CEREBELLAR SYMPTOMS AND CEREBELLAR LOCALIZATION

INCLUDING KINEMATOGRAPHIC OBSERVATIONS ON CEREBELLAR PHENOMENA *

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RECENT ADVANCES IN CEREBELLAR SYMPTOMATOLOGY

In recent years, and especially under the lead of Babinski and Rothmann, some features of the old cerebellar symptomatology have come to be looked on in a different light and some of the symptoms regarded as elementary have been subjected to considerable dissection. The so-called cerebellar ataxia, now regarded as a symptom complex rather than as a pure symptom, has been more clearly differentiated from the ataxia of tabetics. Luciani's astasia, asthenia and atonia are acquiring a new interpretation.

Our studies emphasize the fact that asynergy is the fundamental symptom of cerebellar disease.

Cerebellar tremor and the new symptoms, hypermetria and adiokokinesis, all now recognized as important cerebellar disorders, when reduced to their symptomatic elements, are seen to be dependent in large part if not entirely on loss or disturbance in the power of performing more or less complex movements together for the accomplishment of a definite end.

Luciani's asthenia, atonia and astasia are to be regarded not so much as special manifestations of asynergy as derivatives or resultants of asynergic effort. Asthenia is due to the exhaustion which results from efforts to perform movements which cannot be properly grouped and directed. Cerebellar atonia, which is very irregular in its expression, is a relaxation dependent on the fact that tonectic stimuli from the cerebral cortex cannot rhythmically combine with unsynergized movements. Primarily, tone is a cerebral, not a cerebellar attribute.

Attention may be fixed on the views just expressed by the following tabular statement:

Fundamental Symptom in Cerebellar Disease:

Asynergy.

Special Symptomatic Manifestations of Asynergy:

Hypermetria.

Adiokokinesis.

Tremor.

Symptoms Resulting from Asynergic Efforts:

Asthenia.

Atonia.

Ataxia.

Whether vertigo and nystagmus, which are so often present in disease of the cerebellum, are ever true cerebellar symptoms is a question which has been much discussed. From the time of Flourens' early experiments, physiologists and clinicians have concerned themselves with the relations between laby-

rinthine or vestibular nerve phenomena, and those dependent on pure cerebellar activity. Comparisons and parallels have been drawn and the extraordinary similarity in some instances and even the identity between the results of experiments on the vestibular nerve apparatus and the cerebellum have been shown by many competent investigators. The decision whether vertigo and nystagmus are cerebellar or vestibular symptoms must be largely determined by a thorough study of each case.

From the position of the cerebellum and its peduncles, the cranial nerves and particularly those from the fifth to the twelfth are frequently implicated in cerebellar affections, the complex resulting being compounded of true cerebellar symptoms and those referable to such of these nerves as may be involved. To this type of case Stewart and Holmes have given the name of "extracerebellar." The well-known and much-studied affections of the cerebellopontile angle belong in this category, although extracerebellar symptoms are not limited to the phenomena of lesions of this angle.

Besides the cranial nerves, the nuclei and the tracts of the neuraxis are not infrequently invaded in cerebellar lesions, and we have still another combination of symptoms, cerebelloneuraxial, which requires close scrutiny in the process of diagnosis.

The clinician is indebted to Babinski for the fixation of his attention on cerebellar asynergy. Ferrier, however, recognized the fact that synergic control was the particular rôle of the cerebellum. Discussing the mechanism of cerebellar coordination and the relative development of the cerebellum, he says:¹

Every form of active muscular exertion necessitates the simultaneous cooperation of an immense assemblage of synergic movements throughout the body to secure steadiness and maintain the general equilibrium; and on the hypothesis that the cerebellum is the center of these unconscious adjustments we would expect the cerebellum to be developed in proportion to the variety and complexity of the motor activities of which the animal is capable. The facts of comparative anatomy and development are entirely in harmony with this hypothesis.

Synergy or synergia is the power or faculty by which movements more or less complex, but functionally definite, are associated in a special act or acts. In a broad sense it is motor association, this association being carried out in movements of different parts of the same limb or in synchronous movements of the trunk and limbs, or of the head and trunk and limbs, etc.

Movements are mismeasured, giving dysmetria or hypermetria because the patient with cerebellar disease is unable motorially to associate the different elements of such movements. Adiokokinesis, as illustrated for example by the impossibility of correctly and rapidly pronating and supinating the hand on the forearm, is due fundamentally to the inability to carry out fine motor associations of an antagonistic kind.

The method usually employed in clinical study or class instruction of demonstrating hypermetria is the well-known finger-to-nose test; for adiokokinesis, partly flexing the forearm or forearms on the elbow and then rapidly pronating and supinating the hand, the movement being largely one from the wrist. Adiokokinesis and hypermetria are both demonstrated by the rapid pronation and supination of the hand on the

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¹ On account of lack of space this paper has been abbreviated for THE JOURNAL. It will appear in full in the Transactions of the Section and in the authors' reprints.

1. Ferrier, David: Functions of the Brain, Ed. 2, 1883, p. 200.

knee. Tremor is exemplified by the finger-to-nose test and by efforts to grasp an object or by writing. Hypermetry is shown by the finger which usually is able to touch the end of the nose overshooting to one side, or in the hand-knee test by the hand not keeping within the normal range of movement.

The phases of asynergy described as dysmetry or hypermetry are discoverable, however, in cerebellar cases in the abnormal attitude or movements of the head, in the bending of the trunk, in the abduction, sprawling, overstepping or understepping in walking, in the spreading of the limbs in standing and in much else that is done by the patient, and these dysmetric phenomena are frequently accompanied by tremor and adiadokocinesis, all of which are well defined in kinematographic observations.

KINEMATOGRAPHIC OBSERVATIONS

Our kinematographic investigations indicate the necessity of some revision of views both as regards the methods of describing and the intrinsic characteristics of cerebellar symptoms. Some new points in cerebellar symptomatology were elicited by these investigations.

The *gait* of a cerebellar patient in the majority of cases is chiefly trunkal. The trunk may go backward, or forward, forward and to one side, or simply to one side. The inclination may be total or partial. In every attempt on the part of the patient to walk, for example, the trunk from the first leans backward, forward or to one side, it being impossible for him to stand for any length of time in the erect posture. He may be able, however, for a short time to stand erect, or to walk either with the trunk erect or leaning, but even when this is possible he is likely soon to lurch forward or backward or to one side. In this type of case the movement of the trunk is predominant and forms the most impressive part of the picture, the legs seeming to act simply as props for the trunk. The trunk leads, and whatever way it goes, the legs follow. If, for example, the trunk leans forward and to the left, the swing of the left leg is shorter than that of the right, or if the trunk goes forward and to the right, the swing of the right leg is less than that of the left, the legs accommodating themselves to the movements of the trunk.

Our observations on pelvic girdle and shoulder girdle movements in locomotion, both when the patient is standing and when on all fours, are especially instructive. In some of the cases the asynergy is just as marked in the shoulder girdle as in the pelvic girdle. In those cases, however, in which the asynergy is more marked in the pelvic girdle, even if both girdles are affected, the gait is entirely different. Here the legs are held farther apart and the arms are nearly always held partly outstretched and semiflexed at the elbows. If the asynergy is shown alone in the pelvic girdle movements, the trunk assumes a different relation to the legs than in the cases just described. Here the trunk is held rigidly erect and the legs are pushed forward from the pelvis, giving the impression that the trunk goes after the legs. In the extreme pelvic girdle cases, it is impossible for the patient to walk without help, but when assisted, the trunk is very rigid, the legs being thrown out in almost any direction.

The cerebellar gait is often described as drunken or reeling, but from our observations, the gait is not like that of one who is drunk. A drunken man will

reel in any direction, but he does this largely because of his mental, that is, of his cerebral reduction. A slightly drunken man simply reels forward or to one side, while one who is very drunk is unable even to stand up and any attempt on his part to do so brings on a sort of crumpling of the whole body. In such attempts the legs give way and the man falls because of this and not because his trunk forced him in a given direction. Besides, there is no attempt on the part of a drunken person to hold his arms outstretched for protection, whereas, the cerebellar patient is always careful as to how he walks, and knowing that he tends to stagger, makes efforts to obviate this and assumes as far as he can protective positions. He not only uses his cerebrum, which is largely out of commission in the case of the drunken man, but he even compensates in some degree for his cerebellar impairment by the forced or overuse of his cerebrum.

As has already been mentioned, when a cerebellar patient walks, the whole trunk may be projected in a given direction or one shoulder or one side may be moved more than the other, as for example, when a patient walks forward and to the left, in which case the left shoulder and left trunk are forward, the right side of the body lagging. The same thing will be true no matter what other position the body assumes, as when the patient changes to a sitting or standing from a recumbent posture. If the case is left-sided, then the left shoulder and trunk move first and more than the right; if right-sided, the right shoulder and trunk are more in the picture. If the case is bilateral or central, that is entirely trunkal, no difference in the movement of either side is detectable.

In the pelvic girdle cases when the patient attempts to get up from a recumbent posture and temporarily assumes in doing this a position on his hands and feet, the sway of the pelvis is very marked and may be chiefly to one side, but is nearly always to both sides. It is noticeable that in this position, the taking of which is one of the best methods of showing the relative degrees of pelvic girdle and shoulder girdle asynergy, if the pelvis only is involved, the trunk will not sway and whatever trunkal movements are present, are compensatory. These cases are much more common than those of the shoulder girdle. The methods thus indicated of demonstrating pelvic girdle and shoulder girdle asynergy have not, we think, been described before.

Turning now to some of our observations regarding *the movements of the limbs*, we are convinced that in testing for hypermetry, for example, it does not matter very much whether the finger goes beyond the nose, for many patients because of being repeatedly asked to do this learn to put their fingers to their noses quite well. The important thing is that if there is an asynergy of the upper limb when the patient attempts to place his finger to his nose, the movement being of wide range as when it starts with the hand on the knee, the whole arm including the shoulder takes part in the movement. The circle described by the hand is greater than it should be and in the majority of cases the movement is quicker than normal, although in some it is the contrary. In some cases when the patient is asked to put his finger to his nose the arm is swung inward; in some cases, outward and in some directly to the nose. The more marked the dysmetry the greater is the tendency for the sweep to be inward, that is, toward the body, and the greater is the involvement of the shoulder.

In testing hypermetry in the legs, if the patient is in a recumbent position and asked to put his heels to his knees or his heel to any point indicated, there is first an overflexion of the thigh on the abdomen and the heel nearly always overshoots the desired point. The nearer the pelvis is the point to be touched, the greater the sway of the leg, but the heel is usually placed on the desired point.

An equally good way to test hypermetry is by asking the patient to put the heel to the buttock. In this the movement is nearly always quick, the thighs are much more flexed on the abdomen than they should be and in the height of the excursion, with the heel approximating the buttock, there is always a to-and-fro sway of the limb, the degree of this depending on the severity of the symptom.

In testing for adiadokocinesis the attempts at alternate pronation and supination of the forearm and hand quickly show the degree of asynergy of the limbs. Adiadokocinesis may be tested in the lower limbs as well as the upper by alternate rotations or adductions and abductions. The defect is readily observed. The excessive movement may be either inward, outward, upward or downward in the upper limb and inward or outward in the lower limb. This is best brought out if only one side is involved, for then it is possible to compare the movements with those of the limbs of the other side. In some cases the movements are slow, but the important thing to look for is the overmovement.

In a case recently placed on record by one of us there was a *loss of emotional expression* on the right side of the face although the patient could use this side for every other purpose. The loss of emotional expression, while evident to ordinary observation, was emphasized by the kinematograph. In other cases, as for example, in paralysis agitans, disseminated sclerosis and focal lesions of the pons, we have been able to study changes in emotional expression more thoroughly than by the ordinary clinical method.

Not only can unilateral loss of emotional expression be exhibited, but a loss of all or almost all expression. One of our patients who could not be made to laugh or cry talked in a slow, monotonous, stupid manner with drooling of saliva. The moving pictures show not only the loss of emotional expression, but also the manner of speech. It is interesting that in this patient the movements of the limbs and body are of the same character as those of speech.

We believe in a true *cerebellar speech*, one type of which is shown in the patient described above. In another case which was for a long time in the nervous wards of the Philadelphia General Hospital the history was such as to indicate that the patient had had a hemorrhage into the anterosuperior portion of his cerebellum. He had most exquisite asynergy in his tongue, facial and laryngeal movements. His speech might be described as jerky and crackling. In this patient and in one other whom we recall, not only was the speech affected in the manner described, but mastication and deglutition were almost impossible because of the asynergy of the involved musculature.

In most of our cases examined kinematographically there were no asynergic *movements of the head and neck*. The head in these cases usually maintains the same plane as the trunk. In one case, however, shown in the series of pictures, the head is carried distinctly to one side. While the cases seemed to be relatively limited the fact that we have had a few

speaks for the localization of movements of articulation, phonation, mastication and deglutition.

So far as our kinematographic observations are concerned, we showed, in one case, previously mentioned, of cerebellar agenesis, what we regard as true *asynergia of the eyeballs*. The eyes are never at rest. They move upward, downward, to either side, and in a rotary direction and combined, with the nodding of the head, give a furtive appearance, as if the patient were constantly dodging something. No two successive movements of the eyeballs are alike and it is with difficulty that the movements can be followed with the naked eye, although with the kinematograph this becomes easy.

In one of our patients vertical nystagmus was always present, and this occurred no matter in what direction the patient attempted to look. We believe because of the symptomatology that this patient had a lesion of the upper cervical cord and inferior cerebellar peduncles. We regard the nystagmus as due to involvement of the vestibulocerebellar apparatus, probably of the parts connecting the vestibular nuclei with the deep nuclei of the cerebellum.

In one of our patients in whom an exposure of the cerebellum was made, the cerebellum was incised to about the depth of half an inch at about the junction of the left superior semilunar lobe with the vermis. Directly after the operation and ever since, marked lateral jerkings of both eyeballs have been constant, but these have been more marked on the left. If the patient looks to the right the nystagmic movements are not so forcible, but on looking to the left they are strikingly exhibited. It is not that the left eyeball moves without the right, but that the excursion in the left eye is more marked than in the right and gives one the impression that the left eyeball alone is moving. It will be remembered that the incision was on the left. As these movements were not present before the operation it is apparent that they were the direct result of the incision into the cerebellum.

Babinski has described catalepsy as a new cerebellar symptom. In demonstrating this the patient is placed on his back, the thighs semiflexed on the abdomen, the legs on the thighs. After a few oscillations, according to Babinski, the legs become stationary and maintain their position for a longer than normal period. These phenomena in one patient were shown by Babinski by means of a moving picture at a meeting of the International Congress, 1913.

We found that most of our patients were too asynergic and asthenic to maintain their legs in the above-described position for more than a few moments. In other patients in whom the asynergy was not so marked, and particularly in the unilateral cases, we tested both the upper and lower limbs at the same time. The upper limbs in this test were first placed in a vertically-extended position. The limbs on the affected side slowly drooped and reached the level of the body sooner than those of the unaffected side. In not a single patient did we find true catalepsy and we therefore do not look on it as a manifestation of pure cerebellar disease. In one of our patients, a very powerful man, one of our chief illustrations in the series of moving pictures, the man placed on his back was able to maintain his legs and arms in a set position—that of semiflexion of the lower limbs and vertical extension of the upper—but in this case there was no preliminary swaying and we regard the exhibition as pseudocataleptic and simply due to the great

strength of the individual. The case was one in which the asynergic phenomena were expressed bilaterally, although the abnormal movements were more marked on the left and especially in the pelvic girdle.

CEREBELLAR LOCALIZATION—FOCAL SYMPTOMATOLOGY

In studying the focal symptomatology of cerebellar disease, hypermetria, adiadosis and tremor at times indicate not only the presence of cerebellar asynergy, but give the clue to the part of the cerebellum most involved, as when these phenomena are most markedly exhibited in a special part of the body—the trunk, the upper or lower extremity, the head, face or eyes. These facts of localization are, we believe, emphasized by kinematographic investigations, as we have just tried to show.

The clinician soon finds that the focal symptomatology of cerebellar disease is not so easily comprehended as cerebral focal symptomatology. He recalls, however, from his experience, observations which have a bearing on this question. He has had cerebellar cases with marked unilaterality in their manifestations, indicating that one-half of this organ exerts its influence with marked predominance on one side of the body. In other cases, not on the whole numerous, ocular movements have been disordered in a way not explicable by limited lesions of parts of the brain other than cerebellum. In other instances, also not numerous, the speech of the patient is affected in a manner not to be explained merely by bulbar or cerebral involvement, while in many instances both ocular movements and speech disturbances are wanting. He has noted that in different cerebellar patients the disordered movements of the trunk differ from each other in ways which can be definitely discriminated. Shoulder girdle movements in one instance, and pelvic girdle movements in another, are more affected. The changes in emotional expression sometimes observed differ in different cases. The head takes a special attitude in a few cases; in many others this not occurring. Extraordinary combinations of abnormalities of movement may be discoverable on casual observation or elaborate investigation.

The cerebellum as a whole and all of its parts are concerned with the function of synergia. When, however, a particular part or parts of the body are the seat of abnormal motor phenomena of cerebellar origin, such manifestations are focal and more or less capable of localization. If these focal symptoms were arranged in tabular form, we would have a list something like the following:

Focal Symptoms Indicated by Localized Asynergic Movements:

- Eye movements.
- Attitude and movements of head.
- Movements of jaw, face, tongue, larynx, etc.
(Disturbances of speech, emotional expression, etc.).
- Position and movements of trunk.
- Special movements of upper extremity.
(Disturbances in fine movements including writing).

Movements of trunk and upper extremity (shoulder-girdle movements).

Special movements of lower extremity.

Movements of trunk and lower extremity (pelvic-girdle movements).

CEREBELLAR LOCALIZATION—COMPARATIVE ANATOMY AND EXPERIMENTATION

Some of the results of embryologic and morphologic investigation of mammalian cerebella indicate the development and elaboration of function in this organ. Among those who have contributed work of great value in this direction we find some of the most distinguished names in the field of neuro-anatomy: Kölliker, Schwalbe, Elliot Smith, Bolk, Van Rynberk, Charnock Bradley and others. To the results of the investigations of some of these, Rothmann has appealed in corroboration of his own experimental and pathologic findings.

Studying the mammalian cerebellum from the lowest types to man, certain facts of paramount interest regarding the development of fissures, folia, lobules and lobes attract attention. The methods in which fissures appear, extend, recede and disappear and the horizontal and sagittal expansion of cerebellar substance go hand in hand, as in the development of the cerebrum with additions and intensifications of function.

In the lower mammals like the squirrel, the ox, the dog and the monkey, the cerebellum has a less marked subdivision into a middle lobe and lateral lobes than in man. Such subdivision appears and becomes more definite as the evolutionary series approaches man. Glancing, for example, at the dorsal aspect of a series of the

Fig. 1.—Bolk's schema of the mammalian cerebellum; on the left half the new anatomic names; on the right half the functions of special areas (Von Bechterew).

cerebella of apes or their semidiagrammatic representation as given by Bolk, one deep somewhat anterior fissure usually called the *sulcus primarius* is uniformly observed traversing the entire width of the cerebellum, while above and below this are distinct fissures shallower and of varying lateral extent, only one, much more posterior than the primary fissure mentioned above, crossing the full width of the cerebellum. In the cerebella of these animals a vermis of moderate extent is distinctly to be seen in the posterior region of the cerebellum. In *Lemur albifrons* the deep transverse fissure is seen with shallower fissures anterior and posterior to it. In its posterior median portion is a well-defined middle lobe, to the right and left of which are lobes traversed by a short fissure with radiations. This intercrural fissure separates two crura or limbs of a cerebellar lobe, the *crus primum* and *crus secundum*. Many of the references to the experiments on lower animals, as on dogs and monkeys, are to the effects produced by extirpation or irritation of these parts.

Bolk, Elliot Smith and Bradley have made schema of the mammalian cerebellum. Von Bechterew adapted the schema of Bolk so as to give a general view of the functions of the cerebellum (Fig. 1).

It is in the parts homologous in the human brain with the *crus primum* and its correlated vermis that the highly evolved synergic movements of the upper extremity and trunk appear to be represented, and in the *crus secundum* and its correlated median and paramedian regions the highly developed synergic movements of the lower extremity and trunk, those especially concerned with the maintenance of the erect position of man and his ability to perform complex synergic movements in this position.

In the anterior portion of the human cerebellum as in lower mammalia, movements more or less common to both them and to man—movements of the eyes, head, jaws, face and larynx—are represented, although this representation in man is of higher synergies than in lower animals. This anterior lobe is to be regarded more as a whole—as transverse or azygos—without so much reference to a separation into middle and lateral parts as has hitherto been considered essential, although the superior vermis and its wings may have subdivisions of their general representation.

The demand for a complex representation of movements which are complex and elaborate has led to the tremendous development in man of that subdivision of the cerebellum which is posterior to the primary fissure.

The localization of cerebellar function and the abnormal phenomena produced by limited cerebellar lesions have been chiefly investigated by extirpation and electrical irritation. The extirpation experiments have been of varying character, sometimes decapsulation of a whole lateral lobe or of this and the vermis or of the vermis alone; and sometimes by extirpation of small areas in definite parts of the cerebellum as in the anterior lobe, in the *crus primum*, *crus secundum*, the posteriomedian lobe or inferior vermis, or the paramedian region.

The electrical-excitation experiments have been performed on carefully selected spots and areas of the cerebellar cortex and some observers have endeavored to isolate their irritation experiments to the deep nuclei of the cerebellum. We are in accord with Rothmann in our belief that the cerebellar cortex is excitable to the electric current, a fact which was long ago demonstrated by Ferrier and which we have confirmed in one case on a human subject. A stronger or longer-continued current seems to be required to bring about movements in the case of the cerebellar cortex than in that of the cerebral cortex, but such

excitation is possible and can be more or less circumscribed.

In another communication, reviewing the neurologic contributions to the Seventeenth International Congress, one of us² has summarized the findings indicating special localizations by recent cerebellar experimentalists (Rothman, Prus, Adamkiewicz, Pagano, Bolk, Van Rynberk, Luna, Katzenstein and Rothmann, Bárány, and others). It is not always easy or perhaps possible to homologize the parts isolated in experiments on lower animals with divisions and subdivisions of the human cerebellum, and clinical contributions supported by necropsies have not yet been sufficiently numerous and exact to furnish absolutely dependable corroborations of the work in experimental physiology. Based on our studies of the literature of cerebellar

embryology, comparative anatomy, experimentation and clinicopathology and on the results of our direct and kinematographic clinical observations, these studies in a few instances being reinforced by operations and necropsies, we have attempted a tentative schema of localization in the human cerebellar cortex (Figs. 2 and 3). It must be understood that this is regarded by us not only as tentative, but in some particulars as merely suggestive. One cannot with the same accuracy and certainty as in the case of the cerebral cortex indicate this or that region of the cerebellar cortex as exclusively concerned with the movements of the eyes, head, face, jaws, trunk, extremities or special parts of the limbs. The important fact that the cerebellum as a whole and in subdivision is concerned with synergy indicates that movements in which various parts of the body

are at the same time concerned cannot be fully represented by a center or area for movements of one of these parts. The eyes may move to the right or left, or up or down without any association with other movements, but on the other hand, the eyes may move synergically with the head or with the head and trunk or with the head and trunk and limbs. The trunk may be bent forward or backward or twisted to the right or left with little or no association with movements of the extremities, but such comparatively simple trunkal movements are not the rule in bodily actions. The rôle played by the cerebellum has its best exemplifications in such acts as advancing and retiring in the erect position or in the performance of complex movements

Fig. 2.—Cerebellar localization; zones and centers of the superior surface of the cerebellum.

Fig. 3.—Cerebellar localization; zones and centers of the inferior surface of the cerebellum.

2. Mills, C. K.: Neurology at the Recent (Seventeenth) International Congress of Medicine, New York Med. Jour., 1914, xlix, No. 5.

while standing, as in fencing, boxing or public speaking; or in the driving and regulating while sitting of the movements of a rapidly running automobile; or in any highly trained movements such as are exhibited in a series ascending in complexity and rapidity of association from a game of tennis or baseball to the handling of an aeroplane. These wonderful representations of instantaneous synergic activity must be represented in the cerebellum by complexly associated neural mechanisms. In other words, cerebellar localization is more compound in its cortical representation than is cerebral localization. A composite, however, has always within it factors or elements which can to a less or greater extent be separated from the entire mass.

In the human cerebellum we must be able to recognize, in the first place, centers for synergically simple movements and in the second place, centers and zones for more and more complex synergic movements. Each simple synergic movements has, however, its special cortical representation.

To illustrate the principles just expounded let us refer to some of the results of experimentation and the difficulty of applying these in ordinary clinical work, at the same time showing that this application is possible. Bolk found a center for bilateral movements of the anterior limbs in the *crus primum* and a similar center for the posterior extremities in the *crus secundum*. A destructive lesion of one of the homologous parts in the human cerebellum would not give us the same simple clinical picture as the lesion of deficit in the dog, this being due, at least in part, to the fact that the dog ordinarily uses all four limbs in station and progression while man step by step with the development of his cerebellum has learned to stand erect and walk and guide his movements chiefly by the motor adjustments between his lower limbs and trunk, the upper limbs acting as auxiliaries in such performances. The aberrant movement resulting from localized deficit or irritation in the case of a man would be more complex, a combination, for instance, of an abnormal shoulder girdle or pelvic girdle movement with specialized dysmetric movements of parts of the limbs. The fact that the representation in certain parts of each hemisphere may be homolateral, contralateral or bilateral makes it more difficult to draw an inference or reach a conclusion as to the localization of function and therefore, of course, as to the results of focal lesions.

How then shall we apply the known facts of cerebellar localization in neurologic diagnosis? Simply by bearing in mind that when the trunkal movements and those movements of the limbs which must act with them to preserve static and dynamic equilibrium are affected, the vermis must be involved in whole or in part. The associated involvement of one lateral lobe in the vermal lesion will be largely determined by unilateral dysmetric phenomena, the extent of the anteroposterior involvement of the inferior vermis by the preponderance of asynergy in either the lower or the upper limbs. In our cinematographic studies the presence of abnormal pelvic girdle movements in one case and of abnormal shoulder girdle movements in another, these symptoms being sometimes more marked on one side than the other, seems to us to give the key to the localization of the lesions both as regards their anteroposterior and lateral positions.

1909 Chestnut Street.—2030 Chestnut Street.

ABSTRACT OF DISCUSSION

DR. HARVEY CUSHING, Boston: I can see the large opportunities this demonstration offers for study and analysis of the motor disturbances in these cerebellar cases. I recently saw some remarkable cinematographs of athletes in motion which had been taken with great rapidity, I think 250 exposures to the second instead of the usual number. When they were shown the reel was slowed sixteen times, so that the films passed very slowly and yet without fluttering. The opportunity of analyzing the movements was most unusual. With such improvements in the technic of taking and exhibiting films we may look forward to the future study of the motor disturbances of disease with the expectation of valuable returns. It has been a great help to me, being only an amateur neurologist, to have Dr. Mills assemble, so simply and clearly, the confusing terms relating to cerebellar incoordination. If we can accept asynergy itself as the underlying factor in the motor disturbances with which we are familiar it will greatly simplify the subject for all of us. So far as the caloric and other tests are concerned, interesting as they are from a physiologic point of view, I am sorry to say that for clinical purposes we have not as yet benefited greatly from them. We have religiously gone through these tests in all of our cerebellar cases before as well as after operation and have made as complete studies as the patients' condition permitted. I have visited Bárány myself and one of my associates has been with him for some time, but I must acknowledge that so far we have not profited by these studies of the cerebellolabyrinthine pathway. Nevertheless, I think they should be made as a routine part of a neurologic diagnosis if there is any suggestion of temporal lobe, of labyrinthine or of cerebellar involvement; and I still hope, purely from the practical point of view, that we may in time gain something of value, even if we cannot expect to secure from the labyrinth information comparable to that which we get from the eye.

DR. OTFRID FOERSTER, Breslau, Germany: I believe that all so-called cerebellar phenomena are only different signs of one elementary symptom, for which I will use the term "incoordination," instead of asynergy. I think it means a little more than asynergy. It is simply a question of examination.

The moving pictures are of great value, not only for demonstration, but also for investigative purposes. Patients often show a certain symptom at one moment and later do not show it. The moving pictures allow us to fix the symptom and to examine it as often as we like in a careful, detailed and analytic way.

DR. CHARLES K. MILLS, Philadelphia: It has been said that we should study more closely than we usually do the part of the body affected. More than this, we should note what part of the body is first affected, what second, and what last, in this way ascertaining the train of phenomena which leads us to the original focus of disease. A common thing for the neurologist to do in a case of cerebral tumor is to study its progressive symptomatology. He notes the occurrence of not only the initial symptom if the patient has a spasmodic attack, but also the serial order of phenomena; if, for instance, the spasm begins in the face, then goes to the leg or arm. If he has a case of parietal tumor he studies first the easily recognized parietal symptoms and then, perhaps, follows the successive phases of changes in the reflexes. I have seen, for instance, the normal plantar reflex change to a stationary position of the great toe and then to extension of this toe. In cerebellar disease—abscess, tumor, and, more rarely, hemorrhage—we can sometimes most readily get the clue by a study of the progressive order of development of the phenomena in the limbs or part affected.

The Death-Rate a Measure of Intelligence.—If the principles of sanitation, as we now understand them, were put into practice, within fifteen years the average life would increase to 65 years. . . . The death-rate to-day is the measure of intelligence.—Victor C. Vaughan, *Journal Michigan State Medical Society*.