THE SYMPTOMS OF ACUTE CEREBELLAR INJURIES
AS OBSERVED IN WARFARE.

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(Continued from p. 475.)

(C) The Rebound Phenomenon.—Several years ago in a paper written in collaboration, Dr. Grainger Stewart and I pointed out a sign of cerebellar involvement that is of considerable importance in the interpretation of the disturbances of voluntary movement produced by this condition. The patient’s elbows are supported on a bed or table and he is asked to pull each hand in succession towards his mouth against resistance offered by the observer who grasps his wrists; when this resistance is suddenly released the hand of the affected side flies to his mouth or shoulder, often with considerable violence, but the movement of the normal limb is arrested almost immediately by a contraction of the antagonists (triceps), and may even be jerked back or rebound. The rebound is excessive in spastic limbs.

The absence of this rebound may be demonstrated in various other actions, as extension of the elbow, elevation or depression of the arm at the shoulder, flexion or extension of the hip and extension of the knee. It occurs only on the same side as the lesion when this is unilateral, but it is seen on both sides when the wound is bilateral. It is only necessary to resist any movement which the patient attempts to perform and remove the resistance suddenly; then the limb or the segment of the limb which he wishes to move swings unchecked or excessively in the direction of the movement attempted and is not quickly arrested as the normal invariably is. If a hand is placed on the antagonistic muscles it is found that these do not contract, or they come into contraction too late.

The occurrence of this “rebound phenomenon” in lesions of the cerebellum has been confirmed by other observers (Bing, André-Thomas) and it was easily demonstrable in all cases of my present series in which there were moderate or severe lesions. As a rule it was equally pronounced at all joints, though it was usually more definite in the upper than in the lower limb, and more easily evoked at the proximal than at the distal joints. It often happens that it becomes less easy to demonstrate after it has been tested for several times, owing to a voluntary effort on the part of the patient to suppress it, especially if the unchecked movement may produce pain or discomfort.

A similar inability to arrest passive movement quickly may be seen if the observer supports the elbow with one of his hands, while with his
other he first moves the patient's forearm about aimlessly and then unexpectedly throws the hand towards his face. The passive flexion of the normal arm is quickly checked, but the affected hand flies, often violently, into the patient's face, just as a flaccid paralysed limb or a loosely-hinged rod would.

Further, if when his elbows are supported, the patient attempts to flex and extend his forearms alternately as quickly as possible the range of movement on the affected side is often excessive, and more than one patient has complained that he has actually jarred or hurt his elbow-joint by the excessive flexion, which is arrested only by the structure of the joint or by its ligaments, and not by contraction of the antagonistic muscles.

This phenomenon is always most pronounced in the early and acute stages of a cerebellar injury and diminishes gradually as improvement sets in. It is consequently more prominent when the limbs are hypotonic, but its relation to hypotonia will be discussed later.

(D) *Adiadochokinesis.*—Babinski originally pointed out that a patient with cerebellar disease is almost always unable to execute alternate movements as quickly and correctly as the normal person, and he termed this symptom adiadochokinesis. It may be tested at any joint at which such movements can be easily and rapidly performed, as flexion and extension, or pronation and supination of the elbow, or flexion and extension of the fingers, ankles, or toes.

When a patient with a unilateral cerebellar injury is asked to pronate and supinate his forearms alternately and as rapidly as he can a very striking difference is noticed between the movements on the two sides, as the rate of the alternate movements of the homolateral limb is slower and much less regular, their range is less uniform, and both the slowness and the irregularity in rate and range become more pronounced the longer the effort is continued. In slight injuries the awkwardness of the attempt and the apparently greater effort necessary for it on the patient's part are more striking than the slowness of its execution, and in very limited lesions or when recovery sets in only this awkwardness and incompleteness may be observable.

Further, while the other joints of the normal limb remain fixed, on the affected side various adventitious movements occur, as irregular flexion or extension of the fingers and more particularly flexion and extension of the elbow, or adduction and abduction at the shoulder. These are generally obvious at once, but if not pronounced the observer by placing his hands under the elbows can feel that while that of the unaffected arm remains steady, the other is jerked about irregularly. Similar adventitious movements at the wrist and elbow can be often observed when rapid flexion and extension of the fingers are attempted, and in the knee and ankle when he is asked to move his toes only.
If the limb is hypotonic part of the adventitious movements may be attributed to flail-like flopping of its distal segments; when for instance the elbow is rapidly flexed and extended the wrist swings about inertly, flexing as the hand is brought towards the shoulder and extending as the elbow is rapidly straightened; and in the same test the elbow is often raised from its support by the momentum of the flexing arm. They depend partly therefore on the failure of the fixing muscles to preserve the correct posture of those segments of the limb that should not move. But there can be no doubt that they are largely due to the active contractions of muscles that are not directly concerned in the act attempted by the patient; this can be easily determined if the arm and shoulder muscles are carefully palpated while rapid pronation and supination of the forearm is attempted; or if a hand is placed on the thigh as the patient attempts to flex and extend his toes rapidly the irregular contractions of its muscles, which produce movement of the knee, can be felt. There is consequently a tendency to an irregular spread of the innervation to other muscles than those which under normal conditions execute the act. When the test is prolonged the movements which the patient wishes to perform may be in fact largely replaced by irregular aimless displacements of other segments of the limb.

Occasionally even the active muscles do not work together accurately and harmoniously, and this increases the awkwardness and irregularity of the patient’s attempts; in rapidly flexing and extending the fingers for instance, all these at first move together as they invariably do in the normal limb, but after a time they frequently get out of line and cease to flex and extend simultaneously or to the same extent. I have even seen the thumb bent involuntarily into the hand and thus interfere with the excursions of the fingers.

The slowness and irregularity can be equally well seen in more complex actions, as in shaking hands, clapping hands, rubbing a mark off a sheet of paper, stamping his feet, etc. When a patient attempts to clap hands both arms generally move at first, but the affected one soon comes to a standstill and is then only passively displaced by the blows of the normal hand.

The causes of this disturbance can be more easily analysed if some simple action, as tapping a table or the observer’s hand, is carefully examined. In the first place the range of movement is irregular; his hand is occasionally raised too high or brought down too firmly, but more commonly it is smaller than that of his normal limb. Often indeed the movement is arrested too soon and the hand may not actually come to the table. The slowness is due chiefly to delay at the turn and not to time lost in the movements themselves, for there is rarely much difference in the rate of these and of those of the normal limb.
The principal features of adiadochokinesis may be seen in figs. 8 and 9. Fig. 8 reproduces tracings of alternate pronation and supination of the forearms, in a patient with a right-sided lesion in whom this symptom was rapidly disappearing. The range of the excursions of the affected (right) arm was fairly regular, though on one occasion the movement was checked in semi-pronation, but it was considerably smaller than that
of the normal limb; the slower rate was due chiefly to time lost at the turn and to slowness in the initiation of each sequence of muscular contractions. In fig. 9 tracings obtained from rapid flexion and extension of the fingers are reproduced; here the same features are present, but the delay at the turn of the movement, and especially in extension of the fingers, is more obvious.

The occurrence of adventitious movements certainly contributes to the awkwardness and slowness, since they confuse the patient in his efforts, and often put the contracting muscles at a mechanical disadvantage. Consequently we can conclude that the condition described by Babinski as adiadochokinesis is due to disturbance of the range of movement and to a slowness in initiating each excursion of the limb, while the occurrence of adventitious movements is partly due to lack of proper co-operation on the part of those muscles which should fix other joints of the limb, and partly to irregular purposeless contractions of other groups of muscles.

Frequently such alternate movements can be better performed by the affected limb when it is tested alone than when both limbs are examined simultaneously. The normal person generally finds it easier, or at least as easy, to perform such rapid alternate movements simultaneously with his right and left limbs as with either separately, but when a unilateral cerebellar lesion exists the more rapid movements of the normal limb seem to confuse those of the affected one and disturb their sequence. The patient has, consequently, to attempt two different actions at once instead of the same action simultaneously with his right and left limbs.

Adiadochokinesis can usually be demonstrated at all joints of the affected limbs, even when only limited lesions exist, but it is usually more pronounced in the arm than in the leg and in complex than in simple actions. During recovery the slowness, irregularity and awkwardness diminish gradually, but adiadochokinesis is one of the most persistent of the ordinary signs of cerebellar injury.

The majority of the abnormalities of movement described above refer to those in which the larger and more proximal groups of muscles are concerned, but similar disturbances can be observed in the finer and more elaborate actions of the hand which are peculiar to the anthropoid, and especially to man. The slowness, awkwardness and irregularity of the finger movements in handling objects, and the difficulty in bringing each finger of the affected hand separately and accurately to the tip of the thumb have been described above, but these defects are even more apparent when the patient attempts to use simple and familiar tools. When a man with a right-sided cerebellar lesion was given a pair of scissors he had, in the first place, difficulty in grasping them, correctly, then failed to direct them properly and was unable to move the blades regularly and appropriately when he attempted to cut a piece of paper with them.
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In writing, too, these disturbances are very obvious when the wound involves the right half of the cerebellum. The pencil is held incorrectly and insecurely, grasped too tightly, and its point is pressed much too firmly on the paper. The letters are frequently unequal in size and irregularly spaced; the individual letters are badly formed and their lines are often jerky and angular. Further, as he writes it can be seen that he pauses frequently, especially between the up and down strokes, and the movements of his pencil are consequently interrupted and discontinuous. If he uses a pen he is liable to run its point through the paper and make ink splashes; his attempt with it is therefore less successful (fig. 10).

Fig. 10.—Specimens of the writing of two men with right-sided cerebellar injuries. The upper is of the words, "Raymond, yesterday"; the lower, "I have been eight weeks ill."

Static Tremor.

I have not observed tremor in any case while the limbs and body were at rest and fully supported, but it often appears during the maintenance of posture that requires muscular contractions. That which occurs during movement has been already described as a component of "cerebellar ataxy."

When a patient with a unilateral cerebellar lesion sits or stands there is frequently tremor of his head, which usually consists of fine or moderate irregular oscillations in any or all directions; it increases as he becomes tired. Similarly, when standing his whole body is often displaced by larger and more irregular swaying movements. This unsteadiness seems to be due to irregular and discontinuous contractions of the muscles that should maintain the attitude.

Tremor is as a rule seen in the affected limbs only when he strives to adopt a posture or as they tire, which they do more rapidly than the normal. When an attitude is once attained, as when his arms are outstretched horizontally in front of him, or his legs raised from the couch and flexed to right angles at the hip and knee, the affected limb is usually held for a
time as steady as its fellow, and often indeed even more so. It is noteworthy that the fine vibratory tremor which can often be seen in the normal arm, and even more distinctly felt, when it is held rigidly extended and unsupported, is generally absent in the affected limb; in one case its absence was so obvious that the photographer who exposed a plate as the patient held his arms in this position remarked how much steadier the affected one was. This condition corresponds to that which Babinski has described as cerebellar catalepsy, or the property of limbs remaining for a long time immobile under the influence of will; but otherwise I have seen no evidence of this symptom in the earlier stages of cerebellar lesions. On the contrary, when the limb begins to tire, and especially if it is still asthenic, a coarse tremor often develops, which is partly due to failure of sustained contraction of the fatigued muscles, but largely to the repeated voluntary attempts of the patient to bring it back to the position from which it tends to fall away. The tremor which occurs in these conditions is comparable to nystagmus and consists of two phases, namely, slow displacements by gravity and quicker voluntary jerks back towards the original position.

Before describing the abnormalities of standing and gait produced by unilateral cerebellar lesions, it is advisable to consider other symptoms which influence them. These are particularly the attitude assumed by the patient and the occurrence of vertigo.

Vertigo.

Many text-books include vertigo among the symptoms of cerebellar disease, but much doubt has been thrown on its direct relationship to cerebellar lesions; in fact, most authorities attribute it to affection of the labyrinth, or of the vestibular nerve or its nuclei.

Giddiness is an extremely common symptom after all gunshot injuries of the head, and almost all patients in whom the cerebellum is involved state on questioning that they were giddy at first or after regaining consciousness. From many of these no accurate description of the sensation could be obtained; but this is not surprising as most men are dull, obfuscated and unobservant for some time after being wounded in the head. Seventeen men, however, described apparent displacement of self, or of external objects, or of both. In twelve of these self and the external world seemed to be simultaneously displaced; in three there was apparent movement of self only, and in two solely of the external world. In fourteen of these seventeen cases the displacement took the form of rotation around the longitudinal axis of the patient’s body; in two they were in the vertical plane; while one man stated that the walls of the room in which he lay seemed to be receding from him.

Among these fourteen patients the same difficulty was experienced in
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attempts to determine definitely the direction of the rotation, since the vertigo rarely persisted more than one or two days. In almost all the subjective rotation of self and the movement of the outer world were in the same direction, but no constant relation could be discovered between the direction of the rotation and the site of the injury. In a series of cases of cerebellar tumour Dr. Grainger Stewart and I found that when vertigo occurred in patients with unilateral lesions the sense of movement of self and of external objects was from the side of the lesion towards the opposite side; but my present series, in as far as one can rely on the statements of the patients, does not confirm this rule.

It is interesting, however, that in the only three cases in which vertigo associated with actual movement occurred under observation, the patients rotated from the affected towards the opposite side (i.e., the shoulder of the affected side moved forwards) and the apparent movement of the external world was in the same direction. In the early stages of other cases too, there was a noticeable tendency for the patients to lie on the affected side. Some expressed considerable reluctance to rest in any other position, though one man stated that if he fell asleep lying on this side he was liable to roll over on his face. Consequently when "forced movements" were observed they took place in the same direction as they do in animals after ablation of one half of the cerebellum.

Further, the common attitude of a patient with a unilateral cerebellar injury, the head rotated towards the opposite side and the homolateral shoulder in advance of its fellow, may be looked upon as a latent tendency to rotation in this direction.

In the two cases in which during vertiginous attacks a sensation of vertical displacement only occurred, external objects seemed to rise in front of the patients, and one man complained that simultaneously his head seemed to be sinking back through the pillow. In both of these men the wound was over the middle of the posterior surface of the cerebellum, which was also much the most common site in the series as a whole.

Spontaneous Deviation of the Limbs and the Pointing Test

which Báránys has described, especially in connexion with labyrinthine vertigo, may be dealt with here.

In order to examine for spontaneous deviation of the upper limbs the patient is asked to hold both arms extended horizontally in front of him and close his eyes. It is advisable for the observer to steady his hands and check any tendency to movement till his eyes are closed. Then in the majority of cases with unilateral lesions the homolateral arm swings either slowly or abruptly away from the symmetrical position and comes to rest gradually. This occurred in all the thirty-three
-cases in which it was looked for. In thirty-two the arm swung outwards, and in one slightly inwards, but the latter case, in which one lateral lobe of the cerebellum was almost completely destroyed and death occurred on the third day, may be neglected as the arm was so asthenic that it could scarcely be raised. We may consequently assume that the involuntary deviation of the unsupported arm is almost constantly outward.

While the observer’s hands are steadying the patient’s arms he can often feel a definite tendency to active displacement of the homolateral arm in this direction.

When in slight injuries this deviation is not obvious, it may be brought out by shaking or tapping the affected arm, this then generally moves in the direction towards which it tends to deviate.

Frequently the arm also deviates upwards or downwards from the level in which it was originally placed.

Bárány’s pointing test confirms these observations. The patient’s extended forefinger is placed in contact with some fixed object, as the observer’s finger, which is held at some distance above the bed, and he is then asked, while his eyes are closed, to bring his finger down to the bed and slowly up again to the object; with his normal arm he can reach the mark accurately or approximately on each attempt, but in most cases the forefinger of the affected side deviates constantly to one side of it, and this deviation increases for a time if the test is continued. In order to avoid conscious efforts to correct the error it is advisable for the observer to allow the moving finger to strike a similar object that can be moved into contact with it; if a tape measure is held horizontally in such a position that the patient’s finger must touch it the error in each movement can be easily measured. If the more proximal segments of the limb are fixed the tendency to deviation of its distal segments can be investigated in the same manner. In the early stages of an extensive injury, the homolateral limbs are often so asthenic and ataxic that the test cannot be easily employed.

In all the thirty-two cases of unilateral lesions, involving different parts of the cerebellum, in which the arms were tested, a tendency to deviation was observed in the limbs of the affected side, and in all the deviation was outwards from the vertical when the arm was moved at the shoulder only. In certain cases vertical movements at the elbow and wrist were also examined, and in these, too, the deviation was constantly outwards, though the error was here much smaller.

In twenty-seven cases movements in the horizontal plane were similarly investigated; in nine progressive deviation upwards occurred, in seven the error was downwards, in six there was no tendency to deviation, and in the other five the direction of the error was irregular. The direction of the error in horizontal movements is not, however, always constant, in a few cases it was in one test upward and in another downward.
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When this test is first seen these errors towards a fixed point in movements that are not controlled by vision suggest strongly a disturbance of the sense of position or of the appreciation of movement ("muscle sense"), in the affected limb, but it can be easily demonstrated that this does not exist; the patient can, for instance, while his eyes are still closed, bring his other forefinger accurately and promptly to the tip of that one which is actually several centimetres distant from the point he wishes to touch by it, showing that he is fully aware of its position in space. This can be confirmed by other tests too.

A tendency to deviation of the lower limbs is less common and the error is less pronounced when it exists. It is remarkable, however, that while the affected arm constantly, or almost constantly deviates outwards, the homolateral leg generally swings inwards (adducts), or is raised obliquely upwards and inwards over the opposite limb. In fifteen cases the pointing test was applied in vertical movements; in four there was no appreciable error, in two the leg deviated outwards, and in nine progressively inwards.

Another feature brought out by the pointing test is a remarkable tendency of the affected limb to overshoot the mark; while the normal limb is arrested at or near the position of the object which the patient wishes to touch, the affected one almost always swings past it, and often as much as $30^\circ$ to $45^\circ$ beyond it. This is obviously a manifestation of dysmetria; no disturbance of any form of sensation that could be responsible for it was demonstrable in any case.

Attitude.

Abnormal attitudes, which are such a prominent feature in animals after experimental lesions of the cerebellum, are much less constant and striking in man. Considerable importance has, however, been attached to the position of the head in cerebellar disease, especially when the affection is unilateral; in gunshot injuries its significance is generally doubtful, since the wound frequently involves the cranial attachments of the neck muscles, and because the patient naturally assumes the position which is most comfortable or which gives him least pain. As a rule, however, the head tends to be flexed towards the side of the wound and rotated towards the opposite side, so that the chin approaches the contralateral shoulder and the occiput is consequently approximated towards the shoulder of the affected side. This is particularly striking in cases in which the wound has healed.

Special attitudes of the trunk are less obvious, but in the early stages of an injury the body is often concave to the side of the lesion even as the patient lies on his back; this is usually more prominent when he sits up, but as he then inclines to and tends to fall towards this side the
upper part of his trunk is often purposely bent over in order to maintain equilibrium so that his spine is convex in this direction.

In certain patients, especially in those who are still or were recently subject to vertigo, the upper part of the trunk also tends to rotate towards the unaffected side (i.e., the homolateral shoulder is advanced), especially when they close their eyes; this attitude can be made more distinct by gently shaking the bed or the chair on which they sit.

In some of my patients, and particularly in those in whom the vermis cerebelli was also involved, the face was stolid and expressionless.

The flaccid and hypotonic limbs generally assume any posture into which they fall or are moved, or which may be given them by gravity, but when the patient holds the arms outstretched that homolateral to the wound is frequently more abducted than its fellow, and in several cases it is described in my notes as more rotated inwards at the shoulder and pronated at the elbow. In a few cases the hand of this side tended to be saddle-shaped, with the wrist flexed and the fingers hyperextended at the metacarpo-phalangeal joints, when the arms were held out.

There is no common noteworthy attitude of the lower limbs as the patient sits or lies in bed.

Standing and Gait.

When a patient who is able to leave bed is placed on his feet for the first time he is shaky, uncertain and unsteady, his whole body sways irregularly, his head oscillates, and he is usually in considerable danger of falling, especially towards the side of the wound and backwards. It often seems as if he were impelled to this side; several patients have, in fact, complained that they felt that they were pulled over, as though by an invisible hand, in this direction. It is, however, remarkable that even after being confined to bed for several weeks with a wound of one side of the cerebellum the patient can generally maintain his equilibrium, and make awkward though appropriate and often successful attempts to recover it if it is threatened. At this stage his attitude in standing is very striking; his head and trunk are both inclined to the injured side and his spine is concave to it, but his pelvis is so tilted that his weight falls chiefly on his opposite foot. The homolateral shoulder is generally higher than the other and it is almost always in front of it, and the trunk is occasionally rotated on its longitudinal axis towards the unaffected side. The homolateral leg is usually abducted and sometimes rotated outwards. His whole body is held stiff and rigid, and even when in danger of falling he does not sway it naturally in his efforts to save himself.

If he is gently pushed to either side, or if his shoulders are tapped firmly, it is found that he can be more easily thrown over towards the side of the lesion and that he makes less appropriate efforts to save him-
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self when falling in this direction. Finally, he can usually stand on his unaffected leg alone, but when he attempts to place his weight on the homolateral limb, he sways and staggers so much that considerable support may be necessary to prevent him from falling. In cases of severe injury this leg also tends to give way suddenly under him as though it were too feeble to bear his weight.

It must be emphasized that the patient can stand as securely with his eyes closed as when they are open, there is consequently no tendency to Romberg's sign. On the other hand, he becomes more unsteady and is in greater danger of falling if his attention is diverted, even if only by conversation; he obviously supplements the normal muscle reflexes that preserve equilibrium by voluntary effort.

When such a patient attempts to walk many remarkable features are seen in his gait. If the lesion is severe and extensive he has often much difficulty in preserving his equilibrium and is frequently in danger of falling, though almost all men with unilateral lesions succeeded in walking unaided on the first day they left bed; this varied between eight and seventy-one days after the infliction of the wound.

The first and most striking feature is the patient's obvious fear of trusting himself on the affected leg. He throws his weight on it slowly and cautiously, and at each step hurries off it by bringing the other limb forward and to the floor, as quickly as he can. At the same time he stumbles, and tends to fall to this side. His steps are generally short, unequal in length, and irregular. In advancing the affected leg, the foot is occasionally dragged along the ground, but more frequently it is raised unnaturally by excessive flexion of his knee and hip, and is brought down with undue force. Further, it often comes irregularly to the floor, the whole sole falling on it simultaneously, or the toes before the heel; and, occasionally, either the inner or the outer margin of the foot alone may first come in contact with it.

This leg is usually abducted and rotated somewhat outwards, but this is not constant; often, in fact, the homolateral foot is brought in front of the other in one step, and in the next is abducted too much.

When the patient is able to walk safely alone, he still stumbles to the homolateral side, and reels abruptly from his proper course in this direction; in walking between two rows of beds, he is therefore liable to run into that on his affected side. He consequently takes a zig-zag course, the abrupt deviations being always towards the side of the lesion, except when he stumbles awkwardly, as he often does, towards the other side in an effort to save himself, or to correct the deviation. The stumbling is often due to excessive adduction of the affected limb, owing to which its fellow in being advanced trips on it; but it is most commonly a manifestation of the tendency to fall to the affected side.
In walking along a straight line he deviates, or shows a tendency to deviate, towards the affected side. This is usually more obvious when his eyes are closed; then his course is often a parabolic curve concave to the side of the lesion. His attitude, with his head rotated towards the opposite side, the homolateral shoulder in advance of its fellow, and the transverse axis of his body consequently oblique, often gives the impression that his direction, even when he walks straight, inclines to the homolateral side of the line he intends to follow.

This tendency to deviation can be well demonstrated by making the patient walk round a chair or a small table; when the shoulder of his injured side is inward, he frequently runs into the chair, while he constantly deviates outwards from it, so that he traces an opening spiral, in walking round it in the opposite direction. In walking backwards, on the other hand, especially when his eyes are closed, he generally deviates in a sharp curve concave towards his affected side.

The patient soon becomes aware of this tendency to stumble, reel, and deviate towards his affected side, and attempts to control it; occasionally, indeed, in his efforts to prevent falling to the one side, he actually stumbles to the other. These symptoms are usually most marked when he walks quickly; but a few patients got along better rapidly than slowly and deliberately.

Further, when walking quickly, he has difficulty in stopping suddenly; when ordered to halt, he often cannot pull up for two or three steps; or, in attempting to do so, he may throw himself forwards so abruptly on to his toes that he is in danger of falling on his face. In certain cases the difficulty in stopping when walking backwards was even greater—one man, for instance, on taking a step or two backwards, could not pull himself up till he ran into some object, or was assisted, for several weeks after the infliction of the wound. This difficulty in stopping resembles that seen in paralysis agitans, in so far as it is due to the legs having to move after the body in order to keep the centre of gravity above the base of support; but in cerebellar lesions it must be attributed to deficient synergia of the trunk and thigh muscles by which this should be promptly attained.

Another example of asynergia is furnished by the fact that as the patient walks the affected arm hangs inertly by his side, and does not swing synchronously with the movements of the opposite leg; nor does he use this arm naturally, in attempting to balance himself. Further, when he is in danger of falling, he does not move either his trunk or arms naturally or adequately in attempting to regain equilibrium, and if he is suddenly pushed in any direction he falls stiffly and rigidly like a doll.

In cases of unilateral cerebellar lesion the chief abnormalities in gait are therefore due to the irregular and incorrect placing of the affected foot, and to the tendency to fall, stumble, and deviate towards the affected
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side. The patient soon attempts to correct these disturbances by voluntary effort; he throws his weight as little as possible on the unsafe leg, and when he can control his direction by vision, he checks, though rarely completely, his tendency to deviate from the direction he wishes to follow.

The disturbances in gait are, it is true, usually greater in relation to the disorders of movement of the affected leg, when this is tested as he lies on his back, than might be expected; but the symptoms of cerebellar deficiency are always most obvious in the most complicated actions, and more complex synergias, involving both the trunk and limb muscles, are called into play in maintaining equilibrium and direction during gait than are required in movements of the leg alone. Many of the older physiologists and certain clinicians have regarded the cerebellum as an organ concerned mainly with the maintenance of equilibrium; but this hypothesis finds no support in the examination of men in whom one side of the organ only has been damaged; in fact, the successful efforts to maintain equilibrium, despite the patient's deficient control over the movements of the one leg, are often surprising.

When a man who has recently left bed attempts to progress on his hands and knees, similar disturbances are seen. The affected arm is abducted, this shoulder is held lower than the other, his trunk is concave to the side of the injury, the hip of this side is depressed, and the leg is usually somewhat adducted. In moving forwards, the affected arm is raised too high, and the hand swoops down too heavily to the ground; the homolateral knee, on the other hand, is generally dragged along the floor. The patient occasionally falls to the side of the lesion, but more frequently he merely slides over to this hip, owing to its excessive adduction, or to the leg giving way under him. The similarity both in attitude and progression on the hands and knees between a patient with a unilateral destruction of the cerebellum and a dog or monkey after ablation of one half of this organ, is consequently very striking.

Disturbances of the Ocular Movements, and Nystagmus.

In animals subjected to cerebellar injuries disturbances of the ocular movements have been observed, but little emphasis has been laid on the occurrence of nystagmus; this is not surprising, as it can be properly investigated only on voluntary movements and fixation of the eyes, and with the co-operation of the subject. Many physiologists have even refused to admit that the nystagmus is dependent on the cerebellar lesion (Munk, Rothmann). It is however remarkable that even from most clinicians these symptoms have not received the attention they deserve; the reason probably is that they are particularly prominent only early after acute lesions.

For some days after a unilateral gunshot wound of the cerebellum the eyes while at rest are generally deviated towards the opposite side, especially
if the patient happens to be unconscious, and at first it is often difficult to make him move them conjugately towards the injured side. When he attempts this the range of movement is occasionally incomplete, but usually a more striking feature is its slowness and the effort necessary to execute it. In one patient at least in whom it was carefully investigated this conjugate paresis was associated with erroneous projection towards the homolateral side. The paresis diminishes gradually but the difficulty in movement to this side, in comparison with deviation in the opposite direction, frequently persists for weeks. The vertical movements of the eyes and convergence are never similarly affected.

In five cases the position known as "skew-deviation" was observed; that is, the homolateral eye was directed downwards and inwards while the other looked upwards and outwards. This lack of parallelism in the optic axes disappeared however on fixation when this could be obtained, and consequently diplopia did not result. Skew-deviation was observed only during the first week or so after an injury of or an operation on the cerebellum, except in two cases in which rapid destruction or compression of this organ, owing to abscess formation occurred.

Nystagmus is a much more common symptom; it was present in fact in almost every case in which injury to the cerebellum produced any trace of functional disturbance, and its chief characters are so constant that it must be regarded as a clinical symptom of the highest importance. It is essentially a fixation nystagmus, that is, it can be seen as a rule only when the patient fixes an object.

It is advisable to describe it first as it most commonly occurs in the early stages of a severe unilateral lesion. In such a case some nystagmoid jerks can be usually observed when the patient fixes an object in any part of his visual field, except in the region of that point, usually 10° to 30° to the unaffected side of the middle line, towards which his eyes when at rest tend to deviate. We shall speak of this as the "rest point."

When he looks at an object held directly in front of him his eyes tend to deviate slowly towards the unaffected side and are brought back to the middle line by sharp jerks of small or moderate range. These movements are usually slow in rate and at first regular, but when the patient's effort or attention begins to tire his eyes may move more widely before their deviation is checked, and the correcting jerks consequently become less regular in rate and larger in range.

It is on looking towards the injured side however that the nystagmus is most pronounced; then "it consists of wide, slow deviations towards the middle line, or more correctly towards the "rest point," and forcible jerks of large amplitude, slow in rate and fairly regular in rhythm, towards the side to which the eyes are voluntarily directed. Its rate was estimated in several patients and in all varied between twenty-three and
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thirty oscillations in ten seconds. Both movements are as a rule strictly horizontal, but occasionally slight rotation, generally downwards, may be seen in the quick phase. This nystagmus generally remains regular in rate and amplitude for a short time, but as the patient tires his eyes are less frequently and less completely pulled back towards the point he should fix.

In this stage too there is almost always nystagmus on fixing an object to his unaffected side, but it is more rapid, finer in range and less regular. Here too the slow deviation is towards the "rest point" and the movements are most commonly horizontal. Frequently in looking towards this side the nystagmus consists of series of rapid jerks with short pauses between each series.

Nystagmus is less constant and less regular in vertical movements. In the majority of early cases, however, the eyes on being directed upwards tend to deviate slowly towards the horizontal and are brought back by sharp quick jerks of small range, which are rarely quite regular in rate or well sustained. Almost always there is either some rotation of both eyes upwards and towards the side of the injury in the quick phase, or the quick movement is more or less obliquely upwards and to this side. This occurs especially when the point fixed is brought to the affected side of the mesial sagittal line. On looking downwards regular and sustained nystagmus is rare, but very commonly slow deviations towards the horizontal line occur, which are corrected by quick, relatively small jerks vertically downwards, or more frequently obliquely downwards and to the side of the lesion, or with rotation to this side. The nystagmus that occurs on vertical movement always increases, or it may appear only when the object fixed is brought to the homolateral side of the middle line.

Finally, on convergence both eyes often tend to deviate away from the side of the lesion and are brought back to their proper position by irregular jerks of small range.

Unless there is much paresis of conjugate deviation towards the injured side the movements are more regular, larger in range and better sustained the farther the point fixed is from the primary central position, or rather from the "rest point," and the jerks increase in range and accelerate in rate when the point is moved farther from this position. The nystagmus also tends to become less regular and less rapid as fixation tires, but it can be evoked again by renewal of fixation, especially if the object fixed is moved slightly farther from the middle line.

This is the typical form of nystagmus produced by recent cerebellar injury, but divergences from it are common. Little or no disturbance may be, for instance, seen on movement of the eyes in one direction, though characteristic nystagmus is associated with all other movements; or the relative amount that occurs when the eyes are moved in different
planes may not be typical. These divergences may be partly dependent on the localization of the cerebellar lesion, though I am not yet able to state definitely that this is so. It varies, however, according to the severity of the injury; when this is recent and extensive and the eyes deviate spontaneously towards the unaffected side and movement to the other is difficult, no nystagmus, or only an occasional jerk, may occur when the patient looks to that side, and on fixing to the side of the lesion only a few slow irregular jerks of large range can be seen before the effort at fixation becomes ineffective.

If the lesion is slighter, or some time has elapsed since the infliction of the wound, and there is no obvious deviation of the eyes, and at the most only slight difficulty in conjugate movement towards the injured side, the nystagmus is also less regular and less characteristic. On central fixation the eyes generally remain steady, or only an occasional deviation of small range towards the unaffected side occurs, which is at once corrected by a sharp jerk. On looking towards the side injured a slow, coarse, forcible nystagmus, with its slow phase towards the rest point, still develops, but it is usually less regular and less well sustained. After a time the oscillations become more rapid and smaller in range before the true nystagmus disappears or is replaced by occasional irregular jerks of the eyes. On fixing to the opposite side the excursions of the eyeballs are still smaller in range and more rapid in rate, but they are less regular and persist for a shorter time. Vertical movements are now less commonly complicated by nystagmoid jerks, and these are in fact rare on downward deviation. In a few severe cases there was at this stage more rotation upwards and to the side of the lesion when the patients looked directly upwards, though in one man, in whom the rotation had been previously to that side, it was upwards and in the opposite direction four weeks after the injury was received. Here, however, the mastoid process and the internal ear probably, too, was damaged.

Finally, in cases with very slight injury, or at a later period after the infliction of a severe wound, the only abnormality in the movements of the eyes may be occasional irregular slow deviations towards the middle line and sharp rapid jerks, irregular in rate and in amplitude in the opposite direction, on prolonged fixation towards the injured side; or there may be only slight irregularity of the eyeballs when they are fully deviated in this direction.

It is obvious that the nystagmus produced by a unilateral cerebellar lesion is essentially a fixation nystagmus, that is, it is seen chiefly when an attempt is made by the patient to fix accurately a point in any part of his visual field; but it may also occur when accurate fixation is impossible. In some of the cases spectacles with high convex lenses, such as have been employed by Wilson and Pike, were placed in front of the patient's eyes,
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and it was then found that when he moved them to order the oscillations were considerably less marked, or did not occur on deviation in certain directions.

Nystagmus of cerebellar origin is therefore characterized by the facts that it occurs chiefly in fixation, that the slow phase is always towards the primary central position or the rest point, and that it is more constant, more regular, better sustained, and the oscillations of the eyes are slower in rate but larger in amplitude, when the patient looks towards his injured side. Finally, it persists for weeks, or even months, after the onset of the lesion, though it gradually becomes less regular, or is replaced by irregular nystagmoid jerks.

The question as to how far this nystagmus is dependent on co-existing labyrinthine lesions at once arises, more especially since labyrinthine disturbances, as Moutier and others have shown, commonly result from gunshot injuries of the head. It cannot be denied that the internal ear was possibly damaged in certain cases of my series, and particularly in those in which the missile entered through or near the mastoid process, but in the majority it certainly escaped, and no essential difference in the type of the nystagmus could be detected in the two groups. Further, the nystagmus has not the character of that produced by destructive or irritative labyrinthine lesions. We owe valuable contributions on this subject to Gordon Wilson and Pike, and to the former I am indebted for the following distinguishing features of the nystagmus which results from destruction of one labyrinth: it persists at the most only two or three days; it is increased when fixation is cut out by suitable lenses placed in front of the eyes in a spectacle frame or by other means, and the slow phase is always towards the injured side, whether the eyes are at rest or deviated voluntarily towards either side.

If the features of that produced by cerebellar lesions are compared with these, it will be seen that nystagmus of cerebellar origin differs in many important particulars from that due to destructive labyrinthine lesions, and we may consequently conclude that injury of the labyrinth plays no direct part in its pathogenesis.

The nystagmus associated with cerebellar lesions has also been attributed to injury or disease of neighbouring centres, and especially to lesions of Deiters' and Bechterew's nuclei. This factor can be certainly excluded in the majority of my cases, and the regularity with which the characteristic nystagmus occurs, even when the wound is small and relatively superficial, and in the absence of all signs of medullary and pontine involvement, makes it extremely probable that it is due to damage of the cerebellum alone.

(To be continued.)