MODERN TRENDS

IN

DISEASES OF THE EAR, NOSE AND THROAT

Edited by

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PREFACE

IN THE past thirty or forty years there has been a tremendous increase in the amount of published work in this specialty in common with others. Journals have increased in number and size, and the clinician, whose time must necessarily be devoted largely to his patients, is faced with an ever-increasing problem in selection. His tastes, and any peculiar circumstances in his opportunities, will naturally influence his reading. Although the greater part of this published work consists of routine reporting, there is a periodic emergence of ideas of value, and, in addition, varying trends of opinion gradually merge into and become accepted and orthodox methods of approach.

To conform to the title of this series, the presentation of ideas has been the chief concern of contributors rather than routine descriptions more properly found in text-books. However, it must be conceded that completely fresh ideas are rare, and that progress in medicine is generally made slowly, often painfully, by selection from among a number of empiric approaches. During the gradual accumulation of clinical experience, coupled with advances in the primary sciences, a fresh conception of an old problem may arise, generally by a shift in emphasis of some aspect of it. In such cases, clarity and coherence seemed best served by a formal description, whereas other topics lent themselves more readily to a broader treatment.

The approach to acute infections has been altered profoundly by the discovery of antibiotics. Their use has engendered and facilitated surgical techniques of previously unjustifiable risk for the relief of deafness and other conditions. At the same time advances in radio engineering have resulted in an enormous improvement in the simplicity and accuracy of hearing tests as well as of hearing aids. These matters and others are discussed in this book, but limitation of space has prevented the inclusion of many other fruitful topics. The subject titles were chosen by the Editor; the views presented and the choice of approach are those of the individual writer concerned.

The Editor is happy to acknowledge the help he has received from the publishers in the preparation of this book. He also most cordially thanks his colleagues for their collaboration in thus describing their outlook on the problems they face from day to day, and he hopes that these opinions based on personal experience will be of interest to others.

MAXWELL ELLIS.

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

CHAPTER 1

FUNCTIONS OF THE LABYRINTH

W. J. McNALLY AND E. A. STUART

INTRODUCTION

TESTS in common use for the detection of disease in the labyrinth or its intracranial connexions are based largely upon the analysis of semi-circular canal reactions. This is readily understandable because much of the physiology of the semi-circular canals is universally accepted while as yet there is no widespread agreement among physiologists on the exact functions of the saccular and utricular otoliths. The basic principles underlying our present knowledge of semi-circular canal functions were established about a century ago. Among the chief contributors were Mach, Breuer, and Crum Brown in 1875, working independently of each other. They established the *modus operandi* of the semi-circular canals. About fifty years later, Magnus and de Kleyn enhanced the importance of the clinical labyrinthine tests by analysing postural reflexes, both those arising from the labyrinth and those closely allied but non-vestibular in origin.

Electro-physiological methods of testing the labyrinth have been devised and developed by Adrian and his co-workers since the 1930's. Action potentials of the individual nerve fibres from the different end-organs of the labyrinth have been recorded while the end-organs were being subjected to stimulation. This is a highly technical method of examination. Before the results of this type of investigation can be finally accepted they must be carefully and repeatedly rechecked. In this connexion the studies of Adrian (1943), Ross (1936), Ashcroft and Hallpike (1934), Löwenstein and Sand (1940). Coppée and Ledoux (1951) and van Eyck (1951) are particularly significant.

OTOLITHS

Breuer, about 1875, suggested that there is a division of function between the semi-circular canals on the one hand and the otolithic organs on the other. Subsequent investigators assumed that the saccule co-operated with the utricle in maintaining static equilibrium. Even Magnus allocated certain postural reflexes to the saccule. McNally and Tait (1925) and Versteegh (1927) were among the first to report experiments in which the nerve to the saccule was cut without producing disturbances of equilibrium. Ross, (*see* McNally, 1934; and Ross, 1936) and Ashcroft and Hallpike (1934) made electrical recordings of single nerve-fibre preparations from the saccule in the frog, and their experiments indicated

that the saccule does not respond to movement but that it is stimulated by vibration. Ledoux, in 1949, studied the electrical discharges from single nerve fibres in the frog and confirmed the above findings. On the other hand, Löwenstein and Roberts (1948) reported that their experiments on the saccule of the thorn-back ray showed that it reacts to vibration and to gravitational stimuli. In 1950, Jonkees reported that the saccule of the rabbit responds to linear acceleration.

It was Versteegh's (1927) classical experiment in which he succeeded in severing the nerve to the utricle in the rabbit which strikingly demonstrated that the utricle was the site of origin of those static reflexes previously allocated to both the utricle and the saccule. The experiments of Tait and McNally (1934) on the frog showed that the utricle was stimulated by centrifugal force. Earlier experiments by Magnus and de Kleyn in 1924 had shown that the utricle responded to linear acceleration both horizontally and vertically.

Because the utricle has been shown to be the seat of many postural and static reflexes, it is often assumed in clinical literature that so-called positional nystagmus is the result of utricular disease. Opposed to this assumption are the well-controlled experiments of Ulrich (1934) and others, in which the utricle has been directly stimulated, without eliciting any eye nystagmus. The fact that the utricle does respond to tilting movements—gravitational stimuli—has been confirmed by recording the electrical activities of single nerve fibres in such animals as the frog and the dogfish. Many workers have contributed to the literature on this subject, including Ross (1936), Löwenstein (1948) and Coppée and Ledoux (1951).

There are no generally accepted clinical tests for saccular and utricular function.

THE LAWS OF FLOURENS AND EWALD

Body posture and particularly the position of the head in space is normally maintained by the labyrinths, the eyes, and the general kinaesthetic mechanisms, all working together. Of these sensory organs the labyrinth is unique in that its only function is the maintenance of balance. Nystagmus is a most important reaction resulting from labyrinthine stimulation and is used as the chief indication of labyrinthine irritation, although dizziness, pallor and past pointing may also occur. In order to interpret the meaning of nystagmus certain rules have been helpful. These are based on the experiments of Flourens (1842)* and Ewald (1892).

Flourens' law

Stimulation of a semi-circular canal tends to elicit nystagmus in its own plane. The nystagmus which follows the stimulation of a horizontal canal is approximately in the horizontal plane. The vertical canals of one ear are at right angles to each other. They are stimulated simultaneously and the effect is a movement of the eyes in a plane, the resultant of the affected canals. It is a rotatory nystagmus in the frontal plane.

* Flourens' reference is not available to us.

Ewald's laws

(1) A horizontal semi-circular canal is maximally stimulated by a movement of the endolymph towards the ampulla. It is minimally stimulated by a movement of the endolymph away from the ampulla.

(2) A vertical semi-circular canal is maximally stimulated by a movement of the endolymph away from the ampulla. It is minimally stimulated by a movement of the endolymph towards the ampulla.

(3) When a semi-circular canal, either horizontal or vertical, is maximally stimulated it elicits nystagmus with the quick phase to its own side. When a semi-circular canal is minimally stimulated it elicits nystagmus with the quick phase to the opposite side.

At the present time there is some difference of opinion as to whether the experiments of Ewald carried out on the pigeon are applicable to the human labyrinth. Ewald's laws have proven to be a practical guide in the interpretation of labyrinthine stimulation and those who question their applicability in man have not as yet offered indisputable proof that they do not apply. It is generally admitted that the semi-circular canals in reptiles, amphibia and fish respond to a movement of the endolymph in only one direction, that is, in the direction of maximal stimulation, which Ewald demonstrated in the pigeon.

NYSTAGMUS

Normally, nystagmus is a compensatory reaction of the eyes and has for its object the retention of a specific field of vision. If the head moves, or if the field of vision moves, the eyes move in the opposite direction (slow phase of nystagmus) and remain fixed on the original field. Because of the limited excursion of the eyes, however, the original field cannot be held and the eyes are quickly jerked back (quick phase of nystagmus) to take up a new focus which is again held to the limit of eye excursion. If the nystagmus is the result of a head movement it is due to stimulation of the labyrinth and is a vestibulo-cerebral reflex. If it is due to a movement of the field of vision it is from stimulation of the retina and is an oculo-cerebral reflex.

Spontaneous nystagmus

Nystagmus may be caused by disease or irritation of any of the structures concerned in the production of the normal reaction. Such a nystagmus is called a spontaneous nystagmus and its origin may be vestibular, ocular, or central.

Labyrinthine nystagmus

Labyrinthine nystagmus is usually of the horizontal rotatory type, of small amplitude, moderate frequency and of short duration; the eye movements are associated. During the stage of labyrinthine irritation the quick phase is to the side of the lesion. As soon as the labyrinth has been overcome by disease, the quick phase is toward the healthy side and is produced by the unopposed healthy labyrinth. This second stage will not last more than a few weeks, so that a spontaneous nystagmus of labyrinthine origin is relatively of short duration and

is usually accompanied by dizziness and hearing changes This is not likely to be the case in ocular or central nystagmus.

Ocular nystagmus

Usually of long duration, ocular nystagmus tends to be irregular and may be characterized by a to-and-fro oscillation rather than by a slow and quick phase. The amplitude may be wide; it is generally horizontal in character; occasionally rotatory and rarely vertical; there is usually an associated eye lesion.

Central nystagmus

Central nystagmus is due to intracranial disease, is fairly constant and may be of long duration. It may be horizontal, vertical or diagonal in direction. The eye movements may be dissociated. There are usually other signs of intracranial involvement to assist in the diagnosis. Spontaneous vertical nystagmus is characteristic of intracranial disease involving the brain stem. It depends for its production upon the simultaneous stimulation of both posterior or both anterior vertical canals. Such a symmetrical and localized lesion in each labyrinth would be unlikely, whereas simultaneous irritation of the pathways from the vertical canals of both sides where they lie together in the brain stem does occur. Its presence would indicate a lesion of the posterior fossa.

Positional nystagmus

If nystagmus results or tends to recur when the head assumes one particular position it is a modification of spontaneous nystagmus which is referred to as positional nystagmus. It is frequently associated with dizziness which is then called postural dizziness. It is particularly important to look for positional nystagmus in any patient complaining of dizziness which occurs when he assumes a certain position. Nylén (1939) and Lindsay (1945) have stressed the importance of a routine examination to reveal positional nystagmus and especially of examining the patient in the prone, sitting, and supine positions as well as in the lateral and head-hanging positions. Nylén and Lindsay attached certain significance to nystagmus which is altered by the change of the position of the head.

Positional nystagmus affords objective confirmation of a lesion which may be suggested by the symptom of dizziness. Lindsay points out that positional nystagmus is more frequently present in the so-called atypical case of Ménière's syndrome, in which there are cerebro-vascular disturbances, than it is in true Ménière's syndrome. Gerlings (1948) has noted positional nystagmus in patients with middle-ear suppuration.

Directional preponderance

A number of writers, notably Dusser de Barenne and de Kleyn (1923), reported that under certain circumstances nystagmus could be more readily elicited to one side than it could be to the other. They found this to be the case in some patients with Ménière's syndrome and in others with massive lesions of one cerebral hemisphere. Fitzgerald and Hallpike reported in 1942 that this type of nystagmus was more likely to occur in cerebral lesions involving the

temporal lobe. They have described this tendency as a directional preponderance. In a subsequent investigation Cawthorne, Fitzgerald and Hallpike (1942) reported that directional preponderance occured in 21 per cent of 100 cases of Ménière's syndrome. In these cases they localized the lesion to the utricle of the side opposite to which the nystagmus was preponderant. Jonkees (1948) reported that directional preponderance could be demonstrated in about 20 per cent of normal individuals. McNally and his co-workers (1949) did not find that directional preponderance was of diagnostic significance in a series of 200 cases of vertigo.

PAST POINTING

Past pointing, falling, and head turning are all compensatory reactions resulting from labyrinthine stimulation. These are always in the direction of the slow phase of the nystagmus, which is also compensatory. Physiologically, the labyrinth is stimulated by movement and normally these compensatory reactions serve a useful purpose in adjusting the individual's balance. When the stimulation of the labyrinth is due to disease or to the caloric test these compensatory reactions are called forth to adjust for an apparent movement—one which has not really occurred—and the result may be upsetting to the individual.

The sensation of movement following labyrinthine stimulation is not compensatory and is always in the direction of the quick phase of the nystagmus.

Grahe (1932) suggests that the fine shades of past pointing are best brought out by testing both arms simultaneously. He has found that spontaneous past pointing is a fairly common sign of disease involving a cerebellar hemisphere, and that the past pointing is to the diseased side Dorcus and Mowrer (1936) have stressed the importance of not having the patient try to touch the examiner's finger during the test, because in so doing a voluntary act is introduced. Past pointing is not a conscious corrective reaction but an involuntary compensatory reaction. It is not usually observed after minimal stimulation of the labyrinth.

SUBJECTIVE SENSATIONS

The authors have carried out a large number of investigations on the labyrinth using the caloric and rotation tests, and have been impressed by the variety of sensations which have been described by the patients. Rotatory sensations are not always experienced. Vertigo and dizziness are conscious experiences which result when conflicting impulses arise in the postural mechanisms. It would appear that these terms may be used synonymously.

When dizziness is associated with middle-ear suppuration it may indicate threatened labyrinthine involvement. It demands investigation of the ear and may require surgical interference.

LABYRINTHINE TESTS

A complete ear, nose and throat examination together with a careful history should precede the examination of the labyrinth. Spontaneous nystagmus, past pointing and incoordination of the limbs should be looked for and described.

When there is a spontaneous nystagmus, before stimulating the labyrinth the eyes should be directed to a point at which they are at rest, or at which the nystagmus is at a minimum, in order to facilitate the interpretation of the after-test nystagmus.

The hearing must be examined with particular attention being paid to speech audiometry. Dix, Hallpike and Hood (1948) have stated that lowered threshold of discomfort, poor discrimination of speech at higher intensities, loudness recruitment and paracusis may all indicate a cochlear end-organ lesion—Meniere's syndrome—and may serve to differentiate such a condition from a nerve fibre lesion such as an eighth nerve tumour.

Calvanic test

Electrical stimulation of the labyrinth is not generally used because the current may stimulate not only the labyrinth but also the vestibular nuclei. It has been reported as a useful test by Dix, Hallpike and Harrison (1949) and by Ingelstedt and Walander (1949) in patients suffering from streptomycin toxicity.

Rotation test

The turning chair, as a means of testing the labyrinth, has been largely superseded by caloric stimulation. In spite of the fact that turning—acceleration—is the physiological stimulus for the labyrinth, this test is not as valuable to the clinician as the caloric test. Turning stimulates both labyrinths simultaneously and thus makes difficult the interpretation of the results of the test. However, the turning tests are valuable when one wishes to test an individual pair of vertical canals.

By placing the head in the proper position it is possible to stimulate a diagonal pair of vertical canals; for example, the right anterior and left posterior vertical canals may be stimulated by placing the head forward 90 degrees and rotating the hin 45 degrees toward the right shoulder.

A chair is used that can be stopped suddenly. It is turned about ten times in twenty seconds. The sudden stopping sets up a negative acceleration with an endolymphatic current in the opposite direction to that which was present at the beginning of the turning. The results of the test are interpreted according to Flourens' and Ewald's laws.

If one turns a patient to his right with the head erect, at the beginning of the turning, because of inertia, the flow of endolymph is toward the ampulla of the right horizontal semi-circular canal and the nystagmus is to the right. During turning at even velocity the endolymph comes to rest. When the turning is stopped suddenly, a flow of endolymph occurs away from the ampulla of the right horizontal semi-circular canal. This is a flow in the opposite direction to that at the beginning of the turning. The after-nystagmus is in the opposite direction to the turning, and is to the left.

The rotation test has been criticized by van Egmond, Groen, and Jonkees (1949). They consider that it is too severe a stimulation to the labyrinth and they have suggested a modification of the test in which is used varying degrees of minimal stimulation, and in which is recorded not only the after-nystagmus time but also the occurrence and duration of after-turning sensations. Their equipment

is so designed as to exclude most extraneous stimuli. Outside noises are reduced to a minimum, the room is darkened, the turning is done at sub-threshold velocities, and the total stimulus never exceeds 90 degrees per second. A number of turns in clockwise and anti-clockwise directions are applied to each individual and the duration of the after-nystagmus and after-turning sensations are recorded separately on a schematic graph (Fig. 1). The angle of turning by the time taken is recorded along the ordinate, whereas the duration of the after-reactions are recorded on the abscissa. It is noteworthy that the after-sensations have a lower threshold—2·5 degrees per second—than has the after-nystagmus, the threshold of which is usually about 8 degrees per second.

This modification of the turning test is called cupulometry and its originators regard it as a very sensitive index of semi-circular canal function. It must be pointed out, however, that this is still a rotation test and has the disadvantage of stimulating both labyrinths simultaneously.

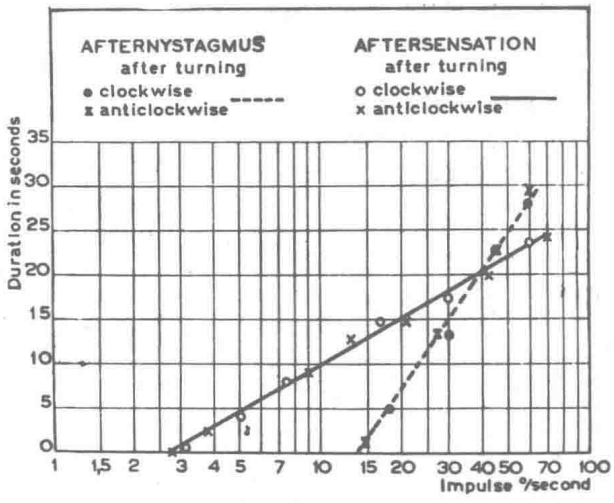

FIG. 1.—A normal cupulogram. (*By courtesy of van Egmond, A. A. J., Groen, J. J., and Jonkees, L. B. W.* (1948). *J. Laryng.*, **62**, 63.)

Caloric test

In describing the rotation test it was pointed out that even though that test was based upon a physiological stimulus—acceleration—it has been replaced by the caloric test which was introduced by Bárány (1907). It had been observed that dizziness and eye nystagmus frequently resulted from syringing an ear during the treatment of suppurative otitis media. After considerable investigation Bárány came to the conclusion that the labyrinth, or more specifically the intra-labyrinthine fluid, was being affected by the temperature of the solution used for the syringing, and that convection currents were set up in whatever canals were in a vertical plane at the time of the syringing. He based his conclusions upon the experiments of Ewald, and set forth what appeared to be a logical explanation for nystagmus, dizziness and past pointing which followed syringing of an ear with fluid which was either above or below body temperature. The resulting nystagmus was in opposite directions when the head was maintained in the same

position, depending upon whether the irrigating fluid was hot or cold. When the head is erect the two vertical canals are stimulated and a rotatory nystagmus occurs in a frontal plane. Putting the head back about 90 degrees brings the horizontal canals into a vertical plane, and the resulting nystagmus is horizontal. From this latter position, if the head is bent forward through 180 degrees, the resulting nystagmus is still horizontal, but its direction is reversed because the direction of flow of endolymph is reversed.

In its original form this test involved the use of a large quantity of water considerably above or below body temperature, and severe labyrinthine stimulation was generally produced. Kobrak (1923) reported a modification of Bárány's test using smaller amounts of solution more nearly approaching body temperature. This minimal caloric test proved to be more effective in providing information about changes in the labyrinth. In other words one could detect smaller degrees of hypo-irritability or hyper-irritability.

Other modifications followed in the wake of Kobrak's contribution. Techniques were reported for the stimulation of both ears simultaneously with solutions at the same or at different temperatures. One of the most informative of these modifications was the alternate hot and cold caloric test which has recently been revised and simplified by Cawthorne, Fitzgerald and Hallpike (1942).

These authors have reported a technique for the alternate hot and cold caloric test. They suggest that for purposes of standardization, the solutions used should be 7 degrees above and 7 degrees below body temperature. In order to avoid minor errors from slight changes in temperature, they advise using a relatively large amount of solution—about 16 ounces flowing into the ear canal for 40 seconds. They record nystagmus time from the onset of stimulation so that it includes the latent period. The results of the test for both temperatures and for both ears are recorded on a graph (Fig. 2) which makes it possible for one to see at a glance any discrepancies.

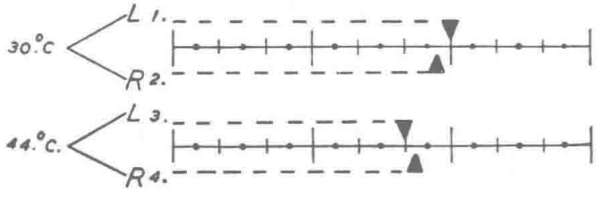

FIG. 2.—The right and left ears are denoted by R. and L. The duration of the nystagmus is represented by the interrupted lines, sub-divided into periods of minutes, 20 seconds and 10 seconds. (*By courtesy of Fitzgerald, G., and Hallpike, C. S.* (1942). *Brain*, **65**, 115.)

The most generally used caloric test is some simple modification of the Kobrak test. Simplicity has merit if it is not at the expense of accuracy or of important information. There are still many clinics and many otolaryngologists' offices in which a labyrinthine test is rarely, if ever, performed. If one hopes to improve this situation an informative simple test must be available. Once these otolaryngologists have been impressed with the usefulness of the test, they may be encouraged to adopt more complicated tests which on occasions will supply more useful information.

Technique

The following technique has the merit of simplicity. The equipment consists of an ordinary luer syringe with a 20-gauge needle to direct the flow of solution against the ear drum, preferably through an ear speculum under direct vision. The solution advocated is 3 millilitres of ice water which, although slightly disagreeable to the patient, has the advantage that the temperature at the outset is always the same; it also permits the use of a small quantity of solution. If 3 millilitres of ice water are kept in contact with the ear drum of the average individual for 20 seconds it will elicit a nystagmus (including the latent period) that will last for about 2 minutes from the onset of the stimulation. The amount of solution and the length of time it is in contact with the ear drum can be increased. If there is no reaction when 30–50 millilitres of ice water is in contact with the ear drum for one minute, the labyrinth is non-reactive. However, before reaching this conclusion the condition of the middle ear and drum must be taken into consideration. If they are not normal there may be something obstructing the heat transfer across the middle ear to the labyrinth.

FIG. 3.—The Dundas Grant cold air tube.

With this method of testing, reactions from both the vertical and horizontal semi-circular canals can be determined with one and the same stimulus. When the test is carried out with the patient sitting up and the head erect the vertical canals are stimulated and there should be a rotatory nystagmus. If the head is moved back 90 degrees the horizontal canal is stimulated and the nystagmus should change from rotatory to horizontal. The direction of the nystagmus will depend on the temperature of the fluid. Having made these observations, the examiner should then direct the patient to move his arms up and down as for past pointing. It should be remembered, however, that past pointing may not be produced with minimal stimulation. The patient should be asked about his subjective reactions. If there is dizziness, he should be asked to compare the after-test dizziness with any spontaneous dizziness he may have had. His answer may give suggestive information as to whether or not his spontaneous dizziness was related to labyrinthine irritation.

If one wishes to carry out a caloric test immediately following a mastoid operation, where sterility is necessary, any cold sterile solution such as saline or sulphonamide solution may be used and introduced through an open mastoid wound. Under such circumstances one should expect slight differences in the reaction because of the more direct application of the stimulating fluid to the bony labyrinth.

An open moist perforation in an ear drum is not a contra-indication to the caloric test. Strictly speaking, one should use a sterile solution, but there should be no objection to any of the solutions that would be used routinely in syringing a discharging ear; for example, chilled boracic acid or saline.

The use of any fluid, sterile or otherwise, is contra-indicated when there is a dry perforation in an ear drum. When this situation arises the caloric test can readily be performed by blowing cold or warm air into the ear canal. A special coiled copper tube devised by Sir James Dundas Grant makes a very easy method of introducing the cold air (Fig. 3). The tube is covered with a cloth material upon which is sprayed ethyl chloride. When air is blown through the tube and against the ear drum for 20 seconds, a nystagmus results which lasts about 2 minutes in the average normal individual. The source of air may be from a hand bulb or from compressed air. It is interesting to note that this stimulation elicits about the same reaction as 3 millilitres of ice water in contact with the ear drum for 20 seconds. The time of this cold air douching can be extended. If there is no reaction after one minute of cold air douching, in what appears to be a normal ear drum and middle ear, the labyrinth is markedly hypo-irritable or, more probably, is not reacting.

This cold air method of testing the labyrinth is recommended for office practice because of the ease with which it can be carried out and because of its safety even in the presence of an open drum perforation.

Fistula test

One of the oldest, most readily available and most informative tests of the labyrinth, the fistula test, is all too frequently neglected or overlooked.

It is a mechanical test for the stimulation of the labyrinthine portion of the internal ear. In the course of chronic suppurative otitis media an erosion of the bony labyrinthine capsule may take place. This is one of the commonest and most serious complications of middle-ear suppuration. When the bony wall of the labyrinth is invaded by a gradual eroding process, such as cholesteatoma, the eroded area is usually walled off. This at first prevents gross infection from entering the labyrinth, but pressure changes within the middle ear may be directly communicated across this barrier to the internal ear canal and the patient becomes dizzy. In the majority of cases the presence of the erosion or fistula is detected when the otologist increases the middle-ear pressure. This may be done through a Siegle speculum, or by using a Politzer bulb with a nozzle sufficiently large to block the external ear canal. The eyes will be observed to move when the pressure is suddenly increased. Some considerable effort has been made to determine the direction and the character of the nystagmus. However, of paramount importance is the fact that the nystagmus and dizziness are produced, and this indicates the presence of erosion of the bony labyrinthine wall.

In rare individuals marked increase of intra-tympanic pressure in the presence of an unusually mobile stapes or round window will produce a reaction simulating a positive fistula test. Such cases can usually be differentiated from cases of true fistula.

If one is sure that a fenestration operation has not been performed, a positive reaction to this test in the presence of middle-ear suppuration usually indicates the immediate need for free surgical drainage of the mastoid and middle ear. A negative fistula test, of course, does not exclude the presence of a fistula unless the caloric test has indicated that the labyrinth is normal. The fistula test should be a part of the first examination in every case of suppurative otitis media and should constitute one of the first steps in the examination.

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