PRESBYACUSIS

A Study

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THE decline of auditory acuity with increasing age is a phenomenon which is widely accepted as being a universal and inevitable part of the process of growing old. It is also disabling, in that it represents a substantial and progressive narrowing of one of the most important fields of sensation. The consequent decrease in the volume of sensory information is itself an integral part of ageing, and is indeed a determining factor in that gradual but relentless loss of independence which—whether considered personally or socially—constitutes the tragedy at the heart of old age.

Even though this phenomenon of loss of auditory acuity with age is one that is common to most old people, and even though its limiting effect on their fields of activity is profound, its natural history and associations appear to have attracted remarkably little attention. Furthermore the possibilities of attempting to prevent, limit, or treat it—apart from the use of hearing aids—have also remained relatively unexplored.

This is, moreover, a matter which is of interest to the gerontologist as well as to the otologist for, of all the functions which may suffer impairment in old age, loss of auditory acuity is one of the few which may reasonably be regarded as a primary and specific manifestation of senility.

The scope of the present inquiry was thus the incidence, aetiology, clinical picture and associations of idiopathic loss of auditory acuity in the elderly, together with its response to the exhibition of certain drugs. By idiopathic loss of auditory acuity is meant hearing loss occurring in the absence of any history or sign of previous disease or trauma involving the apparatus of hearing. Two categories of

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people were investigated for the purposes of this inquiry. The first were elderly people presenting at a hearing aid clinic on account of defective hearing. The second were a random sample of elderly people without any specific complaint of deafness. From both groups were excluded all those who had evidence—either historical or clinical—of previous ear disease.

Possible mechanisms

By presbyacusis is understood a progressive, perceptive type of deafness, usually most severe for high tones and, by definition, related to advanced years. There is no agreement as to whether loss of frequency and loudness discrimination is a feature of the condition or not; or as to whether recruitment—indicating a cochlear lesion—is an integral part of the syndrome. Rigidity of the basilar membrane, degenerative changes in the hair cells of the cochlea, particularly in those of the lower turns, and in the cells of the spiral ganglion and their related nerve tracts, and hyperostosis of the temporal bone have all been described in connection with it. What remains not clear, however, is whether these changes are primary or secondary—whether they precede presbyacusis, are coincident with it or follow it.

There is, however, one feature which tends to be overlooked and is yet of fundamental importance. It is that the deafness can be compensated for—at least in part—by increasing the intensity of the sound transmitted. This is important because presbyacusis is often spoken and thought of as though it represented an irreversible and absolute loss of function—a complete end-organ failure in respect of certain sections of the auditory spectrum. But the fact that amplification of the sound transmitted can enable it to be heard, considered in conjunction with the " all-or-none " law of neurophysiology, precludes such a concept of end-organ atrophy or of failure in the nerve pathways between the end-organ and the brain. Thus the case is not that some part of the end-organ is non-functioning—for in this event no amount of amplification could enable the sound transmitted to be heard—but that its function has in some way been impaired. It is thus not cessation but impairment of function which is at the heart of the problem of presbyacusis.

In trying to move forward from this position, two basic considerations were in mind. First, what structural or functional changes in the cochlea would produce the observed clinical picture. Secondly, what is the relation of the clinical picture that certain possible pathological patterns might be expected to produce to what is in fact observed. In pursuing these questions note was taken of all the

possible factors; their relationship to the clinical facts examined; and the effect of their removal or neutralization, where this was possible, established.

Nature of the study

In attempting to investigate and elucidate the enigma of presbyacusis it was considered that, apart from gathering general clinical information, an attempt should be made to answer certain specific questions, and the form of the studies was designed to make this possible.

The aim was to discover something of the nature of presbyacusis by establishing its relationship to other events commonly associated with growing old and to the behaviour of other faculties in the elderly. It was hoped that it would be possible to determine by this means whether or not presbyacusis could be regarded as a condition in its own right, arising *de novo* in the elderly, or whether it was rather an inevitable by-product of one or more of the conditions to which most elderly people are prone. It was also desired to investigate the possibility of affecting it with certain drugs, and finally to consider what light it might throw on the ageing process in general.

The primary problem was thus to establish the relationship of the incidence and age of onset of presbyacusis, and the degree of hearing loss, to several other factors. The first of these was the sex of the subjects. The second was the presence of tinnitus, vertigo and abnormal caloric responses—and thus of disturbance of other parts of the labyrinth. The next was the difference, if any, in the hearing loss in each ear and at various frequencies. In view of the possible relationship between presbyacusis and acoustic trauma of one kind or another it was desired to investigate its association with acute acoustic trauma, exposure to occupational noise, and relation to place of domicile, as between town and country. It was decided to investigate the effect of smoking on the incidence and severity of presbyacusis and also, in view of the known effects of even temporary anoxia on hearing, the possibility of an association with nitrous oxide anaesthesia.

The strong possibility of an association between presbyacusis and a disturbance of auditory circulation pointed to an investigation of the relationship between it and circulatory disturbance in general and blood pressure, pulse pressure, haemoglobin and arteriosclerosis levels in particular. It was also desired to relate its incidence and severity both to the age in years and to the degree of senility,

or biological age, of the subjects and to correlate its incidence both with dysfunction of the other special senses and with evidence of degenerative conditions elsewhere in the body.

In exploring these problems of presbyacusis, different series of people were studied. Each was felt to be able to provide particular information. In each series those who had either a history or signs of previous ear disease were excluded.

The first series consisted of those patients who had presented at the Hearing Aid Clinic of the Middlesex Hospital on account of deafness during the five years prior to the commencement of this study. Of these 250 were found to have presbyacusis and their medical records analysed for relevant information.

The second series consisted of those patients presenting at the Hearing Aid Clinic of the Middlesex Hospital during the three-year period of the study who, on investigation, proved to have presbyacusis. Of these there were 158.

The third series studied for the purpose of this inquiry consisted of a random sample of elderly people, with no special complaint of deafness, drawn from several old people's homes attached to, and from the geriatric wards of, the Whittington Hospital. As it was not practicable to transport the subjects to a sound-proofed room, the audiometric examinations had to be carried out in the room or ward in which each one lived, under as quiet conditions as possible. Background noise could not, however, be completely eliminated. In view of this, it was considered that in subsequently comparing the results of the two audiometric examinations which each subject in this group had, no account should be taken of differences of less than ten decibels as, under the conditions obtaining, the estimations of threshold were not sufficiently accurate to make comparisons of finer differences valid.

Following their initial examination, each of this group of 101 was given, unless medically contraindicated, one of four drugs for a minimum period of three months after which he or she was re-examined. Which of the four drugs used in this study each subject was given was not known to the investigator, except by a code letter, until the results had been analysed.

The four drugs selected for assessment in relation to presbyacusis were a diuretic, vitamin B, an androgen-oestrogen combination and a vasodilator. A diuretic was included in view of the possibility of presbyacusis being associated with labyrinthine hydrops which it

was felt might respond to a powerful diuretic. The diuretic used was a bendrofluazide (' Neo-Naclex '). It was given in doses of 5 mg. each morning.

Vitamin B was included in view of the suggestion that a cardinal factor in the impairment of cochlear function in presbyacusis might be thiamine deficiency. It was administered in the form of strong tablets of vitamin B compound of which two were given three times a day.

The androgen-oestrogen combination was included in view of the reputed association of the development of senescent changes with the fall in the blood levels of these hormones with the advancing years. It was hoped that, in the event of presbyacusis being primarily a manifestation of senescence, their action might be to decrease this effect. The preparation used was a ' linguet ' each of which contained Methyltestosterone *B.P.* 2.5 mg. and Ethinyloestradiol *B.P.* 0.005 mg. and was known as ' Fermandren '. Two ' linguets ' were administered sublingually three times a day.

The vasodilator was included in view of the possibility that the primary factor in presbyacusis might be failure of the cochlear circulation resulting from spasm or arteriosclerosis of its arterioles or of the internal auditory artery itself. The preparation used was mesoinositol hexanicotinate (' Hexopal ') which Lindqvist (1958) postulated had a specific effect on vessels under pathological constriction. Two 200 mg. tablets were administered each day.

Results

The series of studies has established the following facts:

1. The incidence of presbyacusis increases with age to a peak at about 65 and then gradually falls away again. Most of those likely to be seriously affected present before the age of 70.

2. The greatest number of those to seek help do so with a hearing loss in the 50 db. to 60 db. region, although a substantial proportion do not present until the hearing loss is more than 60 db.

3. Females are liable to develop presbyacusis earlier and ultimately more severely than males.

4. Half of those suffering from presbyacusis have tinnitus as well, a third vertigo, and a fifth both tinnitus and vertigo. The likelihood of presbyacusis being accompanied by tinnitus or vertigo or both increases in direct relation both to the length of the history and to the severity of the hearing loss. So also does the likelihood

of the tinnitus being bilateral or central rather than unilateral, and of it being accompanied by vertigo and an absence of caloric responses.

5. A substantial degree of hearing loss is universal in elderly people. The age of onset, rate of development and ultimate severity of this loss vary widely. This variation is not related either to the actual age of the subject or to his biological age or degree of general senility.

6. The hearing loss is symmetrical in respect of the two ears.

7. The higher frequencies are the first, and remain the most profoundly, affected.

8. There is a slight hereditary predisposition to early onset and severe degree of hearing loss.

9. Although acute or chronic acoustic trauma may hasten the onset and increase the ultimate severity of presbyacusis, it is not a key factor in its overall incidence or severity.

10. Regular smoking doubles the liability to early and ultimately severe presbyacusis.

11. Submission to nitrous oxide anaesthesia does not affect either the age of onset or the severity of presbyacusis.

12. A history of circulatory disturbance was the commonest factor in the history and arteriosclerosis the commonest factor in the examination of all groups. It was particularly common amongst those with the profoundest hearing loss.

13. Amongst those with an early or severe loss of hearing there was a high incidence of deterioration in the other special senses.

14. Hypertension was found to be reflected in early incidence and relative severity of hearing loss.

15. Marked arteriosclerosis was almost invariably accompanied by relatively severe hearing loss.

16. Of those with tinnitus slightly more heard a high pitched rather than a low pitched sound.

17. The onset of deafness tends to precede the onset of tinnitus and both tend to precede the onset of vertigo.

18. The incidence of abnormal caloric responses, particularly of bilateral canal paresis, is directly related to the severity of the hearing loss.

19. There is a definite connection between anaemia, even of

comparatively slight degree, and the extent of the loss of hearing.

20. There is a definite connection between the number of potentially aggravating factors present and the extent of the hearing loss.

21. None of the drugs had either a dramatic or a consistent effect on the degree of hearing loss of most of the subjects. Vitamin B had the most extensive and the most generalized ameliorating effect of the four, closely followed by the androgen-oestrogen combination, whilst the effect of both the diuretic and the vasodilator lagged far behind.

With regard to acoustic trauma, it is of interest to compare the data obtained in this study, which relates to an urban population, with that obtained by Hinchcliffe (1959) for a rural population. For the age groups 55–64 and 65–74 of a rural population, Hinchcliffe demonstrated mean hearing losses of the order of 18 db. and 25 db. respectively, whereas in this study for comparable age groups of urban origin mean losses of 45 db. and 49 db. respectively were obtained. There is thus a startling difference between the age of onset of marked hearing loss as between town and country, presumably associated with the considerably greater volume of noise to which the contemporary city dweller is more or less constantly exposed.

The overall picture of presbyacusis is thus of a condition occurring universally, in some degree, amongst elderly people; the age of onset, rate of progress and severity being related not to the actual or biological age *per se*, but to the presence or absence of several factors, of which regular smoking, circulatory disturbance, anaemia and urban domicile are the chief, whilst heredity and occupational acoustic trauma may be to some extent contributory. It is a picture of a progressive condition commencing with a high frequency hearing loss, gradually increasing in severity and at the same time successively involving lower frequencies and ultimately being accompanied by tinnitus and later still by vertigo. It appears that the cochlea is more at risk than the vestibules, that the tinnitus progresses towards a bilateral or central distribution and the caloric responses to bilateral absence.

It is abundantly clear that presbyacusis can be associated with a multiplicity of factors, any of which may appear to be predominant in a particular case; that even though in a large series two or three appear to be more important than others, none is universally present or clearly of paramount importance compared to the others; and

that there is no dramatic or consistent response to the exhibition of a wide range of drugs. Presbyacusis thus has no single or invariable aetiology. It can equally well be associated with arteriosclerosis or hypertension, or acoustic trauma, or anaemia, or any one of a dozen other conditions. In particular it can be brought about most readily and profoundly by several of these factors acting coincidentally. It is, therefore, not a condition in its own right at all. It is simply the inevitable result of the operation of one or more processes which are capable of upsetting the organ of hearing and which are particularly liable to occur in old age. The inevitable result, because, just as different stimuli to any end-organ must evoke the same sensation, so different kinds of disturbance of the same end-organ can only evoke one pattern of dysfunction, and in the case of the organ of hearing it can only be deafness.

Its universality would thus appear to depend on nothing more than that the great majority of old people—all of the samples investigated in this study—sooner or later develop one of the several conditions common to their age which bring presbyacusis in their train.

Summary

An account is given of the relationship between presbyacusis and sex, age, place of domicile, occupation, smoking habits, family history, blood pressure, incidence of arteriosclerosis, other circulatory disturbances, degenerative changes in other systems, disturbance of other special senses and exposure to acoustic trauma or nitrous oxide anaesthesia. The effect of a diuretic, vitamin B, an androgen-oestrogen combination and a vasodilator on the degree of hearing loss was also investigated.

It is concluded that the age of onset, rate of progress and ultimate severity of presbyacusis are related not to the actual or biological age *per se*, but to the presence or absence of several other factors, of which regular smoking, urban domicile, circulatory disturbance and anaemia are the chief.

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