

and possibly before the senses of taste and smell, though of course it has not as yet been elevated to the dignity of a "sense".

To the more impressionable patients a labyrinthine disturbance may make them feel that the end of the world has arrived and I am told by sufferers from sea-sickness that in the acutest phase of their distress, they wish that it had.

Hence it is not surprising that the clinical picture which we have been considering is not infrequently complicated by psychological disturbances which may be sufficient to divert attention away from the underlying cause.

We have found that once the true nature of the disturbance has been established an explanation of the state of affairs, combined with graduated exercises especially designed to encourage head and eye movements, form the most satisfactory basis for hastening recovery (Cawthorne, 1945).

Since the head exercises, which Dr. Cooksey will describe, were instituted by him and carried out by Miss Swan and Miss Hudson at Horton Emergency Hospital, the rate of recovery after operations on the labyrinth has been greatly hastened and we now expect that such cases can resume their normal occupation from within a month of operation, though of course it may sometimes be advisable to recommend a change of occupation. The post-concussion cases, for whom these exercises are particularly useful can, if they are tackled reasonably soon after injury, usually be prevented from drifting into chronic invalidism. The poorest responses to exercises and rehabilitation were always seen in those cases which had been allowed to drift for months with but little planned treatment.

The management of these cases has been made easy and pleasant for me and for my patients because of the way in which it has been possible for Dr. Cooksey and his assistants, the clinicians and ward sisters, all to work together and to share the problems raised by these cases.

I shall always be grateful to Dr. Cooksey and his assistants for their help and to my colleagues at King's College Hospital, the National Hospital, Queen Square, Horton Emergency Hospital and Hurstwood Park Emergency Hospital and to friends elsewhere for referring their cases to us. We have been able to help some, we have failed with others, but I know that we have learnt a lot from all of them.

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Rehabilitation in Vestibular Injuries

By F. S. COOKSEY, O.B.E., M.D.

In 1941 Mr. Cawthorne put to me the principles governing the restoration of fitness after injury to the vestibule and sought my help to develop a system of rehabilitation for these cases. It happened that about the same time I had arranged with the Staff of the Head Injury Centre at Hurstwood Park Hospital to undertake the rehabilitation of late cases of the post-concussion syndrome in my Department at Horton Emergency Hospital. Thus the system of rehabilitation which I am about to describe was developed for the post-concussion syndrome as a whole as well as for the particular problem of vestibular injury.

The symptom complex for which I had to provide consists of headache, vertigo including the so-called "black-outs", impaired mental concentration and deafness in a proportion of cases. Of these symptoms the vertigo may be the most disturbing; but, fortunately is usually amenable to treatment along the lines I shall describe.

Unfortunately the headaches are often persistent and difficult to alleviate. They tend to be severe and have the double disadvantage that they are easily induced by physical or mental effort and are common on first waking. Thus patients are apt to start the day disinclined to engage in any form of rehabilitation. Even if they avoid waking with a headache they find by experience that noise, bright light, talking to a group of people, reading and physical effort bring on a headache. In similar manner the vertigo can be controlled by slow and deliberate movement, but the quick movements of spontaneous activity readily precipitate an attack. Under such circumstances it is natural that, when left to their own initiative, patients seek solitude and inactivity. It might be expected that the symptoms would disappear with the lapse of time; but in many cases this is not so and it is a common experience to see patients with little or no improvement after a year or longer. We believe that failure to recognize the vestibular lesion together with failure to provide adequate measures to restore confidence and to compensate for the damaged vestibular function are the reason for the undue persistence of symptoms.

It has long been recognized in disease and injury of the locomotor system that spontaneous restoration of function does not always follow resolution of the original lesion. Moreover the convalescence of all cases is shortened by systematic measures to assist the recovery more especially when treatment is instituted at the earliest possible moment. We decided to apply the same principles to our patients with concussion injury and also to those cases in which the vestibule had been destroyed in the operative treatment of Ménière's syndrome. We employ graduated physical exercise, mental exercise and occupational therapy. We find that patients can overcome their disabilities by constant encouragement and practice; also, subject to certain limitations in head injuries, the earlier we commence rehabilitation the quicker and better the results.

I attach great importance to four points: First, the initial interview with the patient when we seek to gain confidence and co-operation by explaining the nature of the symptoms and purpose of treatment, with special emphasis on the need to make regular and gradually increasing efforts to do just those things which they find distressing. Secondly, domestic and occupational anxiety must be relieved at the outset by assuring the patients that they will be able to return to their normal work or, if this is unlikely, by explaining the opportunities for vocational training and the operation of the Disabled Persons Employment Act. In this connexion the services of an experienced almoner are essential. Thirdly, a single member of the rehabilitation team should be made responsible for the welfare of these patients and be present whenever they are seen by the surgeon. Fourthly, the programme of physical exercise, mental exercise and occupational therapy should be planned to occupy the whole day and at the same time allow adequate periods for rest between the various activities.

PHYSICAL EXERCISES

The exercises are designed to restore balance as far as possible and to train the eyes and muscle and joint sense to compensate for permanent vestibular dysfunction. Because so many patients are worse in the dark we pay special attention to muscle and joint sense by performing many exercises with the eyes closed. Patients start with individual exercises in bed. In the case of simple concussion exercises may start at seven days. Fractures of the base may start at three weeks and other fractures of the skull as soon as the condition of the patient warrants. In the operative treatment of Ménière's syndrome patients learn the exercises prior to the operation and commence treatment the day after the operation. The time to start exercises must be determined for each patient by the surgeon, but the general rule is the sooner the better.

As soon as patients are able to get up, even if only in a wheel chair, they do their exercises all together in the gymnasium. It is a great advantage to group patients for exercises. In the first place patients encourage each other and those at the beginning of treatment see the progress made by the more advanced cases. Various games can be introduced to vary the monotony of purely remedial exercises. It is economical of staff and all patients receive thorough treatment whereas, in a busy department, individual treatment is time-consuming and apt to be scamped. Moreover the slacker or true malingerer has little chance of escaping exposure by fellow patients with similar disabilities even though he may at first deceive his surgeon.

The table of exercises which is used at each session starts with slow and easy sitting exercises which all patients can manage. First a few loosening movements for the head and shoulders; then head movements with the eyes focusing on near and distant objects; followed by head and arm movements with the eyes closed and directing special attention to training the sense of position in space. Next the movements are speeded up, and slow and quick movements alternated. At this point the beginners drop out and the remainder

progress to similar exercises in standing. Finally only the comparatively fit patients remain for such exercises as walking up and down steps and ladders, first with the eyes open and then with the eyes shut; games with balls and bean bags, when the instructor tosses a ball, high or low, which the patient catches, holds above his head, turns smartly about and bends down to throw the ball back to the instructor between the legs. It is surprising what patients will attempt when spurred on by the instructor and fellow patients. We have seen no untoward effects and it is our experience that, within reasonable limits, the earlier patients are urged to attempt the more difficult exercises the quicker they regain confidence and balance.

In the final stages patients are transferred to the general physical training exercises in which they mix with patients convalescent from various types of disease and injury. In the case of patients who have to return to occupations involving climbing ladders we endeavour to test them out on a small assault course we have built in the hospital grounds. The exercises are under the direction of a physiotherapist who holds a University diploma in physical education.

MENTAL EXERCISES

Many post-concussion patients complain of lack of mental concentration and to assist recovery the education officer takes these patients for an hour each day. By means of play-reading, debates, "brains trusts" and organized study, patients are trained to concentrate on increasingly difficult subjects.

OCCUPATIONAL THERAPY

This combines physical and mental exercise for the purpose of creative work. The object in these patients is to train them to concentrate and to perform the quick and involuntary movements of normal activities. It is useful also to train patients to work under crowded and noisy conditions. Patients start with sitting work involving minimal concentration in the quiet light-handicraft workshop. As they improve they progress to work which involves more concentration and more moving about, including bending and stooping. Finally they progress to the carpentry shop where noise and hard physical work will either restore their confidence to return to industry or reveal the failure of the earlier treatment.

INDUSTRIAL RESETTLEMENT

Rehabilitation in vestibular injuries is not complete until the patients are returned to their normal work or satisfactorily resettled. Patients who are unable to return to their normal work and in whom the disability is likely to last at least six months are qualified to register as disabled persons. Inclusion on the register entitles these patients to vocational training and placing in suitable work. On the recommendation of the surgeon the almoner will arrange with the disablement resettlement officer at the patient's local office of the Ministry of Labour for registration, vocational training and placing in employment.

If it is possible to combine the few cases of vestibular injury with other head injuries and any medical cases of vertigo, grouping them together, it has the advantage of increasing the size of the group. The principle on which we are working is equally applicable to them all.

Mr. Cawthorne now takes his cases of Ménière's syndrome into hospital a week or two before operation, and while he carries out certain investigations, the patients attend exercises in the gymnasium along with the convalescent cases, so that they begin to learn the exercises and are encouraged by seeing the progressive recovery of these other patients. The orthopædist has also found that to teach patients exercises before operation makes the job much easier afterwards. The time to start the exercises after operation must be determined by the surgeon in each case, but the general rule is the sooner the better.

[At the close of Dr. Cooksey's paper two members of his staff, Miss Swan and Miss Hudson, gave a demonstration of the exercises, one acting as instructor and the other as "patient".]

The President said that in the first place, Mr. Cawthorne had pointed out that it was not very infrequent for a pathological lesion to be found in one portion of the labyrinth.

It was a point not sufficiently recognized that while the labyrinth was one organ, and as a rule did suffer disturbance as a whole, both in its auditory and vestibular portions, it was not infrequent, either as a result of disease or of injury, to get a pathological lesion confined to one part.

Mr. Cawthorne was, he thought, a little puzzled as to the explanation of why eye movement should produce a considerable degree of disturbance, as it did in patients with labyrinthine lesions. The eye picture was a very large part of the whole picture. Surely if it was considered that as a result of abnormal sensation from the labyrinth a central disturbance occurred, then all the other sensations as they arrived at the centre were liable to produce abnormal sensory reaction.

After all, the sensations did not arise in the end-organ; the abnormal sensations arose at a higher level. He thought that the answer was that the higher level became disturbed, and all these exercises they had been witnessing were really examples of re-training at the higher level. At least that seemed to him to be the sort of outlook that a simple-minded non-scientific man might take.

He had been interested in Mr. Cawthorne's remarks on acceleration and concussion. In the past one had imagined that concussion was the result of a blow upon this "box" within which there were certain important structures, but he gathered that in quite a proportion of cases of concussion the injury was produced by movement of the head and not by a blow upon the head. That was an important point. He thought it was very probable that his suggestion that a great part of the picture was produced by this movement on the vestibular apparatus was the correct one, but he rather gathered that Mr. Cawthorne was hoping that some experimental work might be done to furnish support for that hypothesis. He had not himself observed that the patients who had a labyrinthine destruction were more easily tired than others, but seeing that their whole locomotor system worked rather abnormally one might expect that there would have to be a rather greater nervous effort made to produce the same output.

He had been taking advantage of the experience gained by Dr. Cooksey's work in the rehabilitation of cases following labyrinthine destruction, and he had been most impressed; it had entirely altered the outlook on the post-operative phase. His own practice was to get these people out of bed on the third or fourth day and one had a picture within two or three weeks that formerly was not obtained for two or three months even if then. He was sure that mass psychology was a very valuable thing to introduce into rehabilitation.

Mr. E. D. D. Davis said that he could foresee the time when rehabilitation could cure vertigo and the labyrinth operations would be unnecessary. He had had some experience of injuries to the head during the war of 1914-18 and of a number of cases during the recent war. The large majority of fractures of the skull involved the middle fossa and the middle ear. The fracture took the line of the Eustachian tube and the roof of the tympanum and the mastoid antrum and the labyrinth was very rarely injured. It was difficult except in very severe injuries, mostly fatal, to see how the internal ear could be injured because it was encased in the hard petrous bone surrounded by the bony capsule of the cochlea and semicircular canals filled with perilymph and endolymph. He had the notes of 57 cases of injuries of the ear as the result of fracture of the skull and only 5 of these showed any signs of injury to the internal ear. The injury was limited to the cochlea and the labyrinth was normal except in one case. The majority of the patients with fractures of the petrous bones died. Hogarth Pringle (1939) recorded 366 cases of fracture of the skull of which 39 post-mortems showed fractures of the posterior fossa and all the patients who were suspected of having a posterior fossa fracture died. It is the fracture of the posterior fossa which involves the petrous bone. During the war of 1914-18 he was a neuro-surgeon at a casualty clearing station and he only saw about three cases with injuries to the posterior fossa. Most of these cases died on the field of battle.

Gordon Wilson who studied the effect of injuries on the ear (1914-18) stated that it was very rare to find a damaged vestibular apparatus; it was almost always the cochlea.

The injuries to the internal ear could be divided into three groups.

The first group consisted of cases of undoubted and permanent injury to the internal ear showing marked deafness, paralysis of cranial nerves, escape of cerebrospinal fluid, &c. If the hearing did not improve in eight weeks the loss of hearing was permanent. Some of these cases were tested for damage to the vestibular apparatus after recovery from the head injury. The caloric and other tests showed a normal vestibular apparatus in all except one or two.

The second group comprised the so-called cases of psychical deafness. The deafness was usually bilateral and accompanied by other mental and vasomotor disturbances. The hearing tests were often contradictory. When examining such cases it is important to ascertain the position of the patient with regard to the explosion causing the injury. Most injuries to the ear were unilateral and within about 20 feet for the average small bomb. If the patient is immersed in the sea or water the critical distance or danger zone is four times as great, 80 feet. The psychical cases are occasionally suspected of malingering.

The third group are those of temporary deafness, so-called concussion deafness. These patients perhaps sustained other severe injuries and by the time they had recovered from these the deafness had disappeared and the ears were normal. It is difficult to ascertain what anatomical injuries to the internal ear occur. The auditory nerve cannot be seen

like the optic disc but there is a comparison. It is doubtful whether concussion deafness actually exists.

The vertigo following head injuries and fractures of the skull is, in a number of cases, due to damage or contusion of the brain. These patients complained of varying degrees of instability, black-outs, tinnitus, confusion, &c., with normal ears and hearing. The fields of vision may be contracted. The symptoms are not like the rotatory vertigo with unilateral deafness and other signs seen in an aural vertigo. Rehabilitation is valuable for the head injury type of unsteadiness. His experience of the condition of the patient after operations on the labyrinth was similar to that of Mr. Cawthorne. These patients were distressed by intense vertigo and vomiting which took some time to disappear.

REFERENCE

PRINGLE, HOGARTH J. (1939) Some Fractures of the Skull, *Lancet* (ii), 1164.

Mr. F. W. Watkyn-Thomas said that in considering the effects of labyrinthine destruction they had to realize, as Mr. Cawthorne had said, that the labyrinth was part of one of the great protective mechanisms of the body. Its function was to maintain equilibrium; not only a constant relation to fields of gravitational force, but also a constant field of vision. All these things were keyed up on the labyrinth. This meant not only the compensatory movements but everything that went with them, such as the reciprocal innervation and the co-ordinated vasomotor reflexes. A disturbance of the labyrinth meant a complete upset of a mechanism which had been running smoothly for generations, and thus one got the extraordinary general response.

As to the description of labyrinthine vertigo he always recalled the Club of which Mr. Jorrocks was a member in which no member was considered to be drunk so long as he could lie still without holding on to something. It was this which made the recovery so difficult. A disturbance of the labyrinth owing to injury seemed to be a crushing disaster at the time. Curiously, the people whose labyrinths were destroyed for suppuration did not seem to suffer so much after it as those whose labyrinths were destroyed for the cure of Ménière's disease.

On the question of concussion in mastoid operations, he thought that the answer was that they were dealing with an incompressible part of the skull, with a part specially made not to give under a blow but to stand up to a blow. This was suggested by the carefully built-up petrous, with its neat balance of hard and elastic bone. He had once or twice noticed some vertigo, after operating on a mastoid with very hard bone, and gouges were not up to the standard required. In one case this lasted long enough to make him fear that he had damaged the external canal, but events proved that all was well.

There was another point about concussion. It was fairly well shown that the crista was anchored at both ends, to the roof as well as to the ampulla. There was one case mentioned by George Jenkins in which a woman was throwing a child up and catching it, and suddenly she went down on to the floor; whenever she put her head into that same position afterwards she got such intense vertigo that Jenkins was compelled to destroy the labyrinth. He had attributed it to dislocation of an otolith membrane.

The question of rehabilitation was most important. Miss Wadge, his chief assistant, pointed out to him some time ago that the sooner one got a patient sitting up after a labyrinth operation the more quickly he recovered. The consequence of that was that they had cut down the time in bed to the very minimum. But it was a new and excellent idea to start these exercises before the operation was done.

Mr. E. D. D. Davis said that in concussion deafness the membrana tectoria was seen to present almost a vertical instead of a horizontal position in the microscope sections. Gordon Wilson had observed this in one case, and he thought it had been found in others.

Mr. H. V. Forster said that in his clear exposition of a difficult subject, Mr. Cawthorne had stressed the degree of suffering experienced by the patient in disorders of the vestibular nervous system.

At a discussion before this Section in 1937 McNally, *Proc. R. Soc. Med.*, **30**, 905, had explained that in abnormal labyrinth stimulation the autonomic nervous system was set an almost impossible task of readjustment and how in the resulting confusion nausea was produced.

The labyrinth as an organ of special sense did not rank as high as that "distance receptor" the eye, over whose impressions throughout the ages of man's development the vast area of the cerebral neopallium had grown. But Sherrington nevertheless had described the labyrinth as "the chief proprioceptor of the leading segment of the body which is the head" and had given us a concise understanding of its physiology when he wrote: "The labyrinth keeps the world right side up for the organism by keeping the organism right side up to its external world." Sherrington, C. S., "The Integrative Action of the Nervous System" (1909), p. 336, London.

We could imagine that the congenital deaf-mute in a complete "black-out" would have little to guide him beyond the segmental proprioceptors of the trunk and limbs, but to fall then into deep water these too would fail him with an overwhelming sense of "disorientation". He, Mr. Forster, had been taught many years ago that such an event fulfilling these painful conditions had been recorded.

Mr. I. Simson Hall referred to the method of production of these labyrinthine symptoms. Mr. Cawthorne had stated his belief that they were due to the influence on the nerve

endings. One of the mechanisms was by tension or change in the fluid balance within the labyrinth acting upon the nerve endings. It was a point that deserved attention. Whether one injected alcohol into a labyrinth, ablated the labyrinth by operation, or merely made the smallest possible opening into the labyrinth to let out a little fluid, the symptoms were the same. A labyrinthine crisis of vomiting, giddiness and nystagmus was produced. His experience in making a small disturbance in the fluid of the labyrinth in the fenestration operation tended to show that the influence was through the fluid on the nerve endings.

Mr. C. S. Hallpike said that everybody who had studied this subject would know its difficulties, and he thought it would be generally recognized that Mr. Cawthorne's paper represented a very considerable advance. In particular the methods employed would commend themselves as the right ones to all interested in the scientific side of the subject. It was well known that oto-neurological views in the past had been based very largely upon obscure symptomatology, and not, as they should have been, upon physical signs. Mr. Cawthorne had now made it clear, probably for the first time, that it was possible in many of these cases to elicit meaningful physical signs from the affected vestibular system. From this point he hoped very much that further progress would be rapid.

Sir Milsom Rees said that he had been particularly interested in the 8th nerve, because he was almost sure that it was through this nerve that sense of location and direction was possible, and we were enabled to find our way about, with the aid of some form of magnetism. If this theory was correct for human beings it was likely to be so for birds and all other animals, including eels. Some years ago he read a paper to the Royal Society of Medicine on the role of the labyrinth, but the puzzle to him had been and still was, what part of the auditory apparatus actually gave the sense of location. It was old knowledge that birds and animals had an uncanny way of finding their direction and whereabouts, but how they found it had never been explained. He trusted therefore that some of those interested in the anatomy and physiology of the ear would test his own views on the subject and say whether he was right or wrong.

Mr. Terence Cawthorne said that Dr. Cooksey had stated that some of these cases deceived the surgeon. This was true and in doubtful cases it was often possible to pick out the patients who were "putting it on", by watching the head exercises class at work. It was most instructive to see the way in which the genuine cases behaved and on the other hand the way in which those who were "putting it on" staged their symptoms. Some of these latter would put on terrific turns, rather like a comedian on the music hall stage who pretends to be drunk and seems about to fall into the orchestra.

The President had spoken about the pathological lesion being in one part of the labyrinth. He was inclining more and more to the same view.

He was in agreement with Mr. Davis on the frequency with which fractures of the skull involved the middle ear. He had had the opportunity of seeing several such cases, giving rise to ear discharge and granulations, and in some of these cases the cochlea at any rate had been intact.

Mr. Watkyn-Thomas had mentioned the fact that in cases with suppurative labyrinthitis the vertigo was not so intense as after an operation for Ménière's disease. The reason for this was quite clear. The amount of post-operative disturbance was in proportion to the amount of immediate pre-operative function. In the case of the suppurative labyrinth it was possible that the function might have slowly disappeared, whereas in the case of Ménière's disease, particularly if there had been an active labyrinth, it was likely to have been suddenly cut off.

Mr. Forster had mentioned about throwing born-deaf children into baths. There was no reason why such children should not learn to swim because nearly all children born deaf gave an active response to vestibular stimulation.

Mr. Simson Hall had mentioned the altered fluid conditions, and he was sure that they might be expected to play an important part in vestibular disorders.

Dr. F. Cooksey, also in reply, said that he entirely agreed that mass psychology was the key to a large part of this problem. He himself had to be an enthusiast and insist that these patients be spurred on. Danger would only arise if the patients were not carefully selected in the first place by those, like Mr. Cawthorne and the members of the Section, who would guide them as to the essential scientific basis of the disability and principles of treatment.

Some Temporal Bones which had been Subjected to Mastoid Operations.—E. D. D. DAVIS, F.R.C.S.

Mr. E. D. D. Davis exhibited some interesting specimens which he had accumulated over a considerable period of time illustrating some of the naked-eye points in the anatomy and pathology of the middle ear and of operations on the mastoid and labyrinth. The fixing and embedding of the temporal bone in plaster of Paris made macroscopical dissection easier. Mr. Davis said that these specimens were very useful for post-graduate teaching.