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THE STUDY OF THE TONAL RANGES IN LESIONS OF THE MIDDLE EAR.

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The research work which we are reporting represents a large amount of careful, conscientious work, especially on the part of Dr. Bunch, who either made or supervised all the functional tests of hearing which are indicated. This report is confined to the examination of the auditory perception of a large series of cases of so-called middle ear trouble. In all cases exhaustive clinical examination was made. These examinations were grouped and studied, and the results are here summarized and presented for your consideration.

Plate 1 is the diagram of the clinical record made for each case examined. In only a few cases where it seemed desirable to have specific information regarding the vestibular functions were the turning tests made.

The hearing for whispered and spoken voice was first determined. Next the pitch range audiometer was used to determine the audition for tones between 30 and 7070 d. v.

The records with the audiometer are easily indicated by means of a graph shown in the plate. The pitch of the tones is indicated at the bottom and the loudness of the tone by the height of the curve on the graph, no tones at all being normally heard at zero. The curve shown on the graph is the field of hearing for a normal ear.

In the curves of cases studied that we are going to show, the curve was secured by testing the audition of the ear examined for every tone from 30 d. v. to 7070 d. v. The curve thus secured compared with the normal curve, which is stamped on every chart, gives an approximate idea of the relative hearing power for these tones.

If, for instance, the curve at 1,000 d. v. is only half as high as normal, this does not mean that hearing for that note

is one-half normal but only that hearing for the note is markedly decreased. We are not justified in assuming that the curves represent the exact audition for the note that is being tested. The fractions which express quantitatively the audition for various notes, when this is determined with the Bezdold forks, are likewise very inexact. As the intensity of sound varies with the square of the distance, with the square of the amplitude of the vibration, and is influenced by the rapidity of vibration, it is an extremely difficult matter to determine of vibration of sound, it is an extremely difficult matter to determine in any way the exact amount of audition for any given note.

If the curve of the ear being examined should show a tone gap in the tonal range, this does not necessarily mean that there is an absolute tone gap but it does indicate that the ear is unable to perceive the loudest tones capable of being produced by the audiometer. These gaps found by the audiometer have been verified in the psychologic laboratories by tests with organ pipes and other instruments producing pure loud tones. It is easy to conceive that if a note could be produced of greater intensity than that which the audiometer can give, it might be heard when the audiometer would produce no sensation of sound.

In the following charts the normal curve is indicated by a continuous line; curves for the right ear by dashes; and for the left ear by dots.

For the benefit of those who are not interested in the audiometer readings we have made in each case a quantitative determination of the audition for the 50 d. v. fork, the c, c¹, c², c³, c⁴, and c⁵ forks.

The Rinne, the Weber, and the bone conduction tests were made with the 256 fork. In some cases the 128 and 512 d. v. fork was also used. These forks were weighted to minimize the production of confusing overtones.

At the bottom of the plate next to the audiometer curve is a measurement of the upper tonal limit, as determined with the Galton whistle, the Koenig cylinders and the monochord. The upper limit of the monochord is determined both by A. C. and by B. C. With the Galton whistle which we use the normal upper limit is 21,000 d. v. With the Koenig cylinders the

upper limit is 43,960 single vibrations and with the monochord by A. C. 19,000 d. v., by B. C. 20,000 d. v.

In each case studied we have been interested in determining if in addition to the middle ear lesion there was also present a lesion of nerve or end organ.

Suggestive of a lesion of the acoustic nerve or its end organ is the following:

1. The audition for the higher notes is poorer than that for the lower or middle part of the tonal range. If the lower notes of the tonal range up to about 3,000 d. v. are heard normally and there is a diminution in the audition for the notes in the upper part of the range, as is shown by Plate 2, this diminution of audition for the higher notes is suggestive of a lesion of the nerve or end organ. If, however, as is shown in Plate 3, there is a uniform diminution in audition for tones throughout the range, it does not indicate a lesion of nerve or end organ. The curves shown in Plate 3 are the curves secured from: first, a case of impacted wax in the external canal; second, a similar case; third, three cases of individuals with normal hearing where the external canal has been packed with boric acid powder, and lastly, a case of cotton in the ear which was soaked with cerumen and was in contact with the drumhead. In each of these cases you note the diminution in audition for all tones throughout the range. As we view it, there would have to be a distinctly greater diminution for the notes in the upper part of the range as compared with the tone best heard in the lower or middle part in order to indicate positively a lesion of the nerve or end organ. In some of these cases the c^5 fork was not heard at all.

Plate 4 shows the curves of these cases after the removal of the impacted wax, cotton or boric acid powder. Note that the curves are practically normal.

2. A lowering of the upper tonal limit, especially by B. C. The better the hearing for voice and whisper, the more significant of a lesion of nerve or end organ is the decrease in the upper limit by A. C.

Plate 5 indicates the upper tonal limit in three of the cases of obstruction in the external canal just described by A. C. and B. C. determined with the monochord. Note the upper limit by A. C. is lowered 2,000 d. v. from obstruction in the

external canal. There is, however, no cutting down of the upper limit by B. C., and we feel that a lowering of the upper limit by bone conduction is a more definite indication of a lesion of nerve or end organ than the lowering of the upper limit by A. C.

Plate 6. The comparison of the upper limit of audition for high notes as determined by A. C. and B. C. is of interest.

The upper chart shows the A. C. and B. C. as determined with the monochord for twenty-two acute suppurative ears. The vertical figures represent the number of cases; the horizontal the upper limit in double vibrations per second. The curves are similar, but by air the lowest limit was 12,000 d. v., while by B. C. it was 14,000.

The results of examination of twenty-eight cases of chronic otorrhea are charted in the center. Again the larger number of cases make similar curves, but here, while the lowest limit by B. C. is 13,000 d. v., by A. C. it is 6,000—a great difference.

Below are graphs secured for charting the results of forty cases of hyperplastic otitis media. Here the similarity of the curves is lost.

The diagnostic significance of the difference between the upper limit as determined by bone and air conduction with the monochord is here illustrated. In cases of acute trouble 22 per cent gave a difference of 23,000 d. v. or more between the upper limits determined by air conduction and by bone conduction. In the chronic otorrhea cases this percentage was 39, while cases of hyperplastic otitis media gave this difference in 67 per cent.

The determination of the upper limit by B. C. is a far more accurate indication of the condition of the nerve and end organ than its determination by A. C.

3. Positive Rinne.

4. The sensitivity for one note or a group of notes is much less acute than the others when determined with the tuning fork or the audiometer.

To determine whether there is a significant difference between the hearing power for high tones and low tones, we have used the audiometer and the Bezold forks. For example, if the hearing for the c^2 fork is indicated by the fraction $20/24$ while that for the c^5 fork is indicated by the fraction $5/60$,

there is a greater decrease for the c^5 than for the c^2 . This would be shown on the audiometer record by a curve which closely follows the normal curve for a frequency of 512 d. v., but which falls much below the normal curve at 4096 d. v.

Plate 7 is a plate of neurolabyrinthitis showing these distinct depressions in the audiometer curve confirmed by the findings with the tuning forks.

5. Decreased bone conduction as determined by the c^1 and c^2 fork.

This is a very important matter. We feel that a bone conduction decreased two or three seconds is suggestive of a lesion of nerve or end organ when the examination had been properly made. We test bone conduction by placing the tuning fork over the bone just adjacent to the external opening of the bony canal posterior to the upper attachment of the external ear. We keep in mind the influence of mastoid involvement decreasing the bone conduction.

Bezold (*Textbook of Otology*, page 67) thinks that to be significant the perception by bone conduction for the fork placed on the vortex should be very much shortened.

Wittmaack (*Zeit. f. Ohr.*, vol. 60, page 136) is of the opinion that a shortening of the bone conduction is worthy of diagnosis when it amounts to at least 30 per cent of the average value which we get or is received through the examination of a large number of normally hearing individuals with the chosen tuning fork.

As the percentage of decrease will depend altogether upon the energy with which the fork is excited, this statement is of little value.

Bezold feels that an objection to this procedure is that extraneous sounds and the ability of the individual to make an accurate examination and of the patient to cooperate have a decided bearing upon the result. Such criticism is valid for all functional tests of hearing and is as true for determining hearing power by A. C. as well as B. C.

Our examinations are conducted in a room set apart especially for this purpose and, while it cannot be said to be entirely free from external noises, it is probably much more nearly ideal for this purpose than those ordinarily used.

Emerson (ANNALS OF OTOTOLOGY, RHINOLOGY AND LARYNGOLOGY, Dec. 21, page 999) is of the opinion when B. C. is lowered for the 256 or 512 d. v., that fork nerve deafness has been present for a long time.

Werhovsky (Prufung. d. Herdauer in Verlaufe der Ton-skala bei Erk. d. Mit. u. Innern O. Bezold U. d. Funk, Prof. d. Mench. Gehor., 1897-1909) found decreased B. C. in all lesions of the nerve or end organ that he studied. He reports B. C. decreased two seconds in one case of nerve deafness and three seconds in another.

He says that B. C. is less with higher forks than with lower and cites a number of observations to confirm this.

In describing his technic, he does not state the length of time his forks vibrate with a given stimulus. Our higher forks vibrate longer than the lower, and consequently the decrease in B. C. with the higher forks would be greater.

Siebenmann in an article translated by Dench (Archives of Otology, vol. 22, p. 5) says that in apparently normal ears there may be functional defects in the test for the upper tone limit and in the perception of sound by B. C. He also shows that B. C. is sometimes decreased by aspiration of the middle ear.

Page (Proceedings N. Y. Acad. of Med., Oct. 13, 1921) says that the early cases of otitis media have a negative pressure in the tympanum.

Kerrison (Text Book of Otology, pg. 89) suggests that the hearing by bone should be decidedly decreased to be significant.

Schwabach (Über Harprufung, etc., Archiv. f. Ohren., vol. 31, page 6) says that B. C. is longer than with normal persons in lesions of the transmitting apparatus, while it is the same as normal persons or less in lesions of the perceiving apparatus of the ear.

In our study of acute middle ear infections we have found it very unusual to find an infected ear without evidence of a lesion of its nerve or end organ.

Siebenmann, in an article translated by Dench (Archives of Otology, vol. 22, page 12) reports that in making functional examinations of pure cases of catarrh of the eustachian tubes he found the upper tone limit usually lowered and not restored by inflation. He assumed that the lowering of the upper limit

was due to a passive hyperemia of that portion of the scala vestibuli lying next the oval window.

Plate 8 shows curves of a case of acute tubal catarrh where we found no definite evidence of lesion of nerve or end organ. The decrease in hearing for the voice and whisper was apparently due to the middle ear condition and disappeared wholly on inflation. B. C. in each ear was normal. Upper limit by monochord, R., A. C. 16,000, B. C. 19,000; L., A. C. 17,000, B. C. 19,000. As with the blocking of the external canal the upper limit was lowered by air and not by B. C. Unfortunately, after inflation the upper limit was not tested by A. C.

The curve before inflation shows rather a uniform decrease in audition for all notes except the very lowest, which were not heard at all. The audition for the notes became almost normal on inflation.

Twenty-two acute infected ears were studied. Of the twenty-two, fourteen had positive Rinne and eight had negative Rinne; fifteen had decreased bone conduction for the c^2 fork and fourteen had the upper tone limit decreased 2,000 or more by A. C. as determined by the monochord. Thirteen of the fourteen had the upper limit by B. C. decreased 2,000 or more. Twelve cases had decreased bone conduction as well as lowered upper limit. Two cases had decreased B. C. with upper limit normal and two cases had upper limit by A. C. lowered but B. C. normal.

Plate 9 shows the curves of ten acute infected ears. The dots, dashes and circles in the curves are added so that they may be more easily followed through the entire field. You will note that curves Nos. 2 and 3 show complete gaps. Partial gaps are shown in all the curves except No. 4. Ninety per cent of the curves of acute infected ears are suggestive in this manner of lesions of the nerve or end organ.

A careful analysis of the clinical charts of the twenty-two ears studied shows that in every acute infected ear except one there was either decreased B. C., upper limit lowered by B. C. 2,000 or more, or a defect in the audiometer curve suggestive of lesion of nerve or end organ.

These evidences of lesion of nerve or end organ appear very early in the course of the disease.

Plate 10. H. B. Examination was made within twelve hours after first evidence of infection. With good hearing for voice, spoken, 45 feet, and whisper, 15 feet, in each ear; frank earache in the left, slight earache in the right; drumheads reddened, no bulging; Rinne positive in each ear, c^5 fork in left 30/60; with other forks normal. Two partial tone gaps in left ear with audiometer curve. B. C. 2 sec. each; upper limit lowered 2,000 by B. C. with monochord. No leucocytosis at this time. Patient discharged ten days later, B. C. normal; c^5 heard normally, upper limit normal by A. C. and B. C.

In cases where the infection was unilateral the evidences of a lesion of nerve or end organ were not confined to the infected ear.

Plate 11 shows the findings of the good ear in six cases of unilateral acute infection of the middle ear. Only one case, the first, had no suggestion lesion of end organ or nerve in the good ear. In the second, third, fourth and fifth cases the upper limit is lowered; in the fourth, fifth and sixth B. C. is decreased. The audiometer curves of the first case, and of cases three and four, were somewhat suggestive of lesion of nerve or end organ so that in at least five out of six of the unaffected ears, and probably all six, there is evidence of involvement of the nerve or end organ.

Plate 12 B. D. This case is interesting because a few days before infection of the left ear the ears were tested and were apparently normal. Note that in the right ear where there was no redness of drumhead or other evidence of middle ear infection, the decreased hearing for voice and whisper, the decreased B. C., the decreased upper limit by B. C., and the slight diminution for the c^1 , c^2 , c^3 , c^4 and c^5 forks, for the left ear, the decreased B. C., the tuning fork tests and the audiometer curve are all suggestive of lesion of nerve or end organ.

Treatment and eradication of the middle ear condition may have no influence upon the lesion of nerve or end organ.

Plate 13 E. B. shows the findings at the height of an acute tubal catarrh. The tubal orifices were edematous, covered with dilated blood vessels; the drumheads were reddened, not bulging. B. C. decreased each 2 secs. Upper limit each B. C. 17,000 by monochord.

Plate 14 shows the findings after the eradication of the middle ear lesion. B. C. —3. Upper limit lowered by B. C. Audiometer curve indicative of lesion of nerve or end organ. The findings remained the same as long as the patient remained under observation.

Plate 15 shows the findings A. A. S., taken one month after an infection of the left ear was apparently well. Curve and tuning fork findings for left ear indicate a lesion of importance involving nerve and end organ. Whisper and voice are poorly heard.

Plate 16 B. D. shows findings in both ears in a case of acute infection of the left ear one month after discharged as cured. The curve left, tuning fork tests left, and decreased B. C. each indicates a lesion of nerve or end organ left and probably also right. At no time during the disease was there evidence of acute middle ear infection right. Nevertheless, the hearing right which was W15, V45, before the infection of the left ear is now W13, S45, while the B. C. is —5. Before the infection of the left ear it was normal.

After acute infections of the middle ear with return to normal audition for voice and whisper there may be definite indications of lesions of nerve or end organ.

Twelve cases of bilateral chronic otorrhea and fifteen cases of unilateral chronic otorrhea, or thirty-nine ears, suffering with chronic otorrhea, were studied. Rinne was negative in thirty-five ears, positive in four. There was decreased bone conduction in eleven ears, increased in twenty-six, normal in two. Decreased B. C. was not so common as in the acute infections. The upper tone limit was decreased 2,000 or more by bone conduction in thirty ears. In thirty-seven ears the audiometer curve was suggestive of a lesion of nerve or end organ and in two ears not. Marked depressions and tone gaps in the audiometer curves were much more frequent than in the acute ears. The curves were much more characteristic of lesions of the nerve or end organ. If we include the results with the tuning fork tests, in only one ear out of the thirty-nine was there no evidence of a lesion of the nerve or end organ.

Plate 17 R. B. is a typical chart showing the findings in a case of chronic otorrhea. Note that with the tuning forks the

hearing range is from c^1 to c^4 inclusive. The audiometer curve shows the decreased audition for both low and high notes in the range of the audiometer with depressions characteristic lesions of the nerve or end organ. The upper limit in each ear is decreased to 15,000 d. v. or B. C.

From a study of the cases of chronic otorrhea one gets the impression that the extent of the lesion of nerve or end organ corresponded roughly with that of the middle ear lesion, while in the acute cases there was the greatest variation between the extent of the lesions of the inner ear and those of the middle ear. It was not unusual with a very mild acute middle ear infection to have a very well marked lesion of the nerve or end organ. A study of the fifteen unaffected ears in the fifteen cases of unilateral chronic otorrhea shows that Rinne was negative in unaffected ears no times, positive in fifteen. B. C. was decreased in the unaffected ears three times; it was normal ten times and increased twice; the upper limit was decreased by B. C. 2,000 or more five times and was normal ten times. The audiometer curve of the unaffected ears was indicative of a lesion of nerve or end organ in only one case. The unaffected ears in this series of unilateral cases were very good ears with one exception: The hearing in almost every ear was W 15 feet. While these findings suggest that there are a fair number of lesions of the nerve or end organ in the unaffected ears in chronic otorrhea, we do not find the large percentage of involvement of the nerve or end organ as in the unaffected ears in the acute infections. This suggests to us that the involvement of the nerve or end organ in the unaffected ears in acute infections is frequently not a permanent affair; otherwise, we would find the same number of lesions in unaffected ears in chronic otorrhea. The lesions of the nerve or end organ in ears suffering from chronic otorrhea were much more marked than in the acute infections. There is a direct interdependence between the chronic otorrhea and the lesions of the nerve or end organ. The chronic otorrhea has no influence of any moment upon the nerve or end organ of the opposite side. In our acute cases we get the impression that the acute middle ear trouble and the lesion of the nerve and end organ are not interdependent. They may both be due to the same cause but not necessarily so.

Plate 18 is a composite graph of the results obtained from tuning fork examinations. It is difficult to express in a uniform manner the results obtained in tuning fork examinations when different denominators are used to represent normal hearing for different tuning forks. For example, in measuring the hearing power for the tuning forks we represent the hearing for a normal ear in terms of distance as the denominator of a fraction. The hearing power for that fork by a pathologic ear is recorded in the same terms in the numerator. For the c^5 fork, since a very slight impact produces a sound heard at a considerable distance, we use the denominator 60. The 256 fork is heard at a less distance and we use 24 for the denominator. For similar reasons we use the denominator 4 with the 50 d. v. fork.

In order to make an analysis of our results we have arbitrarily divided our results into six classes. Those who do not hear the fork at all are put in Class 1; those who hear the fork when it is very loud, as indicated by fractions equivalent to one-fourth or less, we have put in Class 2; those who hear it by values indicated by the fractions between one-fourth and one-half are put in Class 3; those who hear it by fractions from one-half to three-fourths are put in Class 4; those who hear it from three-fourths to less than normal are put in Class 5; and those who hear it normally are put in Class 6. The curve shows that twenty-one cases did not hear the 50 d. v. fork at all; three did not hear the c^5 fork; fourteen heard the 50 d. v. fork with a fraction equivalent to one-fourth or less; while twenty-seven heard the c^5 fork with results indicated by a fraction of one-fourth or less. You will notice that the 512 d. v., 1024 d. v. and 2048 d. v. forks run almost parallel throughout the entire curve, while the greatest variations in chronic otorrhea cases are shown with the 50 d. v. fork and the 4096 d. v. fork. There were no cases where the hearing was perfect for the low fork and two cases where the hearing was normal for the 4096 d. v. fork.

Plate 19 shows the results of the audiometer examinations in ten cases of chronic otorrhea. It is inserted to show the frequency with which such phenomena as tone islands, gaps and other peculiarities exist. These peculiarities are indicative, in our judgment, of lesions of the nerve or end organ.

For example, curve No. 8 shows simply a region of residual hearing for tones between 500 d. v. and 1500 d. v. No. 7, while rising much higher on the chart, shows two islands with the interlying gaps at 2500 d. v. and at about 3200 d. v. Curve No. 9, even though rising to the normal at 1000 d. v., shows that the low tones are lost, that there is a decrease for notes above 1200 d. v., and a return to almost normal at 5500 d. v.

Sixty-six per cent of the records of cases with chronic otorrhea show either complete or marked partial tone gaps. These do not include such cases as are illustrated by curves Nos. 1, 2 and 8, which are equally significant of an inner ear lesion.

In only one case, L. P., age 13, did a tone gap disappear with treatment.

Hyperplastic Otitis Media.—Thirty cases of bilateral H. O. M. and four cases of unilateral H. O. M., or sixty-four ears, were studied. Rinne was negative in thirty-three ears, positive in thirty ears, questionable in one ear. There was decreased bone conduction in forty-four ears, increased bone conduction in sixteen ears, normal in four ears. The upper limit was decreased by B. C. 2,000 or more d. v. in forty-nine ears.

Twenty-one ears had complete tone gaps in the audiometer findings. In eight more there were marked partial gaps or 45 per cent showing these peculiarities. In addition to this there were 34 cases where there were marked depressions equally indicative of inner ear involvement.

Plate 20 shows the curves of ten typical cases of H. O. M. Complete tone gaps are illustrated in curve No. 10, which has a gap at 2400 d. v. and another at 2000. Curve No. 9 shows a dip or partial gap at 1600 d. v. No. 6, while not showing either a partial or complete gap, shows that the hearing was normal up to 1500 d. v. and decreased more and more for tones higher in the scale. A curve of this type certainly indicates a lesion of the nerve or end organ. Curve No. 8 shows only a patch of residual hearing between 100 d. v. and 1500 d. v. Each curve shows marked diminution in the audition for the c^5 fork. In the next plate you will note that in only eight of the sixty-four ears was the c^5 fork heard normally.

Plate 21 shows a composite of the tuning fork cases in hyperplastic otitis media. Here we have made the same arbi-

rary divisions as we did with Plate No. 18. Here again we see that the larger variation is shown with the 4096 d. v. and the 50 d. v. forks. The 1024 d. v. and the 2048 d. v. forks run almost parallel through the entire range. While there were no cases where the 4096 d. v. fork was not heard there were 51 cases who could hear this fork only when it was struck very loud as, for instance, when the fork was forcibly struck against the heel of the shoe, twenty cases did not hear the 50 d. v. fork.

Note that in eight cases the 50 d. v. fork was heard apparently normal. In these eight cases the lesion of the nerve or end organ overshadowed the middle ear lesion.

A study of the clinical charts of these cases shows evidence of the involvement of the nerve or end organ in every ear affected save one.

Plate 22 F. K. shows the curves of a bilateral case of H. O. M. Note the negative Rinne, slightly decreased B. C., power of hearing low and high notes markedly interfered with in each ear, tone gaps in the audiometer curve, and upper limit markedly decreased both by A. C. and B. C.

Plate 23 C. L. shows in the right ear bone conduction normal, and negative Rinne, audiometer curve practically normal, upper limit normal. In the left ear B. C. is decreased five seconds. The right ear of this case was the only one of the sixty-four ears studied that did not show some evidence of involvement of nerve or end organ. Hearing was poorer in the right ear.

There was found no definite relation between the extent of the inner ear lesion as compared with the middle ear lesion.

Plate 24 shows the findings in H. S., aged 62, and in C. P., aged 62. The objective findings of the middle ear were similar. In one case the bone conduction is —5 seconds and in the second case it is —12 seconds. In the first case the audiometer curve shows a tone gap in the left ear and in the second case there is none. In the audiometer curve the upper notes are heard much poorer in the first than in the second. In the first case the upper limit is so low that it cannot be detected using the Galton whistles or the monochord, either by A. C. or B. C., and with the Koenig cylinders it is only approximately half normal, 21,000 s. v. instead of 41,000, while

in the second case the upper limit is decreased, it is 16,000 by B. C. with the monochord. The lesion of the nerve or end organ is much more marked in the first than the second case. In the second case, the one with the least involvement of the nerve, had a positive Wassermann, the first one not.

Plate 25 (Findings of Miss D. and H. B.).

The age of the first is twenty-five years and the age of the second is twenty years. The hearing in the left ear is approximately the same for whisper. In the first case B. C. left is increased, the tuning fork test shows fair hearing for the c^4 and c^5 fork, the upper limit by B. C. is normal, the audiometer curves, while there is a gap in the right ear and depressions in the left, shows fair hearing for some of the notes in the higher part of the range. In the second case, however, B. C. for c^1 fork is -5 , c^2 fork -6 , hearing for the c^4 and c^5 fork is markedly decreased, the audiometer curves show a cutting down of the higher notes to 4,000, the upper limit by B. C. is 15,000. The evidence points to a much more marked lesion of the nerve or end organ in the second case than in the first.

In one case of H. O. M., while under observation acute suppurative otitis developed. With the diminution in hearing the B. C., which was plus 4 in the left ear, became decreased. With the disappearance of the acute otitis it became plus again.

Our cases of H. O. M. frequently tell of improvement in hearing that is satisfactory to them following one kind of treatment or another. Our tests have failed to show any actual improvement in any case unless the lesion of the nerve or end organ greatly overshadowed the middle ear lesion, and the improvement resulted from the treatment of the case for syphilis, or removal of tonsils, or what not.

Plate 26. H. J. is a case of H. O. M. where there was also a plus 4 Wassermann. Note the positive Rinne with the c^2 fork and the greatly decreased B. C. with the same fork and a negative Rinne with the c^1 fork, which is decreased only six seconds. This patient's deafness has rapidly appeared in the last six months. It has progressed too rapidly for H. O. M. The syphilitic lesion of the nerve or end organ is more responsible for the deafness.

Plate 27. J. C. is a case of H. O. M. with negative Wassermann and no evidence of syphilis, where the lesion of nerve or end organ greatly overshadowed the middle ear lesion. Note the Rinne plus, B. C. decreased 6 seconds and 4 seconds, the tuning forks suggestive of lesion of nerve or end organ. The upper limits by B. C. 12,000 d. v. and 13,000 d. v. The curve is also characteristic of lesion of nerve or end organ.

A study of the unilateral cases of H. O. M. gives some very interesting information. Four cases were studied. In the unaffected ear, negative Rinne in no cases. Decreased B. C. in two cases, upper limit decreased 2000 or more by B. C. in three cases. In all four of the unaffected ears there was some evidence of lesion of nerve or end organ if we include the findings with tuning forks and audiometer.

CONCLUSIONS.

1. The determination of the upper limit by B. C. is a far more accurate indication of the condition of the acoustic nerve and its end organ than its determination by A. C.

2. It is usual in acute middle ear infections, even in the early stages, to find evidences of involvement of nerve or end organ. Rarely with the present methods of diagnosis are we unable to find evidences of such involvement.

3. The lesion of nerve or end organ is not necessarily dependent upon the acute middle ear infection. There is no definite relation between the severity of the middle ear infection and the lesion of nerve or end organ. When the middle ear infection is unilateral the unaffected ear usually presents evidence of a lesion of nerve or end organ.

4. After the disappearance of the acute middle ear infection there may remain a permanent lesion of nerve or end organ.

5. In every case of chronic otorrhea except one there was evidence of a lesion of nerve or end organ. There is an interdependence between the middle ear lesion and that of the nerve or end organ.

6. In the H. O. M. cases every ear studied save one presented evidence of lesion of nerve or end organ.

7. In H. O. M. there is no constant relation between the extent of the lesion in the middle ear and the lesion of the nerve or end organ.

OUTLINE FOR NEUROLOGICAL, NERVE DEAFNESS AND LABYRINTHINE CASES.

NAME

DATE

	Before inflation		After inflation	
Hearing (Right)	W	S	W	S
(Left)	W	S	W	S

Paracusis Willisii

Tinnitus

Dizziness

Staggering

Vomiting

Rinne (Right)	Weber	Tests		Bone conduction (R			
(Left)		Politzer		(L			
Fistula Test:							
Gelle Test:							
Hearing	50DV	C	C ¹	C ²	C ³	C ⁴	C ⁵
Right							
Left							
Low limit		High limit					

	Balance sense		
Romberg-walking crack	On one foot		Hopping, eye shut
	Tests of vestibular apparatus		
	Spontaneous		

Past-pointing	Extra ocular muscle balance			
	Maddox Dist.			
	Bi.	Bo.	Bu.	Near
Nystagmus	Up	Down	Right	Left
	Caloric			

Right			Left	
After	Min.	Sec.	After	Min.
Nature of nystagmus			Nature of nystagmus	Sec.
Amp.			Amp.	

	Head back	
	Head forward	
	Past-pointing	
	Falling	

	Rotation
	(Eyes closed during rotation)
	Head 30 degrees forward

R to L turns in 20 seconds:	
Nystagmus	Duration
L to R turns in 20 seconds	
Nystagmus	Duration
R to L 10 turns in 10 seconds:	
Pointing	Falling
L to R 10 turns in 10 seconds	
Pointing	Falling
	Head forward 120 degrees

R to L 10 turns in 20 seconds	
Nystagmus	Duration
L to R 10 turns in 20 seconds	
Nystagmus	Duration
R to L 10 turns in 10 seconds	
Pointing	Falling
L to R 10 turns in 10 seconds	
Pointing	Falling

Vertigo during various tests:

PLATE I.

Upper limit: Galton, R., 23,000 d. v.; Koenig, R., 43,960 v. s.
 Monochord: A. C., R., 19,000 d. v.; B. C., R., 20,000 d. v.

PLATE II.

PLATE V.

Upper limits in cases of occlusion of external auditory meatus.

Before Removal

No. 2. F. A. B. A. C. 17,000 B. C. 19,000

No. 3. C. C. J. A. C. 15,000 B. C. 18,000

No. 4. C. C. B. A. C. 17,000 B. C. 20,000

After Removal.

No. 2. F. A. B. A. C. 18,000 B. C. 19,000

No. 3. C. C. J. A. C. 17,000 B. C. 19,000

No. 4. C. C. B. A. C. 19,000 B. C. 20,000

PLATE VI.

Upper limit—Comparisons of A. C. and B. C. with monochord.

PLATE VII.

Mr. N., age 17. Cause: Mumps.

PLATE VIII.

Mr. C. C., age 15. Diagnosis: Acute tubal catarrh. Before inflation: Voice, R., Wh. 9 ft., Sp. 16 ft.; L., Wh. 6 ft., Sp. 15 ft. After inflation: R., Wh. 15 ft., Sp. 45 ft.; L., Wh. 15 ft., Sp. 45 ft. Upper limit, monochord: R., A. C. 16,000, B. C. 19,000; L., A. C. 17,000, B. C. 19,000.

PLATE IX.

PLATE IX

PLATE X.

Mr. H. B., age 18. Diagnosis: Acute otitis media. (Twelve hours' duration.)

PLATE XI.

Uneffected Ears in Unilateral Cases.

Name	Rinne	B. C. (c ₂ fork)	Monochord	
			A. C.	B. C.
A. A. S.	+	Normal	19,000	19,000
M. K.	+	Normal	15,000	17,000
G. V. B.	+	Normal	16,000	17,000
E. C.	+	—	17,000	18,000
B. D.	+	—	18,000	18,000
E. S.	+	—	19,000	21,000

PLATE XII.

B. D., age 22. Voice, R., W. 8 ft., Sp. 40 ft.; L., W. 30 in., Sp. 36 ft. B. C. (c^2 fork), R., 1 sec.; L., 4 sec. Upper limit: Monochord—R., A. C. 18,000, B. C. 18,000; L., A. C. 18,000; B. C. 19,000.

Forks 50 d. v. c c^1 c^2 c^3 c^4 c^5
 R.... 4/4 8/8 11/12 22/24 36/36 44/48 50/60
 L.... 4/4 8/8 10/12 20/24 36/36 40/48 40/60
 Diagnosis: Acute suppurative otitis media left.

PLATE XIII.

E. B., age 49. Voice: R., Wh. 12 ft., Sp. 45 ft.; L., Wh. 13 ft., Sp. 45 ft. B. C. (c² fork), R., —2 sec., L., —2 sec. Upper limit, monochord, R., A. C. 14,000, B. C. 17,000; L., A. C. 13,000, B. C. 17,000. Diagnosis: Acute tubal catarrh.

PLATE XIV.

E. B., age 49. B. C. (c² fork), R., —3 sec., L., —3 sec. Upper limit, monochord, R., A. C. 16,000, B. C. 17,000; L., A. C. 14,000; B. C., 17,000.

PLATE XV.

Mr. A. A. S., age 18. Voice, R., Wh. 15 ft., Sp. 45 ft.; L., Wh. 10 in., Sp. 2 ft.

Forks	50 d. v.	c	c ¹	c ²	c ³	c ⁴	c ⁵
R.....	4/4	8/8	12/12	24/24	36/36	48/48	55/60
L.....	3/4	6/8	7/12	18/24	24/36	20/48	15/60

PLATE XVI.

Miss B. D., age 22. Voice, R., Wh. 13 ft., Sp. 45 ft.; L., Wh. 12 ft., Sp. 45 ft. B. C. (c^2 fork), R., —5 sec., L. —4 sec. Upper limit, monochord, R., A. C. 19,000, B. C. 19,000; L., A. C. 18,000, B. C. 19,000.

Forks 50 d. v.	c	c ¹	c ²	c ³	c ⁴	c ⁵	
R.....	4/4	8/8	12/12	24/24	36/36	48/48	60/60
L.....	4/4	8/8	12/12	24/24	36/36	40/48	55/60

PLATE XVII.

R. B., age 14. Diagnosis: Bilateral chronic otorrhea, persisting after bilateral radical mastoid operation. Voice: R., Wh. 18 in., Sp. 3 ft.; L., Wh. 4 in., Sp. 9 in. B. C., R. and L. increased (c^2 fork). Rinne, R. and L. negative. Upper limit, monochord, R., A. C. 14,000, B. C. 15,000; L., A. C. 13,000, B. C. 15,000.

Forks 50 d. v.	c	c ¹	c ²	c ³	c ⁴	c ⁵	
. R.....	0	0/8	1/12	1/24	1/36	1/48	0/60
. L.....	0	0/8	0/12	0/24	0/36	1/48	0/60

PLATE XVIII.

PLATE XIX.

PLATE XX.

PLATE XXI.

PLATE XXII.

F. K., age 27. Diagnosis: Hyperplastic otitis media. Voice: R. and L., Whisper 2 ft. Rinne: R. and L. negative. B. C. (c^2), R., —2 sec., L. —1 sec. Upper limit, monochord, R., A. C. 17,000, B. C. 17,000; L., A. C. 16,000, B. C. 17,000.

Forks 50 d. v.	c	c ¹	c ²	c ³	c ⁴	c ⁵	
R.....	0	0/8	2/12	4/24	6/36	12/48	15/60
L.....	0	0/8	1/12	3/24	3/36	6/48	8/60

PLATE XXIII.

Mrs. C. J. L., age 25. Voice: R., Wh. 5 ft., Sp. 15 ft.; L., Wh. 10 ft., Sp. 30 ft. Diagnosis: Hyperplastic otitis media. B. C. (c²), R., normal; L., —5 sec. Rinne: R. neg., L. pos. Upper limit, monochord, R., A. C. 17,000, B. C. 19,000; L., A. C. 18,000; B. C., 20,000.

PLATE XXIV.

H.S., age 62. Diagnosis: Hyperplastic otitis media.
Voice: R., Wh. 1 ft., Sp. 3 ft.; L., Wh. 6 in., Sp. 18 in. Rinne: Positive each ear. B. C.: R., increased 2 sec., L., decreased 5 sec. Upper limit: Monochord, not heard; Galton whistle, not heard; Koenig cylinders, R. and L., 21,845 v. s.

C. P., age 62. Diagnosis: Hyperplastic otitis media.
Voice: R., Wh. 15 ft., Sp. 45 ft.; L., Wh. 6 ft., Sp. 20 ft. Rinne: Positive each ear. B. C.: R., -5 sec., L., -12 sec. Upper limit, monochord: R., A. C. 13,000, B. C. 15,000; L., A. C. 14,000, B. C. 16,000.

L. D., age 25. Voice: R., Wh. 6 in., Sp. 18 in.; L., Wh. 4 ft., Sp. 10 ft. B. C. (c²), R. normal, L., increased.

Forks:

50 d. v.	c	c ¹	c ²	c ³	c ⁴	c ⁵	
R....	0	1/8	1/12	2/24	8/36	5/48	2/60
L....	2/4	6/8	8/12	10/24	20/36	24/48	30/60

Upper limit: Monochord, R., A. C. 17,000, B. C. 19,000;
L., A. C. 17,000, B. C. 19,000.

H. B., age 20. Voice: R., Wh. 2½ ft., Sp. 5 ft.; L., Wh. 2½ ft., Sp. 4 ft. B. C. (c²), R., -4 sec., L. -6 sec.; (c¹), R., -4 sec., L. -5 sec.

Forks:

50 d. v.	c	c ¹	c ²	c ³	c ⁴	c ⁵	
R....	0	1/12	1/18	1/24	1/36	2/48	1/60
L....	0	1/12	1/18	1/24	1/36	2/48	1/60

Upper limit: Monochord, R., A. C. 15,000, B. C. 17,000;
L., A. C. 13,000, B. C. 15,000.

XXVI.

H. J., age 21. Diagnosis: Hyperplastic otitis media; Wassermann, 4 plus. Voice: R. Wh. 0, Sp. 11 in.; L., Wh. 0, Sp. 11 in. Rinne: c^2 positive on each side; c^1 negative on each side. B. C. (c^2) —14 sec. each side; (c^1) —6 sec. each side. Upper limit: Monochord, R., A. C. 8,000, B. C. 9,000; L., A. C. 8,000; B. C. 9,000.

PLATE XXVII.

J. C., age 48. Voice: R., Wh. 9 ft., Sp. 45 ft.; L., Wh. 8 ft., Sp. 40 ft. Rinne: Positive each side. B. C. (c²), R., —6 sec., L. —4 sec.

Forks 50 d. v.	c	c ¹	c ²	c ³	c ⁴	c ⁵
R... 4/4	7/8	10/12	20/24	30/36	40/48	0/60
L... 4/4	8/8	12/12	24/24	30/36	40/48	0/60

Upper limit: Monochord, R., A. C. 11,000, B. C. 12,000; L., A. C. 12,000, B. C. 13,000. Diagnosis: Hyperplastic otitis media.