DYSSYNERGIA CEREBELLARIS PROGRESSIVA—A CHRONIC PROGRESSIVE FORM OF CEREBELLAR TREMOR.[1]

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INTRODUCTION.

As *dyssynergia cerebellaris progressiva*, I would direct attention to a chronic progressive tremor disturbance, which seems deserving of differentiation as a definite clinical type of nervous disease.

This affection is characterized by generalized intention tremors, which begin as a local manifestation and then gradually involve in varying degree the entire voluntary muscular system. The tremor which is extreme when the muscles are in action, ceases entirely during relaxation and rest. If this disorder of motility is subjected to more detailed study, it will be found that, associated with the tremor, there is a well-marked disturbance of muscle-tone and of the ability to measure correctly direct and associated muscular movements; the clinical manifestations of this are *dyssynergia, dysmetria, hypotonia, adiadokokinesis* and *asthenia.* All of these symptoms, including the volitional tremor, which is only the extreme expression of the underlying disturbance of muscle-tone and synergy, indicate a disorder of cerebellar function.

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I, therefore, regard this affection with its progressive tendency, chronic course and well-defined cerebellar symptomatology, as an organic disease caused by degeneration of certain special structures of the cerebellar mechanism, which are concerned in the regulation of the tonus and synergies of muscles.

These cases are further distinguished by the absence of true nystagmus, objective vertigo ("Drehschwindel"), cerebellar fits, vestibular seizures and disturbances of equilibrium, symptoms which are so frequently associated with gross lesions of the cerebellum.

The clinical picture is, therefore, strictly limited to a progressive disturbance of synergic control, the most striking characteristic of which is the ataxic intention tremor, which accompanies any movement of the affected part, whether volitional, reflex or automatic.

Chapter I.—Report of Cases.[1]

Case 1.—*A woman, aged 47. Onset at the age of 40, with volitional tremor of the left arm. One year later similar involvement of the right arm, followed by gradual extension to the muscles of the head, trunk and lower extremities. The clinical picture is one of generalized, coarse, ataxic tremor on attempting any movement, however slight, which ceases during rest. A study of the motility shows also a disturbance of the cerebellar function, viz., dysmetria, dyssynergia, hypotonia, adiadokokinesis and intermittent asthenia; otherwise the neurological examination is negative. The chief symptom is generalized dyssynergia with tremor movements on intention.*

History.—The patient is a woman, aged 47, born in Germany, of Jewish parentage, who was admitted to the Montefiore Home, in August, 1908, since which time she has been under continuous observation.

Family history.—Her father died at the age of 84; her mother is 83, and still living. The parents were not related. One of her brothers died of "scrofula" at the age of 17, and another brother and a sister died in infancy of unknown causes. No members of her immediate family have been subject to tremors of any kind, nor is there any history of such tendency in the collateral branches.

Previous history.—The menses appeared at 13½ years, were regular and of normal character. Menopause at the age of 40. She married at 24, and was never pregnant. For fifteen years she has been a widow. Previous to her marriage she had been a cook, and this occupation she resumed after her husband's death.

Her only previous illnesses have been an attack of enteritis in the summer

[1] From the Neurological Wards of the Montefiore Home and Hospital.

of 1899, influenza in 1890, and pleurisy in 1892. Otherwise she has been well and strong and in excellent health. She was always moderate in the use of alcohol, as well as tea and coffee. There is no history of mental or physical trauma or of venereal disease. For eighteen years she has had a small, firm enlargement of the isthmus and right lobe of the thyroid gland (without symptoms of Graves' disease).

Present illness.—Onset of the disease seven years ago, with an awkward tremor movement of the left hand on attempting to grasp an object. The intensity of this gradually increased, so that with every effort to move the arm there was an awkward shaking tremor. When the arm was at rest there was no tremor. For an entire year this symptom remained limited to the left arm. At the expiration of this time, the same disturbance of motility (volitional tremor) developed in the right arm, and this in turn gradually increased in severity. In the course of the next year a similar shaking and tremor made its appearance in the head and then gradually extended to the trunk and lower extremities. The speech also became affected.

This peculiar motor agitation has shown slow and steady progress, involving in turn the upper and lower extremities, the head and trunk and the muscles of articulation.

The left arm was first affected, a year later the right arm, a few months after this the head and neck and muscles of articulation; after this there was a steady progressive involvement of the trunk and lower extremities, together with an increase in the general severity of the entire tremor disturbance.

During this period of progression, and occasionally since, she has suffered from headaches in the frontal region, but these were never very severe and have not been frequent. They were not accompanied by nausea or vomiting. There has been no diplopia and no attacks of objective vertigo ("Drehschwindel"). A subjective sensation of dizziness and vertigo is not uncommon, especially when the head tremor is excessive. There were never attacks of spontaneous vertigo in the recumbent posture. She has never had any fainting or convulsive seizures.

There is no subjective disturbance of vision, other than that which would naturally accompany the constant nodding and shaking of the head. There have been no paræsthesiæ, girdle sensations, and no vesical disturbances. There is no tendency to undue hilarity or exaltation, no explosive emotional attacks and no especial depression. Memory is good and the mentality shows no deterioration or change which is worthy of special mention.

She complains of fatigue and dull aching pains in the muscles of the extremities after exertion; but has never been subject to sharp or lancinating pain.

As a rule she sleeps well, and during sleep all trace of the tremor disappears. When any movements in the bed are made, such as a sudden start or turning, the tremor appears and wakes her; when there is any noise or disturbance in the ward she often wakes in tremor.

The tremor.—If the patient is lying in the recumbent posture with the

body completely relaxed and the head supported by a soft pillow, there is no vestige of any movement.

The slightest attempt at innervation, such as fixation of the eyes, a movement of the hand, a simple flexion of the extremities, or even attempts to speak or smile, are sufficient to produce tremor which is usually increased by the patient's attempt at repression. Mental excitement and effort are also effective in aggravating the tremor. The automatic act of respiration alone, when the patient is quiet and relaxed, does not produce a tremor; during the more violent exacerbations of tremor the respiratory movements are sometimes jerky and arrhythmical.

The favourite position of the patient while sitting is leaning forward, resting the head, arms and upper portion of the body on a table. In this position she will often remain for long periods perfectly quiet and relaxed, unless she is questioned or her attention attracted, when immediately more or less violent tremors result.

While sitting quietly in a chair before the examiner with the arms resting on the lap, the tremor may be confined to nodding and shaking of the head, some facial movements and oscillations of the body; but mental excitement or a slight attempt at voluntary innervation, such as speech or movements of the fingers, seem to disturb the balance and adjustment of the patient, and violent tremors result.

There is no true nystagmus. If, however, the tremor is checked by holding the head, tremor will occasionally appear in the eyes. Such oscillations, however, are not obtained by fixation of an object with the eyes. The overflow of tremor also takes place if the movements of an upper or lower extremity are forcibly checked.

The tremor of the extremities is of the volitional or intention type, and consists of a coarse ataxic shaking and tossing of the extremities rather than a true rhythmical tremor, although in certain positions this ataxic shaking assumes a more or less rhythmical character. It reaches its highest degree of intensity in the upper extremities which are sometimes hurled and thrown about with such violence while under innervation, that severe bruises and contusions may result.

On attempting to place the index finger upon the tip of the nose, the arm is jerked and thrown about with ataxic violence, the motor agitation subsiding, and becoming less severe when the object of the movement is finally reached. On attempting to place the heel upon the knee in the recumbent posture, the same coarse volition disturbances appear; and if the leg is elevated, as with the arm, a violent ataxic tremor develops. Closure of the eyes has no appreciable influence upon the extent or character of the movements.

On standing, the general tremor is much increased, the legs shake, the trunk oscillates, the head is in constant movement, and the arms are tossed and thrown about in most bizarre fashion. Because of the severity of the motor disorder the patient receives all her food and drink from the hands of a nurse. This has been necessary for the past three years. Chewing and

swallowing aggravate the tremor, which adds still more to the difficulty and embarrassment in taking nourishment.

Static equilibrium is well maintained even on a narrow base, and closure of the eyes in this position has no apparent effect upon posture or the intensity and character of the tremor.

For some years all finer movements of the hands have been impossible, and for several years the handwriting has been reduced to illegible scrawls and scratches.

If the patient has had an exciting or fatiguing day, some after-tremor may persist for several hours, even during the period of rest.

On several occasions, during the years of observation in the hospital paroxysms and crises of tremor have occurred, lasting for weeks at a time, in which all of the tremor symptoms have been greatly exaggerated. During this crisis of tremor, standing and walking were difficult and precarious, because of the violence of the motor agitation. After a time, however, the crisis diminishes, equilibrium is restored, and there is a return to the original degree of disability which is chronic and permanent.

The tremor is usually more severe in cool weather.

The speech is slow and scanning and is frequently broken and interrupted by violent explosive efforts and utterances. Under excitement these brusque explosive discharges render it almost unintelligible. The speech disturbance is evidently caused by the same disharmony which characterizes the other muscular efforts. During the act of articulation there are associated tremor-like contractions of the facial movements, and the tremor of the head is much exaggerated.

Asthenia.—There is no paralysis of the muscular system in the usual sense of the word, and the initial muscular effort is carried out with approximately the normal degree of force. There is, however, a curious asthenic symptom of an intermittent character. This is characterized by the inability to sustain or fix a muscular contraction except for short periods of time. If, for instance, the patient is instructed to grasp the hand of the examiner and to maintain the grasp, it is found that the initial effort is of normal force, but after 5 to 10 seconds the grasp relaxes in spite of every effort to maintain the contraction. Immediately after the relaxation of the hand, which is involuntary, another effort is again made, only to suffer the same spontaneous relaxation; so that instead of a single sustained contraction, we are confronted with a series of brief, intermittent muscular contractions of fair intensity. This inability to sustain a muscular contraction, I would designate *intermittent asthenia*, as the clinical impression produced is that of asthenia, although it is not improbable that the underlying disturbance is very closely related to the dyssynergia which will be referred to later.

The intermittent asthenia may also be demonstrated in other muscles of the extremities, as in flexion and extension of the wrist and elbow, abduction of the arms and in the various movements of the legs. It is therefore, like the tremor, a generalized manifestation.

On a few occasions, the patient has suddenly fallen to the ground, because of the giving way of one of the legs when attempting to stand in one position, as before a looking-glass in preparation of her toilet. Such falls are apparently due to an intermittent asthenia of the lower extremities, and are unaccompanied by vertigo or obscuration of consciousness. The electrical reactions of the muscles are normal, both quantitatively and qualitatively. It is interesting to note that strong faradic currents produce sustained muscular contractions without the intermittent relaxation which accompanies voluntary movements.

Hypotonia.—The muscles are well developed and free from atrophy. They are, however, soft and flabby to the feel and there is present a definite hypotonia. The joints are relaxed and flaccid and may be over-extended. This is present in both the upper and lower extremities, and especially in the arms. If the arms are watched during the volitional tremors, it will be seen that, especially in the movements of the hands and fingers, extreme attitudes indicating hypotonia are assumed.

The Stewart-Holmes sign of hypotonia is also present in the upper extremities, i.e., the failure of rebound or recoil when flexion of the arm is resisted and suddenly relaxed. The flexion movement continues until mechanically checked without the intercurrent contraction of the antagonistic triceps. The mechanical irritability of the muscles on percussion is normal; no myotonic phenomena are present.

Dysmetria and dyssynergia. — When the individual movements of the extremities are carefully analysed, a distinct disturbance of the ability to measure, regulate and harmonize voluntary movements is found. In order to eliminate the tremor as far as possible, so that isolated muscular movements may be studied, it is best that the patient be placed in the recumbent posture with the arms relaxed and the head supported. In this position complete motor relaxation and quiet may be produced. If the patient is instructed, with the arm resting on the bed or upon a table, to elevate the index finger and then allow it to fall and to continue repeating this single movement, a number of interesting phenomena become apparent. These tests may also be made with the patient sitting in a chair with the arm relaxed and resting on a table.

This test movement of the index finger is produced by the contraction of the extensor indicis, which is immediately relaxed. Instead of the normal elevation and fall of the finger as should occur, an overaction is observed. The index finger is thrown brusquely as high as possible and remains fixed, relaxation not taking place immediately. Or instead of a single extension movement there may be two or sometimes three successive attempts before the finger is brought into extension. It will also be observed that instead of allowing the finger to fall by simple cessation of contraction, there is an overaction of the antagonists and the finger is thrown down, striking the table with some force.

If the forearm of the patient is encircled by the examiner's hand during these efforts, it will be found that there is a synchronous contraction of the

flexors (antagonists) of the forearm and also occasionally in the muscles of the upper arm.

These symptoms of dysmetria and dyssynergia, which may be demonstrated with ease in the contractions of single muscles, are also very evident in the larger and more complicated movements of both the upper and lower extremities, but may be overlooked and masked by the general tremor which is produced.

Adiadokokinesis was distinctly present in both upper extremities. On attempting to perform quick alternating movements of supination and pronation the movements are slow and interrupted, and there is an inability properly to control and measure them, so that a quick rhythm of normal rapidity is impossible.

This disturbance may also be demonstrated in the movements of the index finger and thumb, preferably tested while the arm is relaxed and resting upon a table.

Sensation.—The general sensations, both superficial (touch, pain and temperature) and deep (muscular and articular), are entirely normal. There is no demonstrable defect in the ability to distinguish the relative difference of weights placed in the hands.

Vision, the sense of smell, taste and hearing are normal and equal on the two sides.

The Bárány rotation and caloric tests show the normal nystagmus reactions on both sides. These reactions are delayed and are obtained with some difficulty, requiring strong stimuli for their production. This is probably due to a certain diminished sensitiveness of the peripheral apparatus of equilibrium by reason of the constant violent oscillations of the head.

The pointing tests ("Vorbeizeigen") are difficult of interpretation because of the violence of the volitional tremor.

Reflexes.—The tendon reflexes of the upper extremities (supinator biceps and triceps jerks) are present, not exaggerated, and are equal on the two sides. The jaw-jerk is present and not exaggerated. The knee-jerk and ankle-jerk are present on both sides and are of equal intensity and not exaggerated. The abdominal reflexes are present and equal. The plantar reflex gives a normal flexor response on both sides, and the Babinski reflex has not been demonstrable during the many years of observation in the hospital.

Cranial nerves.—The pupils are equal and react promptly to light and accommodation; the pupillary skin reflexes are normal.

Ophthalmoscopic examination shows normal optic nerves; no signs of neuritis or pallor of the disc. The ocular excursions are normal, no true nystagmus. The innervation of the facial muscles, the muscles of mastication, soft palate and tongue is normal, but produces marked tremor disturbances.

General examination.—The apex beat is in the fifth interspace within the nipple line. There is a systolic murmur over the body of the heart; the second sounds are not accentuated. Percussion of the lungs and the breath sounds are normal. Percussion and palpation of the abdomen are

negative. There is a slight, firm enlargement of the isthmus and right lobe of the thyroid gland without pulsation or bruit, tachycardia, exophthalmus or other symptoms of Graves' disease. The urine is normal.

The blood contained 4,720,000 red cells; 62,000 white cells; hæmoglobin, 88 per cent. Wassermann tests of blood and cerebrospinal fluid are negative. There was no increase of cells or globulin in the cerebrospinal fluid. There is a marked dermographia, but no pigmentation of the skin or cornea. The gynæcological examination showed no abnormality.

CASE 2.—*A woman, aged 29; onset at the age of 23, with volitional tremor of the left leg. Two years later the left arm showed similar involvement: one and a half years after this the right arm became affected. Since then increase in severity and gradual extension to the head, trunk and right lower extremity. With the tremor are the associated symptoms of a cerebellar disorder, dyssynergia, dysmetria, adiadokokinesis, hypotonia, and intermittent asthenia: otherwise the neurological examination is negative. The clinical picture is one of generalized intention tremors which cease when the muscles are not in action.*

History.—Patient is a married woman, aged 29, of Jewish parentage, who has been under my personal observation for the past year and a half.

Family history.—Her father died of tuberculosis at the age of 45; her mother is still living and is in good health; two sisters and one brother are living and well; two brothers died in early life of unknown causes. There is no history of tremor in the family.

Previous history.—Menses began at the age of 13, are regular but somewhat painful. She married at the age of 24, and has been twice pregnant, bearing healthy children; she has had no miscarriages.

She had measles, diphtheria and scarlet fever before the age of 9 years. With these exceptions she has had no illness and has been in good health until the onset of the present disease. She does not take alcohol and is moderate in the use of tea and coffee. There is no history of luetic infection, physical trauma or mental shock.

Present illness.—The affection from which she now suffers first made its appearance six years ago with tremor of the left leg. On standing or walking the leg is subject to jerky, irregular movements, which interfere with the free-and-easy motion of the extremity. There is no paralysis, no paræsthesiæ, and no pain; when the leg is at rest or in the recumbent posture all tremors cease. Occasionally, however, after fatigue and excitement some tremor persists in the ankle-joint for a short time.

For two years the disturbance was confined to the left lower extremity, gradually increasing in severity. At the expiration of this time the left arm began to show some involvement. Any attempt to grasp an object was accompanied by irregular awkward movements, which ceased as soon as the arm was placed at rest.

One and a half years later a similar tremor appeared in the right arm and has gradually increased in severity.

During the past year the head and trunk show evidences of tremor, and the speech is slow and slightly dysarthric. There is also some tremor in the right leg, so that at the present time there is a generalized intention tremor which affects both upper and the left lower extremity and in a lesser degree the other voluntary movements.

For the past three years all finer movements of the hands have been impossible. It is very difficult for her to eat and drink, and the handwriting is an illegible scrawl. She has at times been able to do coarse work about the house, such as required no special accuracy of movement.

During the course of this affection she has suffered from occasional headaches, chiefly frontal. These occur especially during the menstrual periods. She has had no obvious attacks of vertigo and no diplopia. Occasionally when the head tremor is most severe a sensation has been present of giddiness and lightness in the head. She has had no epileptiform or fainting attacks. The sleep is fair and is undisturbed by any tremor. There are no sphincter disturbances. Her memory is good and there are no evidences of mental deterioration; no emotional crises, and no attacks of forced laughing or crying.

The symptoms have been strictly limited to a chronic, coarse tremor of the intention type, beginning in the left leg and gradually extending to the other extremities, including the head and trunk. This tremor produces some disturbances of gait and station, a marked limitation of the use of the arms, more or less constant nodding and oscillation of the head when held erect, and a slight difficulty in articulation.

The tremor.—If the patient is at rest in the recumbent position, with the head supported and the arms and legs completely relaxed, so that all voluntary muscular innervation is eliminated, there is no sign of tremor. The muscles of the extremities are in a state of perfect rest and quiet. The only exception to this rule is following periods of mental excitement and physical exertion, when some after-tremor may persist for a time; but this passes away if the rest is prolonged. Any attempt, however slight, to carry out voluntary movements—as, for example, fixation of an object with the eyes, a movement of the hand or leg—causes an immediate disturbance of muscle equilibrium, and coarse tremor movements appear in the corresponding region of the body.

In the erect posture, if the patient stands upon a narrow base, there is no sign of ataxia with the eyes either opened or closed. There is simply a nodding and shaking tremor of the head with some oscillation of the trunk and more or less coarse tremulousness of the arms and legs. In walking there is no ataxia in the ordinary sense, but the gait is jerky, uneven and the rhythm and harmony of movement is disturbed by the coarse tremor.

If an attempt is made to place the index finger upon the tip of the nose, the arms are immediately thrown into the violent motor disorder which characterizes the intention tremor. The same is true of the left leg, and to a less extent of the right leg when the heel is carried upon the knee of the opposite leg.

If the arm or leg is elevated, the extremity is immediately thrown into a violent atactiform shaking tremor, which ceases as soon as the voluntary

innervation is removed and the part is placed at rest. Even slight voluntary movements, as of the fingers or hand, tend to produce considerable motor disorder of the whole extremity, unless the voluntary innervation is checked and the part placed at rest.

The speech is slower than normal and slightly scanning and at times uneven and slightly dysarthric. Mastication and deglutition are performed without difficulty, but are associated with an increase of the head tremor. There is no tremor of the facial muscles.

Asthenia.—The gross motor power of the extremities is undisturbed. There is, however, an intermittent asthenia or inability to sustain, except for brief periods of time, a co-ordinated muscular movement. For example, on attempting to maintain a hand clasp, in spite of every effort the grasp will relax and another attempt must be made, which in turn is only of short duration; so that instead of a single sustained contraction of the muscles concerned in maintaining a grip of the hand, there occurs a succession of interrupted efforts towards the same object. This may also be demonstrated in flexion of the elbow, extension of the foot or any other voluntary movements in which such a test could be carried out.

The electric excitability of the muscles to both faradic and galvanic currents shows no deviations from the normal. With strong faradic currents, tonic contractions of the muscles may be produced without the intermittent relaxation noticed in voluntary effort.

Hypotonia.—The muscles are fairly well developed and show no signs of atrophy. They are, however, soft and flabby on palpation and the joints are relaxed and flaccid. This is especially true of the upper extremities, in which the Stewart-Holmes sign of hypotonia is present. Mechanical irritability of the muscles is normal on percussion.

Dyssynergia and dysmetria.—If the arm is placed in a relaxed position and the muscular contractions of single movements are studied, there will be found evidences of dyssynergia and dysmetria. This is even more apparent in an analysis of the more complicated co-ordinated movements of the extremities, although somewhat masked and less readily identified because of the marked generalized tremor disturbance which results.

Adiadokokinesis is present on both sides.

Sensation.—Superficial and deep sensibility are entirely normal. There is no demonstrable defect in the ability to determine the relative difference of weights placed in the hands.

Vision, smell and hearing are normal. The Bárány rotation and caloric tests produce the normal nystagmus reactions, showing the integrity of the labyrinthine apparatus on both sides. The pointing tests are difficult of interpretation because of the coarse tremor.

Reflexes. — The supinator, triceps and biceps jerks are present, not exaggerated, and are equal on the two sides. The jaw-jerk is present and not exaggerated. The knee-jerks are active, slightly exaggerated and are of equal intensity on the two sides. The Achillis jerks are present and equal on the

two sides. There is no patellar clonus and no ankle clonus. Frequent examinations have shown that the abdominal reflexes are constantly present and equal on the two sides. Plantar stimulation produces normal flexion of the toes. (No Babinski.)

Cranial nerves.—The pupils are equal and react promptly to light and accommodation; the pupillary skin reflexes are present. The ocular excursions are normal; no nystagmus. Ophthalmoscopic examination of the optic nerves is negative. There is no pallor of the disc and no sign of neuritis. Innervation of the face, muscles of mastication, soft palate and tongue are normal.

General examination.—There is a moderate degree of dermographia; no pigmentation of the skin or cornea. The heart and lungs are normal; urine is normal.

Wassermann tests of the blood and of the cerebrospinal fluid are negative. There is no increase of the cellular elements or of the globulin content of the cerebrospinal fluid. Abdominal palpation and percussion are negative. No enlargement of the thyroid gland.

Gynæcological examination shows multiple stellate lacerations of the cervix, anteversion of the uterus and a mass in the right broad ligament with thickening of the Fallopian tube. The ovaries are normal.

CASE 3.—*Onset of the disease in a man, aged* 28, *with intention tremor of the right arm, followed six months later by a similar disturbance of the left upper extremity; gradual extension to the head and muscles of articulation. Slight involvement of the lower extremities; otherwise the neurological examination is negative. The clinical picture consists of intention tremor of the upper extremities, with involvement of the head, speech, and in a lesser degree of the legs. In the upper extremities, dyssynergia, dysmetria, adiadokokinesis, hypotonia and intermittent asthenia are associated with the tremor.*

History.—Patient is a man, aged 31, a native of Bohemia who has lived in the United States for the past six years. He is a labourer by occupation, is married, and has two children living and well. His wife has had no miscarriages. There is no history of tremor in the family, and his parents are still living and in good health. There is no history of venereal disease and no trauma. He is unable to give any satisfactory data as to the diseases of early childhood, but since that time he has always enjoyed robust health and has had no serious illnesses.

Present illness.—The disease from which he now suffers made its appearance a little over three years ago, with a shaking tremor of the right hand on attempting any movement. This gradually increased in severity; six months later a similar tremor made its appearance in the left arm and gradually progressed. Following this, oscillations of the head appeared while sitting or standing, together with a disturbance of speech. Later the lower extremities became somewhat affected, but in a less degree.

There have been occasionally frontal headaches since the beginning of the tremor, but they are not severe and are unaccompanied by nausea and vomiting.

He has had no vertiginous seizures, and no diplopia. There have been no pains in the extremities, no paræsthesiæ, no vesical disturbance, no attacks of forced laughter or crying, no fainting and no convulsive seizures. Because of the tremor, the man was forced to abandon his occupation, which consisted of general work of a coarse nature. Movements of the arms, as are required in dressing, eating and drinking, are rendered very difficult and almost impossible by reason of the coarse volitional tremor. There are no subjective disturbances of sight or hearing, and apart from the tremor disturbance his general health is good.

Tremor.—In the recumbent posture, with the head supported there is no visible or palpable tremor movement of the head, trunk or extremities. If, however, the arm is elevated there immediately develops a coarse shaking volitional tremor, which continues as long as the innervation is maintained. If the arm is replaced by the side and voluntary innervation is interrupted, all tremor immediately ceases. The same tremor disturbance is present in the left arm and to a lesser extent in the legs.

If, when lying in the recumbent posture the leg is elevated or an attempt is made to place the heel upon the knee, a coarse shaking and volitional tremor makes its appearance. If the forefinger is carried to the nose, violent tremors of the intention type are produced. It is impossible for the patient to carry a glass of water to the lips without forcibly spilling the contents.

On standing there develop nodding and oscillation of the head. There is also a slight palpable tremor of the lower extremities and some oscillation of the trunk in the erect posture. After excitement or prolonged examination some after-tremor may persist in the recumbent posture, but soon passes off with the rest.

The tremor movement is slow, ranging from three to five per second. The rate and amplitude are increased by excitement and effort. The gait is but little disturbed. The patient can walk a fairly straight line, and the chief manifestations during walking are the shaking of the arms and head. There is no tremor of the face or of the eyes; no nystagmus. The speech is slow and scanning in type, and becomes dysarthric and difficult to understand during excitement.

Asthenia.—The gross motor power of the arms and legs is undisturbed. In the upper extremities, however, there is a distinct inability to sustain prolonged muscular contractions (intermittent asthenia). This is not so evident in the lower extremities where the tremor is comparatively slight.

Hypotonia.—The muscles are well developed and show no signs of atrophy. There is, however, some hypotonia of the upper extremities. The joints and muscles are flaccid and relaxed and the Stewart-Holmes sign of hypotonia is present.

Dyssynergia and dysmetria.—If single movements are studied, like those of the extensor indicis, evidences of dyssynergia and dysmetria are demonstrable. These are also present in the larger movements of the upper extremities and to a lesser degree in the lower extremities.

Adiadokokinesis is present in both upper extremities.

Sensation.—Superficial and deep sensibility are normal. Vision, smell and hearing are normal.

Reflexes.—Supinator, biceps and triceps jerks are equal and normal. The knee-jerks are present and equal, not exaggerated. The ankle-jerks are present and equal, and there is no clonus. The cremasteric and abdominal reflexes are present and equal. Plantar stimulation produces flexion of the toes; no Babinski.

Cranial nerves.—Pupils are equal and react promptly to light and accommodation. Ocular excursions are normal; no nystagmus; the optic discs are normal in appearance. Innervation of the soft palate, tongue, and muscles of mastication are normal.

General examination.—Patient is a strong, robust looking man; no pigmentation of the skin or cornea. Heart and lungs are normal; urine is normal. Wassermann tests of the blood and cerebrospinal fluid are negative. No increase of cells or of globulin in the spinal fluid.

Chapter II.—Analysis of the Symptomatology.

General remarks.—The three cases which have been described are similar in their symptoms and clinical course. They differ only in degree and in the duration of the disease.

In all, the symptomatology is limited to a more or less generalized tremor during muscular activity, which is especially severe in the extremities. Associated with and underlying the volitional tremor, are symptoms of dyssynergia, dysmetria, adiadokokinesis, asthenia and hypotonia. In all other respects the neurological examination is negative. There is no nystagmus, no objective vertigo, no disturbances of the static or kinetic equilibrium, and no convulsive seizures. The intellectual functions are intact and the optic nerves are normal. Occasional frontal headaches were observed in all of the cases. These were never severe and were not associated with nausea or vomiting. Subjective sensations of giddiness and vertigo were present at times, especially in Case 1. This was not associated with a feeling of rotation or of movements of external objects, and was apparently caused by the constant shaking of the head. In none of the cases was there a family history of tremor, or evidence of a tremor tendency before the onset of the disease.

The tremor. — The intention tremor is the most striking and characteristic symptom of the disease. This begins in one extremity and progresses slowly, involving gradually and successively the remaining

portions of the body. Three or four years were required for the tremor to become generalized. It consists of a coarse, irregular, atactiform shaking or " Wackeln " on attempting any movement. The tremor movement is slow, ranging from three to five vibrations a second; both the rate and amplitude are increased by mental and physical activity. It ceases entirely in a relaxed or recumbent posture and is consequently absent during sleep. It may happen, if the paroxysms of motor agitation have been prolonged and severe, that some after-tremor may persist, even during rest. This, however, is only observed after unusual efforts or excitement and is of short duration, gradually subsiding with rest and quiet.

If in a relaxed or recumbent posture with the muscular system quiescent, the slightest attempt is made to innervate a muscle, the tremor immediately reappears. It will sometimes happen that the head and extremities are not well supported in the recumbent posture, and some motor perturbation continues even in a state of apparent rest; this persists until the patient is placed in a more favourable position in which the muscular relaxation is complete.

In its severer form, the gait is affected and becomes jerky and uneven, the head is in constant and violent oscillation, the face tremulous, speech scanning and explosive, and the arms are tossed and thrown about in a most bizarre and random manner. In this state of general motor agitation the appearance of Huntington's chorea is more or less suggested, except that the character of the movements is irregularly tremulous rather than choreiform. There is no true nystagmus on fixation of an object with the eyes. If, however, the tremulous shaking head is firmly held and the tremor thus checked, it may overflow and reappear as an oscillation of the ocular movements. At times there are spontaneous rhythmical and rolling movements of the eyes. These may also occur on fixation of an object and are related to the general motor disturbance, and have not the character or constancy of true nystagmus.

There are days, and sometimes longer periods of even weeks, during which the tremor suffers temporary exacerbations. After the subsidence of these crises of tremor there is a return to the usual chronic condition. The whole course of the disease is chronic and slowly progressive, and the motor life becomes more and more restricted; so that the patients in time are almost entirely dependent upon the care of nurses or relatives. Once established, the tremor never disappears, except during rest. In one patient it was exaggerated by cold.

Those muscles which are concerned in the performance of certain automatic functions, like the diaphragm and intercostals, show but slight involvement, and this only during paroxysms of tremor. On such occasions, jerky respiratory movements are not infrequent; at rest in a recumbent position the breathing is regular and uninterrupted. The large muscles of the trunk are but little affected in comparison with the extremities; this is shown by oscillations and tremulous movements of the body in the sitting and erect posture, and by occasional contractions and stiffening of the abdominal musculature.

The tremor is therefore greatest where the voluntary muscular activity has reached its highest degree of functional development and differentiation, as in the upper and lower extremities, and in the head and neck.

The dyssynergia and dysmetria. — The general disturbance of motility is so gross in these cases, that in order properly to study the motor phenomena it is necessary to analyse such movements as require the contraction of a single muscle only or of a small number of muscles. A study of isolated single movements will reveal immediately a difficulty in controlling the measure and association of such movements (dysmetria and dyssynergia). The movement occurs too brusquely or with undue force, so that the aim is over-reached; or it may be insufficient and fall short of the object. This disturbance is usually greater on first efforts or if it be requested that the movement be performed quickly.

Closure of the eyes has no apparent effect upon these motor disturbances, which are very evident in the various segments of both the upper and lower extremities, but which are to a large extent concealed and masked by the tremor.

As a preliminary to performing these tests, the patient should be placed in a recumbent or sitting posture with the arm relaxed and supported by a pillow, preferably with the hand prone. In this position all spontaneous tremor may be eliminated. If the patient is then requested to raise (extend) and then drop the index finger, a disorder of the movement becomes evident at once. In an effort to repeat rapidly the movement of lifting and then letting fall the index finger, it is over-extended and is held fixed in this position of over-extension, and immediate decontraction does not take place; or it may be that two or even three successive attempts are first made before the finger is brought into a position of extension. Then instead of the simple normal relaxation which would allow it to fall almost by its own weight, it is brought down with undue force by a contraction of the flexor muscles. In

other words, there is an inability to carry out quick, rhythmical movements, requiring contractions and relaxations of a very simple kind.

If during these attempts at rhythmical extension of the index finger the muscles of the forearm are encircled by the examiner's hand, it will be observed that with the effort to contract the extensor indicis strong simultaneous contractions of the flexor muscles of the forearm frequently occur, indicating a disturbance in the harmony of the association mechanism of movement (dyssynergia). Such disturbances of the synergy and the measure of movements are even more apparent when larger and more complicated co-ordinated acts are attempted, such as extension of the hand, flexion of the forearm, and the like.

The presence of these disorders of motility gives an insight into the true nature of the tremor, and explains the general motor agitation which is produced whenever the muscular system is thrown into action. With the very evident lack of control in regulating single movements, it does not seem surprising that the patient is utterly at sea in the effort to control the muscles during the activity of an entire extremity. In the effort to control and regulate the muscle synergies under these conditions we have produced the coarse atactiform tremor which is characteristic of the disease.

Adiadokokinesis.—The adiadokokinesis of Babinski is also typically present in these cases. Because of the tendency to general tremors of the arm, this symptom may also be tested to advantage with the arm relaxed and the hand resting on a table. In this position, it is apparent that the power to perform quick successive rhythmical movements is very much diminished. The initial movement is prolonged or insufficient, relaxation does not take place at the proper time, and the succession movements are therefore slow and interrupted. The close relationship of this symptom to the dysmetria and dyssynergia is also very evident.

Intermittent asthenia.—Although the patients tire readily, there is no true paralysis in this group of cases. There is, however, a curious disturbance of the innervation which is best designated as intermittent asthenia. This consists of an inability to sustain or fix muscular contractions except for brief periods of time. For example, if a patient is asked to grasp the hand of the examiner and to maintain the grip firmly, this is found to be impossible. The patient grips the hand firmly at first, and sustains the contraction for a few seconds (five to ten seconds), when spontaneous relaxation takes place. Another attempt is then immediately made only to suffer relaxation again, and even with the greatest effort the contractions cannot be sustained, and are interrupted by spontaneous and involuntary relaxations.

Again, if an attempt is made to hold out the extended arm at right angles, it will be observed that in spite of every effort it tends to fall from the horizontal position and is again thrown back into the horizontal. After this effort has been repeated a few times the arm suddenly falls to the side, the patient apparently being unable any longer to sustain the muscular contractions. After a short period of rest the test may be repeated but with the same result. This inability to sustain contractions may also be demonstrated in flexion movements of the arm, dorsal flexion of the foot, abduction of the arm; in short, any of the movements of the extremities. The efforts to carry out such tests of the motor power are accompanied by considerable fatigue.

In the demonstration of this test, as in those for the dysmetria and dyssynergia, it is preferable that the arm be relaxed and at rest on a table, thus eliminating as far as possible the volitional tremor.

In some respects, this symptom of intermittent asthenia is the reverse of what Babinski has described as cerebellar catalepsy, the ability to fix unduly and immobilize a movement. It is possible that the cerebellar catalepsy is an irritative or spasmodic manifestation while the intermittent asthenia results from the loss of certain cerebellar functions of control.

It is of interest to note, that the intermittent relaxation does not occur when the muscles are contracted independently of the will by strong faradic currents.

Hypotonia.—In the recumbent posture with the muscular system relaxed, palpitation shows the muscles of the extremities to be soft and flabby and the joints unduly relaxed and flexible. This condition of hypotonia is present in both the upper and lower extremities, more especially in the arms. This is by no means so extreme as in certain cases of tabes dorsalis, and while the joints may be unduly extended, the limbs cannot be placed in those abnormal attitudes which is sometimes the case in the severer forms of spinal hypotonia.

The Stewart-Holmes sign of hypotonia in the upper extremities is present: i.e., a failure of the recoil or rebound on resisting a flexion movement of the arm and suddenly releasing it. In performing this test, it is found that the flexion movement of the arm after its sudden release is continued until mechanically checked, there being no reflex contraction of the antagonists, the extensors of the upper arm.

The myotatic irritability of the muscles is unchanged and the tendon reflexes are of normal intensity, showing neither special increase nor diminution.

Chapter III.—Differential Diagnosis.

In general appearance, the motor disturbance which characterizes the progressive cerebellar dyssynergia is similar to the intention tremor of multiple sclerosis. It differs, however, in the slow and gradual manner of progression and the strict limitation of the symptomatology to tremor and the associated dysmetria, dyssynergia, hypotonia, and intermittent asthenia.

All other symptoms of multiple sclerosis, such as nystagmus, objective vertigo, pyramidal and sensory tract symptoms, temporal pallor, hemiplegic attacks, forced laughter, alterations of the reflexes are absent; so that a cerebellar type of this affection may be reasonably excluded.

The pseudo-sclerosis of Westphal may also be eliminated by reason of the strict limitation of the symptomatology to the volitional tremor, together with the absence of mental deterioration, pigmentary deposits and the other symptoms which characterize the recorded cases of this obscure affection.

The theory of a functional disturbance, in the nature of hysteria or the traumatic neurosis, is not tenable in the absence of an adequate etiological factor, and the mental and somatic symptoms which characterize these affections.

The rare tremor type of Parkinson's disease may likewise be excluded by reason of the nature of the tremor and the existing hypotonia and dyssynergia, which differ fundamentally from the muscle manifestations which characterize this affection.

Huntington's chorea, athetosis and myoclonus multiplex are readily differentiated by the character of the motor disorder and persistence during muscular relaxation.

Of especial importance from the diagnostic standpoint is the group of the so-called essential, hereditary or family tremors, the first systematic description of which was given by Dana in 1887. In the original description of this affection the clinical picture was defined by Dana [3] as follows: "The affection in question consists of a fine tremor, constantly present in typical cases during waking hours, voluntarily controlled for a brief time, affecting nearly all the voluntary muscles, chronic, beginning in very early life, not progressive, not shortening life, not accompanied with paralysis or any other disturbances of motor function. It resembles to some extent the tremor of paralysis agitans, still more a simple neurasthenic tremor. It ceases during

sleep, and can be inhibited temporarily by the will. It does not interfere with delicate co-ordination. It neither stops nor increases on ordinary voluntary movements."

At the present time there is an extensive literature treating of this subject (Flatau [4]), the great majority of the recorded cases coinciding in the main with the clinical picture as outlined by Dana. In a few, however, the tremor is described as coarse ataxic and of the intention type, and especially in those cases recorded by Minkowski [6] and Graupner [5] the tremor was gradually progressive and of a severe intention type. The resemblance of such cases to those which are the subject of this study is very striking, and it is not improbable that some of the cases which are now grouped with the hereditary and essential tremors would show on closer examination the same progressive disturbances of the cerebellar function as do the cases which are the subject of this study. It is certainly desirable that the cases of so-called hereditary and essential tremor should be approached from this point of view.

From my own investigations, I am inclined to make a sharp distinction between the hereditary tremor of the type described by Dana and the motor disturbance which is here described as progressive dyssynergia. This is not a true tremor, but a synergic disturbance which is evident only when the extremity is in action, and consists of coarse irregular tremor-like movements in which the constant, vibratory characteristics of the true tremor is almost entirely lacking.

Furthermore, the cases of essential tremor which have come under observation during my investigations of this subject have failed to show the gradual mode of progression, and the associated symptoms of cerebellar disturbance which characterize the dyssynergia.

It may be well to emphasize the fact that in none of my cases of progressive cerebellar tremor was there any hereditary tendency or the slightest indication of tremor before the onset of the disease, which is so common a forerunner of the essential tremor neurosis.

Chapter IV.—The Relation of the Symptomatology to the Cerebellar Mechanism.

The more recent clinical and experimental studies of cerebellar function have shown very clearly that this organ, in addition to the role of maintaining equilibrium, plays an important part in the regulation and control of voluntary movements.

It is this function of the cerebellum which shows evidence of disturbance in dyssynergia progressiva. The absence of nystagmus, objective vertigo, cerebellar fits and disorders of the equilibrium would indicate that the structures subserving those functions are not affected.

The special influence which the cerebellum exercises upon voluntary movements is that of a controlling and reinforcing mechanism which is directly concerned with the regulation of tone, and the direction and measure of movements, the maintenance of attitudes, and the control of the synergies of co-ordinated movements. When these functions are disturbed there result the recognized classical symptoms of cerebellar origin; hypermetria, dysmetria, hypotonia, asthenia, cerebellar ataxia, volitional tremor and asynergia.

All modern authorities agree that the synergic function of the cerebellum is one of special importance. This is the faculty of accomplishing simultaneously and harmoniously the several movements concerned in a co-ordinated act. A disturbance of this function produces asynergia, which is so important a factor in the production of the cerebellar ataxia.

The cerebellar tremor, which is a volitional tremor, is also closely related to the loss of synergic control, and is regarded by most investigators in this field as an expression of asynergia. In other words, cerebellar tremor and cerebellar ataxia may be summed up as a cerebellar asynergia.

Babinski [1] has expressed this view in his brochure published in 1906, as follows:—

"The intention tremor which was first observed in multiple sclerosis is, according to all appearances, due to an alteration of the cerebellar mechanism. It may be explained by a defect in synergy among the different elementary movements of the upper extremity and more particularly in a disharmony in the function of antagonistic muscles."

Stewart and Holmes [9], in a discussion of the symptomatology of cerebellar tumours, record the interesting fact in their remarks upon cerebellar ataxia that "in cases of chronic course, or when the lesion has became latent, the ataxia is as a rule less definite. Then it may be less typical and approximate to the intention type, characteristic of disseminated sclerosis."

My own observations of the progressive cerebellar tremor fully confirm this point of view, namely, that intention tremor is essentially a disturbance of the synergies of muscles, and for this reason

the designation progressive cerebellar dyssynergia was chosen, as best expressing the true nature of the motor disturbance and its relation to the cerebellar mechanism.

If the symptomatology of the group of tremors under discussion is given careful consideration it becomes apparent that in all respects it is identical with the recognized symptomatology of cerebellar disease. There is the same hypermetria, dysmetria, hypotonia, asthenia, asynergia and tremor. All are present in their most exquisite form.

The exact localization of these functions in the cerebellar mechanism is still unknown. It can hardly be doubted, however, from recent experimental, anatomical and clinical investigations, that the cerebellar hemispheres (the "neo-cerebellum") are chiefly concerned with the regulation of the activities of voluntary movements.

Furthermore, the studies of Van Rynberk [8], Bárány [2], and Rothmann [7], have shown that there is a cortical representation in the cerebellar hemispheres, not only of the extremities but also, in all probability, their individual segments and articulations; so that the existence of cerebellar cortical centres for the control of co-ordinated movements is by no means improbable. If these results are confirmed, we have here represented the cortical mechanism for the control of voluntary movements, the loss of which results in these various motor disturbances of cerebellar disease.

In dyssynergia cerebellaris progressiva the clinical symptoms would indicate a progressive disease of that portion of the cerebellar mechanism which is engaged in the regulation of the tone, measure and synergies of co-ordinative movements. It begins gradually, and in the manner of an organic degenerative affection slowly affects the entire mechanism of the cerebellum. Apart from this, there are no other symptoms, the clinical picture is one simply of more or less generalized dyssynergia. For these reasons I believe that in this affection we have to do with a progressive degeneration of certain specialized cell or fibre systems of the cerebellar mechanism, the exact localization of which must await the results of pathological investigation.

Summary.

The results of my investigations may be summarized as follows:—

There exists a chronic progressive form of cerebellar tremor, the most striking and characteristic symptom of which is a generalized volitional tremor which begins locally and gradually progresses.

In its advanced stage the disorder of motility is comparable in severity and violence with that of Huntington's chorea or the generalized athetosis. There is, however, this difference, that in a position of rest and muscular relaxation the tremor movements cease.

An analysis of the motor disorder show a marked disturbance of the ability properly to control and regulate co-ordinated movements. This is shown by the presence of hypermetria, dysmetria, adiadokokinesis, dyssynergia, hypotonia, and intermittent asthenia.

All of these symptoms, including the volitional tremor, coincide with the classical symptomatology which results from a loss of the cerebellar control over voluntary movements. The disorder is, therefore, regarded as of cerebellar origin.

The local onset, gradual progression, and chronic course indicate a progressive degeneration of certain special structures of the cerebellar mechanism presiding over the control and regulation of muscle movements.

Other symptoms of cerebellar disease, such as disturbances of equilibrium, objective vertigo, nystagmus, cerebellar fits and seizures are absent. For this chronic progressive disorder of the cerebellar mechanism the name *dyssynergia cerebellaris progressiva* is suggested as best indicating the essential element in the motor disturbance (dyssynergia), its progressive tendency and relation to the cerebellum. The chronic progressive cerebellar tremor is, however, equally descriptive and may be found preferable.

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