pigment but otherwise no noteworthy change was observed.

In the thoracic region the same condition obtained but some cells in the left anterior horn were atrophied, taking the stain poorly.

In the lumbar region the cells of the anterior horn showed some degeneration consisting of atrophy of the pigment, displacement of the nuclei and swelling of the cell body.

The pia of the cord was somewhat thickened but presented no evidence of round-cell infiltration at any levels.

There was a small area of intense degeneration in the left optic thalamus.

RÉSUMÉ

The patient, a woman of 43, became paralytic in the left arm and leg at the age of eight and remained in this condition until the time of her death.

Symptoms at the time of death consisted of paresis of the left arm and leg, contracture of the Achilles tendon and spasticity of the knee joint, contractures at the shoulder joint, flexor contractures of the left elbow and wrist, retraction of the lower jaw, indistinct and spastic speech, moderately fine, rhythmical tremor in the left arm and leg and tremor of the jaw; increased knee jerk more on left without Babinski phenomenon or clonus. The right side was unaffected.

Pathologically there was a lesion of the right putamen in its inferior and posterior portion; degeneration of the right ansa

lenticularis, right red nucleus, left superior cerebellar peduncle and left dentate nucleus. The left inferior olive was totally degenerated, the right to a slight degree and the right corpus restiforme was smaller than the left.

This case, I believe, shows what has already been described but not histologically proved, viz., an anatomical connection between the dentate nucleus through the superior cerebellar peduncle with the contralateral red nucleus.

Our present knowledge of the anatomy of these tracts and centers is as follows: From the red nucleus it is well known that fibers go to the optic thalamus. From the red nucleus there is a descending tract leading down to the anterior horns, the fasciculus rubrospinalis.

Jacob (1) stated that the red nucleus was a motor organ for the transmission of direct cerebellar impulses and perhaps also for those coming from the lenticular nucleus by way of the lenticular loop to the red nucleus, but added that the histology of this tract had not yet been demonstrated.

Fibers go from the lower olive to the contralateral restiform body and some to the restiform body of the same side. Some fibers go to the raphe. The fibers of the restiform body pass lateral to the spinal fifth root. Mingazini has described these fibers as the retro-trigeminal and inter-trigeminal cerebello-olivary fibers.

From the olive, fibers go to the cerebellum on the opposite side and to the same side. Some go to the central tegmental tract of Bechterew. Obersteiner (2) believes that in this tract there is a direct connection between the basal ganglia (perhaps the lenticular nucleus) and the lower olive. Fibers in the spinal portion of the restiform body go to the vermis, while in the olivary portion are found chiefly fibers which surround the corpus dentatum, known as the "Vlies."

The possibility of a connection between the lenticular nucleus and the rubro-cerebellar tracts has therefore been a matter of discussion—though this has not to my knowledge been anatomically proved.

In my case there is evidence to show that there exists a connection between the lenticular nucleus by way of the ansa lenticularis with the red nucleus and opposite dentate nucleus. This case also demonstrates a tract connecting the dentate nucleus by

means of the vllies with the lower olive on the opposite side mainly and to a less extent on the same side.

These connections are, I believe, the underlying pathological basis for extrapyramidal motor disturbances. This case seems to be a clear-cut illustration of this view. For in my case there was clearly made out degeneration in the right putamen, ansa lenticularis, nucleus ruber and opposite superior cerebellar peduncle and dentate nucleus. Furthermore a degeneration could be traced in the fibers surrounding the dentate nucleus of the restiform body and in the olives.

In the cases in which the lenticular nucleus alone or the lenticular nucleus and the ansa lenticularis are implicated as in Wilson's (3) cases, there is a break in the chain of connections from the lenticular nucleus to the dentate nucleus by way of the red nucleus and from the dentate nucleus to the lower olives and hence the symptoms are anatomically explained. This tract is located probably in the lower part of the putamen, as in my case, which may explain why all lesions of the lenticular nucleus do not give the same symptom complex.

This case is unique at least pathologically. Clinically the left-sided paresis with tremor, the retracted jaw, the dysarthria, the contractures, the rigidity present symptoms in the nature of a unilateral lenticular degeneration. Wilson's cases are bilateral however, and differ further from my cases in the duration of the disease and slowness of onset, and pathologically, in the absence of degeneration of the red nucleus, superior cerebellar peduncle, dentate nucleus and olives.

There have been for a number of years cases reported in the literature presenting symptoms of paresis of the extremities associated with spasticity, contractures, tremor, choreiform movements or athetosis without involvement of the pyramidal tracts. In other words there is a well-recognized group of cases presenting disorders of motion which are extra-pyramidal in origin. In cases of this character the symptoms may be confined to one side or may be bilateral. The cases illustrating the first type are those described by Marie and Guillain (4), Landouzy (5), Demange (6), Eisenlohr (7), Halben and Infeldt (8) and myself (9) (in a previous communication) and in the case described in this paper. The bilateral type has been elaborately described by Wilson comparatively recently under the title of "Progressive Lenticular

Degeneration." The latter cases in which autopsy has been made are not numerous.

In the former the pathology consists of a lesion of the lenticular nucleus as in cases of Landouzy (one-sided lenticular lesion without pyramidal tract involvement), Demange (bilateral lenticular hemorrhage) and Eisenlohr (bilateral lenticular disease). In the cases of Halben and Infeldt and Marie and Guilain the red nucleus was degenerated and in my own case described in a former communication no lesion whatever was found.

The sites of the lesion in the cases giving rise to involuntary movements as illustrated in the study of the pathology of this group of cases are then the basal ganglia, the red nucleus, the superior cerebellar peduncle, the dentate nucleus and the lower olive. These can be looked upon as extra-pyramidal pathways and the explanation of the disturbances of motion can be looked for in these localities.

Wilson believes that responsible for these disturbances of motion is necessary a destructive lesion which removes the normal inhibiting or steadying influence which the corpus striatum exercises over the cells of the anterior horn. As the result of this he states in these cells this inhibition is impaired and the more the pyramidal path becomes innervated the more apparent is the tremor. An intact pyramidal tract is therefore necessary. He further states that the absence of this inhibitory quality of the lenticular nucleus may be felt by way of the strio-thalamic fibers or the external part of the optic thalamus and thus by way also of the intermedio-precentral and precentral cortex. Thus, a double action of the corpus striatum on pyramidal innervation may be brought about. In his cases there was no definite lesion found in the cerebello-rubro-thalamo-cortical system. He however acknowledges a dynamic modification of the functions of the rubro-spinal system caused by a defect of the nervous influx from the lenticular nucleus. The removal of the lenticular inhibition allows the cortical motor cell to react in such a way that there is increased tonicity of the muscles reached by the pyramidal tract. The removal of the steadying (or inhibitory) influence on the anterior horn cell which is exerted by way of the red nucleus accounts, he thinks probable, for the tremor.

Wilson's theories, while satisfactory for his own cases, do not

explain tremors and hypertonicity in all the cases of extra-pyramidal motor disturbances at least anatomically.

The position recently taken by Dr. C. K. Mills (10) as explaining the occurrence of extra-pyramidal motor disturbances is supported by my findings. He states that the three essential qualities of motor innervation are energy, tone and synergy.

Tone is necessary for the rhythmetization, both of voluntary and involuntary movements, synergy in order that toned movements shall be grouped for the performance of acts which require special adjustments. Tone integrated in the striatum unites with cerebellar synergia through the intermediation of the cerebello-rubro-thalamo-cortical apparatus and the cerebro-rubro-spinal apparatus. If the cerebellar influence is withdrawn asynergic movements are the consequence. If the tonectic excitations from the striatum are withheld hypertonicity and involuntary movement result.

Mills believes therefore that tone belongs to the cerebral cortex, and that the cerebral tonectic apparatus has cortical areas of representation and chiefly mid-frontal. The corpus striatum, according to his view, is an association or integration region where the excitations from the different cortical tonectic zones are regrouped. He further believes that the cortical zone and the striatum are connected by association fibers. "The projection fibers, as has been shown, to pass through the frontal cortex to the striatum probably pass through the caudatum and pallidum on their way to the thalamus, subthalamus or ruber."

That morphologically the striatum is part of the cortex is generally accepted. (Wilson does not admit this.) The striate nuclei may be looked upon, he believes, as cortical regions closely related in function with the mid-frontal or mid-frontal and part of the pre-frontal cortex. Two motor projection systems must be recognized in order to explain the phenomena of movement in this relation to cortical activity. First of these is the pyramidal system, the second "must be postulated for the non-striated or smooth muscle system in so far as this is activated by cortical processes which result in the combination of skeletal and non-skeletal movements."

The observations of Wilson, he states, show a direct connection by way of the *ansa lenticularis* with the nucleus ruber. Mills's case seemed to indicate a similar connection and in addi-

tion one between the nucleus caudatus and the nucleus ruber. There is not improbable a reflex arc by way of this thalamo-strio-rubral path.

"In the facts presented in the study of the case here recorded in detail are some indications, at least, of a caudate syndrome as distinguished from that resulting from lesions confined to the lenticula. Very briefly stated this symptom complex included hypertonicity and tonectic paresis as exhibited especially in the phenomena of involuntary painful emotional expression and various symptoms referable to the cortico-autonomic nervous system, vasomotor and secretory affections, disturbances of temperature, pulse, respiration and of various forms of glandular activity. It will be recalled that the necropsy and microscopical examination showed that the right nucleus caudatus and the anterior limb of the right internal capsule had disappeared, while the head of the left nucleus caudatus, although much atrophied, did not show more than one half the destruction of its fellow on the right, and the anterior limb of the left internal capsule at higher levels was intact. Both the nucleus subthalamicus and nucleus ruber were about one third smaller on the right than on the left. This greater degeneration of the right nucleus subthalamicus and nucleus ruber may have been related to the complete destruction of the right nucleus caudatus and anterior capsule."

We still have cases where the lenticular lesion is absent or small as in my own case and where the chief pathological process is to be found in the rubro-cerebellar and cerebellar-olivary tracts, as in my own case and in the cases of Halben and Infeldt and Marie and Guillain. In Halben and Infeldt's case there was a left ophthalmoplegia, right hemiplegic muscular spasms, hemichorea and epilepsy with increased knee jerks and absent Babinski. The pyramidal tracts were intact and there was no lesion of the lenticula or its fibers. The red nucleus was destroyed, as well as Forel's Haubenfeld, the white nucleus and the median and ventral part of the Hauptschleife. The olive on the same side was smaller and the opposite dentate nucleus was reduced in size and the cells smaller and diminished in number and the vliies was paler.

Marie and Guillain in 1903 described an old lesion of the red nucleus in a patient who developed at the age of two, after con-

vulsions, a left hemiplegia. When examined at the age of thirty-six there was a left hemiplegia with arrested development of the left side of the face, trunk and limbs. There was also constant movements of flexion and extension of the fingers and thumb. The forearm was flexed upon the arm and the arm adducted and abducted upon the chest. The head was inclined to the left shoulder. There was some diminution in volume of the left side of the tongue. Sensation was intact. The right pupil did not react to light or accommodation and there was right divergent strabismus.

There was a lesion in the right red nucleus. The foot of the peduncle was normal. There was considerable atrophy of the left cerebellar peduncle which could be traced to the dentate nucleus. The posterior longitudinal bundle on the right side was also atrophied. The reticular substance was almost entirely absent. Although the foot of the peduncle was more intensely colored on the right than on the left there was no appearance of degeneration. There was an atrophy of the right olive. The fibers of the capsule of the olive and the cells were diminished, explaining the atrophy of the cerebellar olivary fibers. Helweg's tract did not seem to be degenerated. The hilus of the left dentate nucleus was very much atrophied. They could not find any degeneration of the tract of von Monokow. The lenticular and other basal ganglia were not mentioned in this report.

The contribution of Dejerine and Thomas (11) has a bearing upon this subject. They described in 1900 a disease which they called "atrophie olivo-ponto-cerebelleuse" and reported a case with autopsy and a clinical case. The case with autopsy was a woman of fifty-three who died at the end of two years and eight months after the onset of the disease, which consisted of disturbed equilibrium in standing and walking, jerky speech, an awkwardness in handling heavy objects, a tremor upon using a pen and oscillations of the eyeball when looking upwards. The knee jerks and arm jerks were increased, there was no Romberg sign, no paralysis nor sensory disturbances. There was atrophy en masse of the cerebellar cortex which was more marked in the hemisphere than in the vermis. There was also degeneration and disturbances of most of the afferent and efferent fibers of projection and atrophy of the principal nuclei of origin of the afferent fibers. The lower olive and pontine nuclei were atrophied. The dentate

nucleus was relatively well conserved. Fibers of the cerebellar peduncle stained well. Both medullary olives and the juxta-olivary nuclei were extremely atrophied in all their diameters, more marked on one side. The superior external segment of the internal arciform fibers were entirely atrophied. The middle cerebellar peduncle was totally degenerated and all the nuclei of the pons had disappeared. The trapezoid body and the superior olives and the lateral lemniscus were intact. The superior cerebellar peduncles were not degenerated. The red nuclei were very small but symmetrical. One cerebral peduncle was smaller than the other but colored well. There was very pronounced atrophy of the arciform fibers and the restiform body. The pyramidal tracts were intact. The cells of Purkinje had disappeared. This case is quoted because of its relation, although not very direct to the pathology of my case. It is similar however in this respect. The olives in my case were degenerated more on one side and there was degeneration of the opposite restiform body. In the cerebellum the lesion in Dejerine and Thomas's case consisted of a cortical atrophy, while in my case the lesion in the cerebellum was confined to one dentate nucleus. In my case the superior cerebellar peduncle was degenerated, also one red nucleus and the ansa lenticularis. In Dejerine and Thomas's case the lesion was bilateral. In my case the lesion was distinctly not symmetrically bilateral.

It seems to me that we must look upon the cerebellum as exerting a great influence upon the development of these symptoms. The cases of Guillain and Marie, Halben and Infeldt, the case described by Dejerine and Thomas as olivo-ponto-cerebellar-atrophy and my own case, would seem to me to indicate that the explanation of the phenomena must be closely related to disturbances of the cerebellar function. My own case would indicate that this disturbance of function is in connection also with the lenticular nucleus for it will be recalled that although the lesion was small the ansa lenticularis was in part degenerated on the same side. This was related to the atrophy of the red nucleus also on the same side and the superior cerebellar peduncle and dentate nucleus on the opposite side, also with the degenerated cerebello-olivary fibers connecting the right lower olive with the opposite dentate nucleus by way of the restiform body.

It would appear from this study that this case testifies in a

clear-cut manner to the views held by Dr. Mills and also anatomically demonstrates the connection between the lenticula and the rubro-cerebellar system.

It would seem apparent that an intact cortico-lenticulo-rubro-cerebello-olivary tract is essential to explain proper motor regulation. I believe that it would not be going too far to assume that any break in this chain whether it be cortical or elsewhere in this tract could give rise to spasticity, paresis, contractures, and tremor or other disturbances of motion characteristic of extra-pyramidal motor disturbances.

I am indebted to Prof. W. G. Spiller for his kind assistance in the study of the sections.

BIBLIOGRAPHY

1. Jacob. Das Menschenhirn. Eine Studie über d. Aufbau und die Bedeutung seiner grauen Körne u. Rinde, p. 25, Muenchen, 1911.
2. Obersteiner. Nervösen Centralorgane, 1901.
3. Wilson. Lancet, 1912, page 1115. Brain, March, 1912.
4. Marie and Guillain. Rev. Neurolog., 1903, p. 241.
5. Landouzy. Progres Méd., 1878, Vol. 6, p. 79.
6. Demangy. Revue de Médecin, No. 3, p. 371.
7. Eisenlohr. Archiv f. Psychiatrie, 1878, Vol. 9, p. 43, observation 9.
8. Halben and Infeldt. Arbeiten aus der Neurol. Institut, Obersteiner, 1902, p. 328.
9. Rhein and Potts. JOURNAL OF NERVOUS AND MENTAL DISEASE, December, 1907.
10. C. K. Mills. Neurologisches Centralblatt, 1914, No. 24.
11. Dejerine and Thomas. Nouvelle Iconographie de la Salpêtrière, No. 13, 1900, p. 1331.