AUDITORY ASPECTS OF ACOUSTIC NEUROMA DIAGNOSIS

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The early detection and diagnosis of an acoustic neuroma is of paramount importance to the patient with this problem. Early detection, when the tumour is still small and restricted to the internal auditory canal, simplifies the surgical procedure, shortens patient recovery time, and sometimes enables the surgeon to save the residual hearing. Since auditory symptoms are usually the first indications of a growing acoustic neuroma, an awareness of these symptoms is the key to early detection.

The purpose of this article is to review the different auditory tests used in the diagnosis of acoustic neuromas. Typical and atypical findings are reported. Screening tests that do not require sophisticated and expensive equipment are described.

Basic Audiometry

An accurate pure tone air and bone audiogram bilaterally is the first step in the audiologic evaluation. Patients with acoustic neuromas will have a sensorineural type of hearing loss. In a great majority of these cases it will be a unilateral sensorineural impairment. In careful studies of a large series of cases (Johnson, 1969), 97 per cent demonstrated unilateral sensorineural impairment.

A close evaluation of the configuration or frequency loss pattern may be of significance. Audiograms were classified into four different configuration groupings for purposes of study and classification (Johnson and House, 1964). A high tone loss pattern was the type that sloped from low to high frequency. A flat type loss demonstrated a configuration that did not differ by more than 10 dB through the speech range. A hearing loss classified as low type presented a reduced threshold in the low frequencies with a rising curve through the speech range and into the higher frequencies. A trough-shaped pattern was defined as the type of configuration that maintained good responses in the high and low frequencies with elevated thresholds through the speech range. In the most recent study of pure tone configurations (Johnson, 1970), in a series of 219 cases, 63 per cent conformed to the high frequency loss pattern, 23 per cent were classified as flat type configurations, 7 per cent established a trough-shaped configuration, and the remaining 7 per cent were of the low type pattern.

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In summary, the pure tone audiogram in cases of acoustic tumours is a unilateral impairment and in approximately two-thirds of the cases will have a high frequency type hearing loss.

Speech Audiometry

Patients with retrocochlear lesions often experience great difficulty in speech discrimination. The next step in the process therefore is to evaluate the patients ability to hear speech as well as his ability to understand certain parts of speech. The speech reception threshold (SRT) is established by using bisyllabic-type words and the speech discrimination (PB words) is determined by presenting monosyllabic speech material. It is of course, desirable to present speech materials in the native tongue of the individual being tested.

Careful speech testing can be of considerable help in arriving at a diagnosis. Normal individuals and those with conductive impairment will have excellent word discrimination scores. Patients with sensorineural hearing loss will have varying degrees of discrimination impairment. Cochlear lesions such as Meniere's disease, ageing changes in the inner ear, or losses due to hereditary causes will usually show a moderate loss of discriminatory ability. Very often more than half of the monosyllabic words will be understood in those cases. On the other hand, the patient with an acoustic neuroma usually shows gross impairment of understanding. In about a third of the eases with confirmed acoustic tumours, no understanding was possible on the monosyllabic words (zero per cent PB score). Approximately 60 per cent of all of these cases produced scores of 30 per cent or less (Johnson, 1970). One patient previously reported (Johnson, 1965) was unable to understand any monosyllabic words at any intensity level within the limits of the audiometer and still had normal thresholds for pure tones (18 dB in the speech range). This is obviously an unusual case, but it is not unusual to find gross impairment of understanding with an acoustic neuroma.

Schuknecht and Woellner (1953) in an experimental study in cats partially sectioned the cochlea and found that a large number of nerve fibres could be destroyed without affecting responses to pure tones. Discrete pure tone stimuli may be carried by a small number of fibres, but it is believed that a large number of nerve fibres are required for loudness and pitch discrimination. Schuknecht and Woellner suggested that impairment in discrimination ability for loudness and pitch discrimination resulted in poor speech discrimination in patients. It is theoretically feasible to find normal pure tone thresholds with greatly impaired speech discrimination in an ear with subtotal nerve degeneration as in the case of some acoustic neuromas.

Auditory Fatigue Tests

An individual with normal hearing or one with a conductive loss is able to hear a continuous tone presented slightly above threshold for a prolonged period of time without developing fatigue. In sensorineural impairment, a certain amount of auditory fatigue usually occurs depending upon the locus of the lesion. This fatigue is minimal however and is usually limited to the higher frequencies in cochlear disorders. In the cases of acoustic neuromas, tone decay may be severe or it may be total, and it may affect the middle and low frequencies as well as the higher frequencies.

The two tests designed to measure auditory fatigue or adaptation are the modified tone decay test (MTDT) and diagnostic Bekesy audiometry. The MTDT test will be described in the section under screening tests.

Individuals with normal hearing and those with conductive losses show little or no tone decay. Sensorineural impairment due to cochlear lesions, as in Meniere's disease, may show up to 15 decibels tone decay on MTDT or Bekesy audiometry. Tone decay that is greater than 15 decibels in one minutes time or Types III or IV Bekesy patterns indicating moderate to severe tone adaptation, is indicative of retrocochlear lesions.

Diagnostic Bekesy audiometry compares the recorded responses of the patient to interrupted and to continuous tones. Individuals with sensorineural hearing impairment usually show a certain amount of auditory fatigue in this tracing. The configuration of the tracing and the amount of spread between the pulsed and continuous tones may be classified into four distinct patterns as reported by Jerger (1960).

The Bekesy audiometer presents a continuously variable tone at a set rate, shifting from 100 cycles to 10,000 cycles (or reverse presentation). The intensity of the signal changes continuously depending upon the activation of a hand switch that the patient holds. The pulse tone is presented through the full frequency range first and the procedure is then repeated for the continuous tone. It is the relationship between these two tracings that produces significant patterns.

The Type I tracing intertwines continuous tones and pulsed tones through the entire frequency spectrum. This is the type of pattern expected in normal hearing individuals, those with conductive hearing impairment, and occasionally the individual with sensorineural loss.

The Type II tracing is expected in cochlear lesions. This pattern consists of an intertwining of the pulsed and continuous tones in the low frequencies with mid-frequency separation of 5 to 15 dB with the continuous tone below the pulsed tone. In some instances, the two signals may break away in the lower frequencies as well. The significant point about a Type II pattern is that there is separation between continuous and pulsed tones but never more than 15 to 20 dB.

The Type HI tracing is usually found in retrocochlear lesions. In this type of pattern the continuous tone falls abruptly away from the interrupted tone and may not be heard even at the maximum output of the audiometer. This is indicative of total decay or auditory fatigue.

The Type IV pattern is also usually found in retrocochlear losses. This type of pattern consists of a separation of 20 dB or more between the pulsed and the continuous tones, but will trace through the full range of frequencies.

In approximately two-thirds of all of the cases of acoustic tumours surgically confirmed, a Type III or Type IV pattern was found (Johnson, 1968).

In summary, the anticipated findings for auditory fatigue tests in retrocochlear lesions are a significant amount of tone decay that will show 15 dB or more on the MTDT test, or a Type III or type IV Bekesy tracing.

Loudness Function Tests

In the tests previously described, (speech and adaptation tests) the patients with retrocochlear lesions respond abnormally to the test stimuli. In the case of loudness function tests however, the responses are considered to be normal responses. It is this normal response, as compared with the abnormal response in cochlear lesions, that makes these tests valuable in the evaluation of sensorineural loss.

The two loudness function tests that are widely used to evaluate sensorineural impairment are the alternate binaural loudness balance (ABLB) and the short increment sensitivity index test (SISI). The SISI test measures the ability to detect minute changes in loudness in the affected ear and the ABLB test makes a comparison between the loudness of the same tone in the two ears.

The alternate binaural loudness balance test is the most widely used and perhaps the best test to measure loudness recruitment. This was first described by Fowler (1928) nearly a half century ago. The procedure for this test is to present a tone of the same frequency alternately to the two ears. The patient compares the loudness of the sound in the normal ear with the loudness of the same sound in the impaired ear. The intensity of the tone is adjusted to provide an equal loudness balance in the two ears.

It is anticipated that we will find varying degrees of recruitment in cochlear types of sensorineural hearing impairment. Loudness recruitment represents an abnormal increase in loudness in the diseased ear. In other words, the patient with the acoustic neuroma does not usually show recruitment on the ABLB test.

The SISI test requires special equipment or special modifying devices for a clinical audiometer. It is a good test to use however since it can be carried out quickly and easily and does not require the critical value judgements on the part of the patient that the ABLB test requires. This test measures the patients ability to detect small increments of loudness. In cochlear impairments, the individual is usually abnormally sensitive to sound, and test scores will be high. In retrocochlear lesions however, the patient is unable to detect the small increments in loudness and test scores are usually low. A SISI test score is considered low if it falls in the zero to 30 per cent range and is considered high if it is in the 70

to 100 per cent range. In a series of 200 cases **(Johnson, 1968) more than 70 per cent of the cases produced** low **SISI** scores and **only slightly** over **20 per cent** of the cases fell in the high SISI range.

Consistency of Auditory Test **Findings**

A full battery of auditory tests should be given to any patient when it is necessary to rule out or confirm the existence of an acoustic neuroma. In the most recently reported large series of cases (Johnson, 1970) more than half (55 per cent) produced the anticipated type of auditory response to *all* of the auditory tests. Forty-five per cent of the confirmed surgeries resulted in inconsistent auditory responses to one or more of the auditory tests. In cases that deviated in some respect from the anticipated auditory responses, the important point to keep in mind is that all the tests are not mutually exclusive, some patients produce negative results on some of the tests and positive findings on other tests. This emphasizes the importance of the full audiometric battery of tests in every suspected case. Inconsistent results on one or more of the tests are much more likely to occur in small tumours than in larger sized neuromas. The small lesions account for only 34 per cent total number of reported cases, but they constituted 54 per cent of the cases with inconsistent results. Nearly 90 per cent of the cases that produced completely consistent classical audiometric findings were classified as large neuromas (Johnson, 1970).

Auditory Screening Tests

Ideally every ENT specialist would have a fully equipped audiologic laboratory. Practically it is not possible for all physicians to have available all of the equipment necessary to carry out the detailed tests required for a thorough auditory evaluation. Furthermore it is sometimes necessary to make hospital consultations that prohibit the use of bulky and heavy audiometric equipment. Fortunately there are some simple screening tests that will permit examination of the auditory nerve in the office or in the hospital without the equipment necessary for thorough evaluation.

There are small battery operated portable audiometers that are inexpensive, widely available, that will permit detection of hearing impairment. Some of these units have adequate masking noise, but for those devices that do not have masking available, a small Barany noise-maker may substitute for screening test purposes. This type of audiometer unit can be used for hospital or office consultation. It may be determined if a unilateral sensorineural loss is present.

If a speech circuit is not an integral part of the audiometer, a screening speech test may still be given by using live voice. This will enable the doctor to determine whether or not there appears to be marked inability to understand short monosyllabic words. The exact threshold for speech and discrimination cannot be determined in this way, but any gross impairment of hearing for speech may be identified. If there appears to be a significant decrease in discrimination, the patient may then be referred for more definitive speech testing.

A simple screening test to measure auditory fatigue is the modified tone decay test. This may be carried out on any standard audiometer, even on a small portable audiometer in a very brief period of time. Procedure for this test is as follows:

1. Present the tone five decibels above threshold, start timer or look at second hand on watch.
2. Increase the intensity in steps of five decibels whenever the tone becomes inaudible.
3. Calculate the amount of decay in 60 seconds time (the final decibel level minus the initial decibel level).

If the patient shows tone decay of 20 dB or more, this could be considered suggestive of a retrocochlear lesion and referral should then be made for a diagnostic Bekesy work-up as well as the remainder of the test battery.

Summary

Auditory symptoms are usually the first indication of an acoustic neuroma. A high index of suspicion together with the administration of a standard battery of auditory tests will often assist in the early diagnosis of this tumour. Grossly impaired discrimination of speech and abnormal auditory fatigue are of particular significance in evaluating this problem. This article describes the various types of auditory tests and findings, together with suggested simplified screening tests. Early diagnosis of neuromas will result in a significant reduction of patient morbidity and mortality.

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REFERENCES

Fowler, E. P. (1928) Marked Deafened Areas in Normal Ears. *Arch Otolaryng,* 8.

Jerger, J. (1960) Bekesy Audiometry in Analysis of Auditory Disorders. *J. Speech Hearing Res.,* 3.

Johnson, E. W. (1969) Audiologic Diagnosis of Acoustic Neuromas. *Arch Otolaryng,* 89.

Johnson, E. W. and House, W. E. (1964) Auditory Findings in S3 Cases of Acoustic Neuromas. *Arch Otolaryng,* 80.

Johnson, E. W. (1968) Auditory Findings in 200 Cases of Acoustic Neuromas. *Arch Otolaryng,* 88.

Johnson, E. W. (1965) Auditory Test Results in 110 Surgically Confirmed Retrocochlear Lesions. *J. Speech Hearing Dis.,* 30.

Johnson, E. W. (1970) Auditory Test Results in 268 Cases of Confirmed Retrocochlear Lesions, International Audiology, London, Congress, IX.

Schuknecht, H. F. and Woellner, R. C. (1953) Hearing Losses Following Partial Section of Cochkar Nerve. *Laryngoscope,* 63.