PATHOLOGICAL AND SURGICAL OBSERVATIONS
ON THE DISEASES OF THE EAR. .
(EIGHTH SERIES.)

ON
DISCONNECTION OF THE INCUS AND
THE STAPES;

ITS EFFECTS UPON THE FUNCTION OF HEARING,
AND ITS TREATMENT.

BY THE LATE
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Anatomical and Physiological Observations.

THERE appears now to be but little doubt in the minds of those who have studied the physiology of the ear, that the chain of ossicles in the human ear has two distinct functions—*one* to conduct sonorous vibrations from the *membrana tympani* to the labyrinth, the *second* to adapt the labyrinth for the reception of sounds of different degrees of intensity.

That the chain of bones conducts vibrations from the

membrana tympani to the labyrinth, and that the progress of these vibrations is not materially interrupted by the different planes presented by the several portions of the chain, nor by the presence of the articulations, is rendered evident by some experiments of my own, the results of which were laid before the Royal Society in the year 1859; and, above all, by the highly interesting observations of MM. Lissajons and Dessains who have been able to picture undulations upon paper produced by a hair attached to the base of the stapes, and which hair was caused to vibrate by the motions of the drum under the influence of sounds.

But it may be asked, if the main channel for the passage of sonorous vibrations to the labyrinth be the chain of ossicles, how does it happen that cases occur in which this chain is found interrupted after death by the disarticulation of the incus and stapes, and in which, nevertheless, the patient during life was not known to be deaf? The reply is, that a simple disconnection of the incus from the stapes is of comparatively slight importance, so long, at least, as the *tensor tympani* ligament, the *membrana tympani*, and the mucous membrane of the tympanum, are healthy, inasmuch as the stapes and incus are then kept in tolerably close apposition. Thus, if the tympanic cavity be exposed in dissection, and the incus simply disarticulated from the stapes, the two bones will be observed to be in contact, and to remain so even when the whole of the chain is moved by traction upon the *tensor tympani* muscle or by the depression of the stapes.

Indeed if a thin slip of paper or of india-rubber be inserted between the disconnected incus and stapes, the force by which the incus is pressed against the stapes is sufficient to squeeze the foreign body between the two bones and to retain it there. And this force is mainly due to the action of the *tensor tympani* ligament, a structure of great importance in the function of hearing. This ligament is tubular, and encloses the tendon of the *tensor tympani* muscle. It is about three fourths of a line in length, and is attached internally to the cochleariform process, and externally to

that part of the inner surface of the malleus where the long process joins the neck. Its office is to keep the *membrana tympani* and the chain of bones in a state of gentle tension, and, when cut through in dissection or destroyed by ulceration, the *membrana tympani* and chain of bones become flaccid and relaxed.

But it may be asked further, if the chain of bones is the medium for the passage of vibrations to the labyrinth, how it is that when, with a large orifice in the drum, the incus is seen to have lost a considerable portion of its long process, so that its connection with the stapes is not possible, still the hearing power is not very materially affected? The explanation of this phenomenon will be found in a paper giving some researches upon the function of the chain of ossicles in the human ear above referred to. From the experiments detailed in that paper it would appear that the stapes, when detached from the incus, can itself receive sonorous vibrations from the air and conduct them to the labyrinth in sufficient force to ensure tolerable hearing.

That a *second* function of the chain of bones is to adapt the labyrinth for the reception of sounds having various degrees of amplitude, appears also to be proven by experiment and dissection. Thus, when the ear is expecting to receive a loud sound the *membrana tympani* is drawn tense by the *tensor tympani* muscle, and the incus and stapes being pressed inwards, the fluid in the labyrinth is also pressed upon, and the membrane of the *fenestra rotunda* is tightened; on the contrary, during the act of listening the *membrana tympani* is relaxed by means of the stapedius muscle, the office of which is to draw outwards the stapes, the incus, and malleus. Thus, the *tensor tympani* muscle has the function of tightening the *membrana tympani* and the *membrana fenestræ rotundæ*, while the stapedius muscle has the function of relaxing them. But when the long process of the incus has been removed, of course the *tensor tympani* muscle can no longer exercise any influence upon the stapes, and it would seem that in this case the return of the stapes to its state of quiescence, after the action of the stapedius

muscle has ceased, is due to the ligaments which surround the base of the stapes and connect it with the circumference of the *fenestra ovalis*. The adapting faculty of the ear, so essential to the hearing of the human voice in conversation, is then effected tolerably well by the action of the stapedius muscle and the reaction of the ligaments of the base of the stapes. This action and reaction may be demonstrated in dissection by exposing the base of the stapes in the vestibule and then gently pressing upon its anterior extremity; the stapes will be observed to yield slightly under the pressure, and to return to its position so soon as the pressure ceases. If, in another specimen, the incus be removed, and the stapes be drawn backwards in the direction of the pyramid containing its muscle, the stapes will be observed to return to its original position as soon as the traction ceases.¹

From the foregoing observations it may be fairly assumed—

1. That the function of the chain of bones is twofold, viz., the transmission of sonorous waves to the vestibule, and the regulation of their force.

2. That when the continuity of this chain is interrupted by the disconnection of the stapes and the incus, the functions of the chain may, nevertheless, be performed by the combined actions of the *tensor tympani* ligament and muscle, and of the *membrana tympani* itself.

3. That after the destruction of the *membrana tympani* and the loss of the incus, the stapes can still receive vibrations from the air and conduct them to the labyrinth, in sufficient force to allow the patient to hear ordinary conversation with tolerable ease.

4. That after the *membrana tympani* has been destroyed and the incus removed, the combined action of the stapedius muscle and the ligaments connecting the base of the stapes to the *fenestra ovalis* may be adequate to perform the adapting function of the ear, so that the patient may hear ordinary conversation with tolerable ease.

¹ In a paper published in the 'Medico-Chirurgical Review' I have shown that the movement of the stapes in the fenestra ovalis is like to that of a piston in a cylinder.

Pathological and Surgical Observations.

It may appear somewhat remarkable that the lesions of the drum and the chain of bones adverted to in the foregoing remarks are, as a rule, productive of so slight a diminution in the function of hearing that medical men are not commonly applied to for their reparation. These lesions are noticed when the patient applies for other reasons than for the relief of deafness, viz., for discharge from the tympanum, pains, &c. If, however, certain other lesions are superadded to those above named, then most serious deafness ensues. These lesions and the remedial measures adapted for their relief will now be pointed out.

The lesions may be divided into two distinct classes, the *first* being those in which the *membrana tympani* is entire, the *second* those in which the *membrana tympani* is more or less imperfect.

(a) *Of those cases in which the stapes and incus are disconnected, the membrana tympani remaining entire.*

It has been stated above that simple disarticulation of the incus and stapes is not productive of any material diminution in the hearing power, inasmuch as if the *membrana tympani*, the *tensor tympani* ligament, and the muscles, are healthy, the two bones are kept in contact and are enabled to move in concert. But if the *membrana tympani*, or the *tensor tympani* ligament, or the muscles of the chain of bones, or the mucous membrane of the tympanum, are affected, then the incus and stapes can no longer be retained in contact, or at least not without *constant* muscular effort.

The first division of this class of cases to which I shall refer is that in which *the hearing power is imperfect unless the act of listening is practised or the drum is supported.*

Cases have not uncommonly presented themselves to me, where the patients have complained of excessive fatigue and weariness attendant upon the performance of the function of hearing. The patients say "there is no deafness so long as the act of listening is performed, but this unceasing effort of listening entirely destroys the comfort of life."

It is important to understand this kind of defective hearing, because young persons, especially those at school, are liable to suffer from it, and to be treated somewhat cruelly. "It is not deafness, it is only inattention," says the parent or the teacher; "the child hears well enough when it chooses to listen." But no child can be always listening; the healthy ear hears without listening, and if any one will make the experiment and listen attentively, even for a minute or two, to some delicate sound, that is not heard without attentive listening, it will be found that the effort to ear and brain is not a slight one, but is very fatiguing. It has been said already that in the healthy ear this act of listening consists in an action of the stapedius muscle, which draws outwards the stapes, and in consequence the incus, malleus, and *membrana tympani*; the act of listening in the cases under consideration consists in drawing out the stapes, and bringing it into contact with the incus, so as to make the chain of ossicles complete, and also in pressing outwards the incus, malleus, and *membrana tympani*, for it is interesting to observe that the action of listening is the same as that which brings the stapes into contact with the incus, and thus establishes the continuity of the chain of ossicles. It may be asked what evidence there exists that the morbid condition in these cases is disunion of the stapes and incus, inasmuch as it is impossible to see through the *membrana tympani* and thus observe the lesion. The reply is that this lesion is known to be common—this is shown by dissection; that the mucous membrane of the tympanum is known to be subject to affections likely to produce this lesion; that there is usually a history of some such affection; that the condition of the membrana indicates the existence of relaxation; and that the methods of relief cannot be explained upon any other theory than that of the existence of this lesion, or, what is tantamount to it, relaxation of the ligaments of the joint; further still, it may be fairly presumed that this lesion does exist, because *it is seen to exist* in cases where the *membrana tympani* is perforated, and where treatment analogous to that pursued for the relief of the cases now under consideration is perfectly successful.

The *treatment* in this class of cases consists in making gentle pressure upon the outer surface of the *membrana tympani*, so as to keep the incus in contact with the stapes. By means of this gentle pressure the hearing power is perfectly restored. It may be observed that any means whereby the incus is brought into contact with the stapes is equally successful as gentle pressure on the outer surface of the drum; for example, in the following case the sudden drawing inwards of the drum, by what the patient called "a forcible sniff," succeeded in temporarily curing the difficulty of hearing; this "sniff," in reality, produces an exhaustion of some of the air from the tympanic cavity, and a consequent inward movement of the drum and chain of bones, but this condition soon ceases.

CASE 1. *Deafness except during the act of listening; cured by the use of the artificial membrana tympani.*—Master I—, æt. 18; three years before he consulted me he suffered from pain in the right ear, which was followed by discharge; this has recurred several times. He complains also of hollow and whistling sounds in the head, which are sometimes accompanied by giddiness and last a minute or two; he also complains of headache, at times with pain at the top of the head; these symptoms sometimes much increase. The hearing power with the right ear, as tested by my watch, was perfect, and with the left ear my watch was heard at a distance of two inches in place of two feet. As a general rule, a patient hearing my watch normally with one ear is not inconvenienced by defective hearing in society, nor was this youth so long as he listened attentively, for by attentive listening he could hear rapid conversation, even when carried on in a low voice; but let his attention be occupied in a room where conversation is going forward, and he hears nothing, in fact, he sits like one deprived of the faculty of hearing until his attention is attracted and he is induced to listen, when he hears perfectly. Some time since, he discovered accidentally that by "sniffing up forcibly" he could produce a feeling of tightening in the ears, which was followed directly by an

improved power of hearing, so that without any effort of listening he heard conversation distinctly and easily, and this improvement in the hearing was accompanied by a cessation of the unpleasant sensations in the head.

On some occasions a single "sniff" was sufficient, at others four or five rapidly repeated sniffs were required to produce the good result. It may be added that this patient complained of a discharge from the ear into the throat, which had at times a very unpleasant odour. Upon inspection the *membrana tympani* in each ear had a sodden appearance, and the triangular bright spot was much larger than natural. Each Eustachian tube was pervious. My diagnosis in this case was that there had been catarrhal inflammation of the tympanic mucous membrane, which had more or less disconnected the incus and stapes; that by a considerable effort of volition the *tympanic* muscles were able to bring the two bones into perfect contact in the right ear, and into imperfect contact in the left. It also appeared probable that the peculiar head symptoms were the result of the relaxed condition of the stapedial ligaments, which were not sufficiently firm to retain the base of the stapes firmly in the *fenestra ovalis*. Acting on this belief, I applied to the left ear, in the first place, an artificial *membrana tympani*, so as to give very gentle support to the malleus, and by pressing it slightly inwards to place the incus in contact with the stapes. The result was most satisfactory; the patient at once found himself hearing better and without any effort, and so long as the artificial drum remained in the ear he heard without the slightest difficulty, even the lowest sounds. The head symptoms also disappeared with the presence of the drum, and reappeared when it was withdrawn. Subsequently the artificial drum was applied to the right ear with similar effect.

It may be added that the ordinary artificial drum was not successful, but the globular form, to be noticed hereafter, acted perfectly.

In the previous case the hearing power became defective,

that is to say, the patient was obliged to listen attentively, directly the artificial drum was withdrawn. In the following case the benefit remained for a considerable period after the support to the *membrana tympani* had been removed. In other respects the two cases are very similar.

CASE 2. *Deafness except during the act of listening; hearing restored by the use of the artificial membrana tympani, the power retained after its withdrawal.*—Master G. S—, æt. 14, consulted me on account of deafness in the *left ear*, which he considered to be nearly useless. The right ear is perfect when the act of listening is performed, but not otherwise. The cause of the deafness is said to be an attack of scarlet fever when quite a child. My watch was heard at a distance of twenty six inches by the right ear, of nine only by the left. A whisper is heard at a distance of eight yards with the left ear as well as with the right, and this with the back turned towards the speaker; but the father of the patient, who was a witness of the experiments, assured me that when his son sits reading and his attention is absorbed he requires to be spoken to in a very loud voice in order to be made to hear. Each *membrana tympani* is dark and has a sodden appearance. Upon the application of an artificial drum to each ear, the patient experienced an immediate “sense of comfort” and ability to hear without the exercise of any effort. Upon his return home it was found that, whatsoever his occupation, he heard as well as those around him. The hearing power remained for several hours quite perfect after the withdrawal of the drums, and by degrees the drums were wholly dispensed with.

The second class of cases consists of those in which the membrana tympani is perfect, but the hearing power is very defective, even during the act of listening, unless the membrana tympani and chain of bones are supported.

In this class of cases there is usually a history of some catarrhal affection of the mucous membrane lining the tympanum; and although it is impossible to speak positively

as to the exact pathological condition of the ear, there is every ground for believing that the incus and stapes are not in apposition, and that the action of the muscles, pertaining to the chain of bones, is insufficient to bring these two bones into contact. Therefore, the only difference between this class of cases and the preceding one is that, whereas in the preceding class a voluntary effort *can* bring the incus and stapes into contact and keep them so, in the present class of cases the two bones *cannot* be brought into contact by voluntary effort. Perhaps the best illustration I can cite of this class of disease is the case of Dr. Erhard, of Berlin, whom I had the opportunity of examining very carefully when I was in Berlin three years since. If I remember rightly, Dr. Erhard had some catarrhal affection of the mucous membrane of the tympanum in early life. This was followed by deafness in one ear, so that it was almost useless for the purposes of conversation, &c. The *membrana tympani* was entire, but of a dark colour, and it had a sodden appearance. When the tympanic cavity was distended by air the *membrana tympani* bulged out, but no air passed through it. Before testing the ear in various ways, the hearing power was found to be very defective; indeed, the ear may be said to have been useless even when every effort to hear was made by the patient. Gentle pressure was then made upon the outer surface of the drum, in this instance by cotton wool steeped in a solution of lead, and then the hearing power was at once and fully restored. Dr. Erhard, in a very interesting paper, showed clearly that the good effect of cotton wool depended upon its action upon the chain of bones.

The third class of cases consists of those in which the incus is not only disarticulated from the stapes, but the long process of the incus has also been more or less absorbed, the membrana tympani remaining entire.

This class of cases fortunately is not common, inasmuch as the amount of disease in the tympanic cavity, which induces absorption of the long process of the incus, is usually sufficient to cause destruction of a larger or smaller portion of the *membrana tympani*. The only means of affording relief

to deafness in these cases is to press the *membrana tympani* inwards, and to keep it in contact with the stapes, when the vibrations are conveyed to the drum and thence to the stapes.

And it is interesting to find that nature herself not infrequently adopts this process of cure, for dissection has shown that the stapes becomes attached to the *membrana tympani*.

(b) *Of the disconnection of the stapes and incus, the membrana tympani being perforate.*

Cases are of constant occurrence in which there is evidence of the *membrana tympani* being imperfect, and still no evidence of deafness is apparent. Thus, it is common for smokers to send smoke out of the outer ear, which operation, of course, can only be performed when there is an orifice in the drum, but such smokers are usually quite unconscious of the existence of any defect in hearing; indeed, in their ignorance of the structure of the ear, they believe that every smoker may do the same feat. And if these cases of perforated *membrana tympani* be carefully examined, it will be found that there is but little diminution in the hearing power, the remnant of the drum being sufficient to receive and to conduct vibrations to the chain of bones; and the chain of bones is sufficiently normal to conduct them to the nerve; while the entire apparatus of drum, bones, and muscles, can perform the "adapting" function of the ear. On the contrary, cases are being constantly met with in which there may be merely a small orifice, perhaps one half or one third the size it is in the above-named cases, and in which the hearing power is so defective as to render the organ almost useless. In what does the difference between these two classes of cases reside? Simply in the fact that in the former cases the chain of bones is perfect, while in this latter class of cases the chain of bones is imperfect, being flaccid in place of being in a state of moderate tension. This relaxed and flaccid condition of the chain of bones may depend upon the loss or softening of the *tensor tympani* ligament, or upon a thickening of the tympanic mucous membrane, or upon

relaxation of the ligaments connecting the incus and stapes ; but whatsoever the cause may be, the aim of the treatment is the same, viz., to give to the chain of bones its normal resiliency. This is to be effected by applying gentle pressure to the outer surface of the malleus by means of an artificial *membrana tympani*, and it is for these cases that the artificial drum is most frequently used.

There is another class of cases belonging to this division of the subject—*those in which the stapes and incus are not only disarticulated, but in which the incus has disappeared*. I have already mentioned the fact, one well known to students of aural surgery, that the loss of the incus does not necessarily entail deafness. On the contrary, many persons, by aid of the stapes alone, can not only receive vibrations upon the nervous apparatus, but they can adapt the ear, and with great facility, to a variety of sounds. Nevertheless, cases are not infrequently met with where great difficulty of hearing coexists with this condition, and this great difficulty of hearing depends upon the relaxed condition of the ligaments connecting the base of the stapes to the fenestra ovalis ; the stapedius muscle having drawn the stapes outwards, the ligaments have no longer the power to draw it back to its previous position. This disease is fortunately not hopelessly incurable, for if gentle pressure be exercised upon the head of the stapes by some very elastic body, such as the artificial drum, then the bone is pressed back to its position, and the function of hearing may be performed without difficulty.

It can well be conceived that, to exercise gentle continuous pressure upon the *membrana tympani*, the chain of ossicles, or a single ossicle—as the stapes—and still to allow the muscles to move the bones, is a matter of considerable nicety, and the body making the pressure must possess firmness, and still be very resilient. Mr. Yearsley uses cotton wool ; I have hitherto used a delicate layer of vulcanized india-rubber ; the former becomes sodden with discharge, besides being not easy of application. As an improvement upon the layer of vulcanized india-rubber, I have lately suggested the use of an artificial drum, composed

of a bubble of vulcanized india-rubber containing air; by means of this, firmness and due resiliency are attained.

It may be well to sum up here the several pathological conditions of the ear for which the artificial *membrana tympani* has been found efficient.

1. Disconnection of the stapes and incus, the *membrana tympani* being entire, but the tensor tympani ligament, or the mucous membrane of the tympanum, being relaxed.

2. Partial or complete absence of the long process of the incus, the *membrana tympani* being entire.

3. Disconnection of the stapes and incus, the *membrana tympani* being perforated, and the *tensor tympani* ligament, or the mucous membrane of the tympanum, being relaxed.

4. Partial or complete loss of the long process of the incus, the *membrana tympani* being perforated, and the ligaments of the stapes being relaxed.

The foregoing observations upon the pathological conditions of the chain of ossicles in the human ear are based upon dissections, which have, during many years, been laid before this Society, and of which descriptions have been published in the 'Medico-Chirurgical Transactions.'