PRESBYACUSIS

A CLINICAL 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 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 available 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.

The scope of the present inquiry was thus the incidence, ætiology, 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 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.

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 thus to discover something of the nature of presbyacusis

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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 effects 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 anæsthesia.

The strong possibility of an association between presbyacusis and disturbance of auditory circulation pointed to an investigation of the relationship between it and circulatory disturbance in general and blood pressure, pulse pressure, hæmoglobin and arteriosclerosis levels in particular. It was 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 other special senses and with evidence of degenerative conditions elsewhere in the body.

The first series investigated, consisted of those patients who had presented at the Hearing Aid Clinic of the Middlesex Hospital on account of deafness during the 5 years prior to the commencement of this study. Of these 250 were found to have presbyacusis and their medical records analysed for relevant information. This was thus a retrospective study.

The second series consisted of those patients presenting at the Hearing Aid Clinic of the Middlesex Hospital during the 3-year period of this study who, on investigation, proved to have presbyacusis. Of these there were 158 and with them a more detailed study was possible.

The third series studied for the purposes of this inquiry consisted of a random sample of elderly people, with no special complaint of deafness, drawn from the geriatric wards of the Whittington Hospital and from several attached old people's homes.

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Following their initial examination, each of this group of 101 was given, unless otherwise contraindicated, one of four drugs for a minimum period of 3 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-œstrogen 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 bendro-fluazide ("NeoNaclex"). 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-œstrogen 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 methyl testosterone B.P. 2·5 mg. and ethinyl œstradiol 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.

The Results of the Investigations and their Significance

The results of the three separate studies were subsequently correlated and tabulated, and the data analysed to extract the information relevant to the inquiry.

Degree and Distribution of Hearing Loss

It was noticeable that there was no complaint of deafness until the mean hearing loss was of the order of 20 to 30 db., and indeed very few patients presented until it was between 30 and 40 db. and presumably affecting their ability to hear speech. Even this degree of disability only brought 5 per cent. of the sample for advice, the peak incidence of com-

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plaint of deafness not occurring until the mean hearing loss was 50 to 60 db. Over 80 per cent. of the patients presented with a mean hearing loss of between 40 and 70 db., but over 30 per cent. did not come until it was over 60 db. and over 10 per cent. not until the mean hearing loss was greater than 70 db. The trend was even more marked amongst the subjects of Series III, for here it was found that many patients with mean hearing losses of up to 70 db. claimed to be unaware of any deterioration in their hearing.

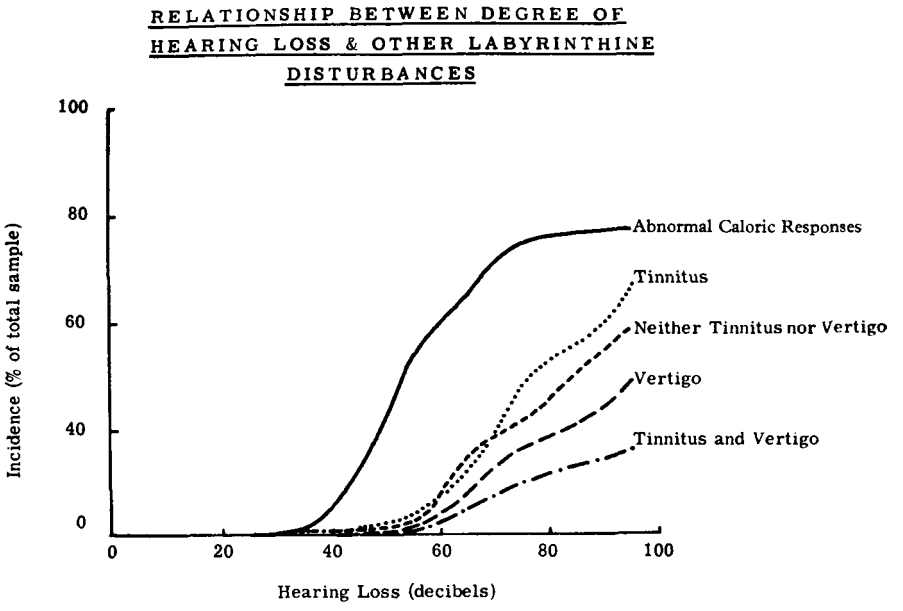


FIG. 1.

This presumably represents either an unawareness of the hearing loss on account of its gradual onset and relatively slow rate of progress, or an understandable unwillingness to acknowledge its presence, or a refusal to have this confirmed and be placed in the position of either accepting or refusing a hearing aid.

In comparing the data from the random sample group with that from the presbyacusis group it is apparent that although one consists of people who specifically complained of deafness and the other of people who did not, the difference in their average degrees of hearing loss, whilst definite, are not as great as might have been expected. Thus, in the presbyacusis group 23 per cent. had an average hearing loss below 50 db., 63 per cent. had a loss of between 50 db. and 70 db. and 14 per cent. above 70 db.;

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whereas in the random sample 38 per cent. have losses below 50 db., 54 per cent. between 50 db. and 70 db. and 8 per cent. above 70 db.

It is thus clear that a certain degree of hearing loss is virtually universal amongst elderly people but that it is by no means always accompanied by a complaint of deafness even when it must be quite disabling.

The degree of hearing loss tends to become more profound the longer the history. Twenty-six per cent. of those with a history of less than 5 years had a mean loss of less than 50 db., 64 per cent. a loss of between 50 db. and 70 db. and 10 per cent. a loss of more than 70 db. Comparable figures for those with a history of between 5 and 10 years are 10 per cent., 76 per cent. and 14 per cent., whilst for those with a history of more than 10 years they are 0 per cent., 30 per cent. and 70 per cent.

For 71 per cent. of those suffering from presbyacusis, the difference in the mean hearing loss in each ear is less than 10 db. and for 85 per cent. less than 15 db. For 45 per cent. of the series the maximum difference in each ear, in respect of any one frequency, is less than 10 db., for 68 per cent. less than 15 db. and for 83 per cent. less than 20 db. The hearing loss in presbyacusis is thus seen to be remarkably symmetrical.

It was also noted that 52·3 per cent. of the sample had greater loss on the right than the left and 47·7 per cent. the reverse. There were 95·5 per cent. found to have a predominantly high frequency loss, 2·9 per cent. a predominantly middle frequency loss and 1·6 per cent. a predominantly low frequency loss. Further study of the audiographs also showed that high frequencies are affected not only first but consistently more severely as the condition progresses so that even in longstanding cases the tendency for the audiograph curve to dip steadily towards the high frequency end of the graph is maintained. From the high frequencies, which are most commonly and severely involved, there is a sharp drop in the incidence and severity of involvement to the region of 1,000 c.p.s. and then a gradual fall to the low frequencies. It is notable that, except in particularly long-standing cases, hearing for low frequencies remains consistently well preserved. These facts would seem to indicate causative factors which are general rather than local, which effect high frequencies more than low ones and which are thus presumably disturbing the basal rather than the apical part of the cochlea.

Sex and Age Incidence

At all ages above 50, women appear to be more susceptible than men to presbyacusis in the ratio 3:2.

Of those presenting with presbyacusis 40·8 per cent. were males and 59·2 per cent. females. This ratio is broadly maintained throughout the various age groups except for a greater predominance of females over males in respect of the age groups under 50 and between 80 to 85.

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The incidence of new cases of presbyacusis was found to rise steadily until 65 and then to fall away equally steadily. There was no sharp peak of incidence at any particular age, but it appeared that the majority of those who are going to develop presbyacusis do so by the time they are 70.

There is no apparent relationship between the age of onset of hearing loss and its ultimate severity.

The incidence of severe deafness, in both sexes, increased with age, although it was clear that it did not do so smoothly, there being a relatively high incidence around the age of 70 and again around 80, with a comparatively low incidence in between. This is in accord with geriatric experience relating to several other conditions associated with old age.

Association with Vestibular Disturbances

Of people with presbyacusis 49·3 per cent were found to have tinnitus, 31·8 per cent. vertigo, 19·5 per cent. both and 38·4 per cent. neither. There would thus appear to be a relationship in some people between presbyacusis and tinnitus and vertigo. On the other hand it appears that, whatever the underlying process, the cochlea is at a considerably greater risk than the vestibule.

Tinnitus without vertigo occurs in these cases more than twice as frequently as the reverse, also considerably more frequently than both together.

Of those complaining of tinnitus without vertigo 74 per cent. had a mean hearing loss of 70 db. or more, whilst 23 per cent. had a mean loss of over 90 db. The inclusion of those who complained of both tinnitus and vertigo does not substantially alter these proportions. A similar pattern occurs amongst those complaining of vertigo—74 per cent. having a mean hearing loss of 70 db. or more and 28 per cent. of over 90 db. Those complaining of neither tinnitus nor vertigo present a distinctly different picture. There thus appears to be a definite relationship between the severity of the hearing loss and the incidence of tinnitus and vertigo.

It is also of interest that of those who complained of tinnitus 43·75 per cent. were aware of it either centrally or bilaterally whilst 56·25 per cent. related it to one ear or the other. Of these 77·7 per cent. related it to the deafer ear. Further study of the data also reveals that those who had central or bilateral tinnitus tended to have more extensive losses of hearing than those in whom it was unilateral.

There thus appears to be a definite association between presbyacusis and tinnitus and vertigo both in terms of absolute incidence and in the pattern of their progression—the tinnitus tending to become central or bilateral and to be accompanied by vertigo as the hearing loss becomes more profound.

Sixty per cent. of patients with presbyacusis, irrespective of any past or present complaint of tinnitus or vertigo, were found to have abnormal

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caloric responses. Furthermore, the proportion of those having normal to those having abnormal responses shows a fall as the degree of hearing loss rises. Thus, of those with a hearing loss of under 50 db. only 23 per cent. have abnormal calorics whilst of those with a loss of over 70 db. all have abnormal calorics.

With regard to patterns of association between particular types of caloric response and particular degrees of hearing loss, the only clear trend to emerge is for the incidence of bilateral canal paresis to increase much more markedly than the other types of abnormal response as the hearing loss becomes more profound.

It is apparent, therefore, that not only does the incidence of tinnitus and vertigo increase in parallel with the degree of hearing loss but that the caloric responses are even more clearly seen to be disturbed, particularly in the direction of bilateral canal paresis.

Significance of Family History

Only 26 per cent. of the presbyacusis sample and 15·5 per cent. of the random sample gave a history that either their parents or their siblings had had deafness in old age. This does not suggest that a positive family history is a strong factor in presbyacusis and it eliminates the possibility that presbyacusis is basically an inherited or familial condition. It does, however, appear to be a contributory factor in some people.

Association with Acoustic Trauma

Only 15 per cent. of the presbyacusis sample gave a history of exposure to acute acoustic trauma such as gunfire or bomb explosions, and only nine per cent. had been employed for any length of time in noisy occupations. Of the random sample 26·3 per cent had been exposed to occupational noise. These figures appear to indicate that acoustic trauma is not a factor of prime importance in presbyacusis as a whole as at least 75 per cent of those who have presbyacusis have not been exposed to specific acoustic trauma.

It must be borne in mind, however, that 95 per cent. of the subjects of both samples had spent all their lives in Greater London. It is thus of particular interest to compare the data obtained in this study with that obtained by Hinchcliffe (1959) for a rural population. For the age groups 55–64 and 65–74 of the 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.

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RELATIONSHIP BETWEEN AGE OF ONSET OF HEARING LOSS AND ASSOCIATED FACTORS

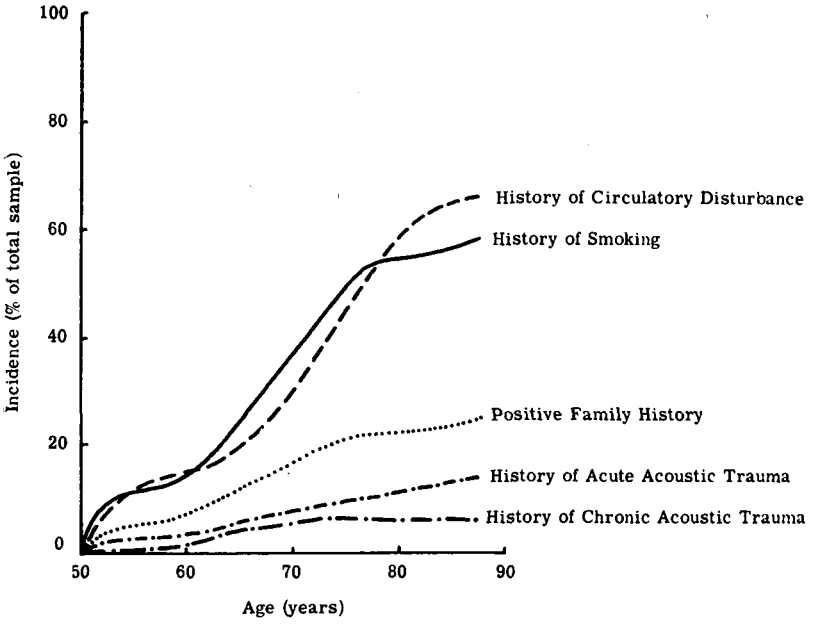


FIG. 2.

RELATIONSHIP BETWEEN ONSET OF HEARING LOSS AND ASSOCIATED FACTORS

II

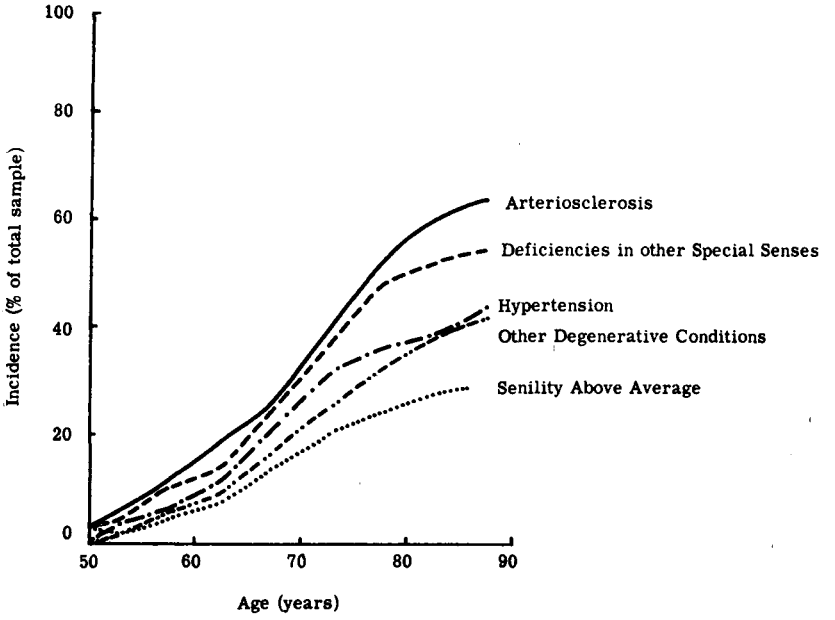


FIG. 3.

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RELATIONSHIP BETWEEN DEGREE OF HEARING LOSS AND ASSOCIATED FACTORS

I

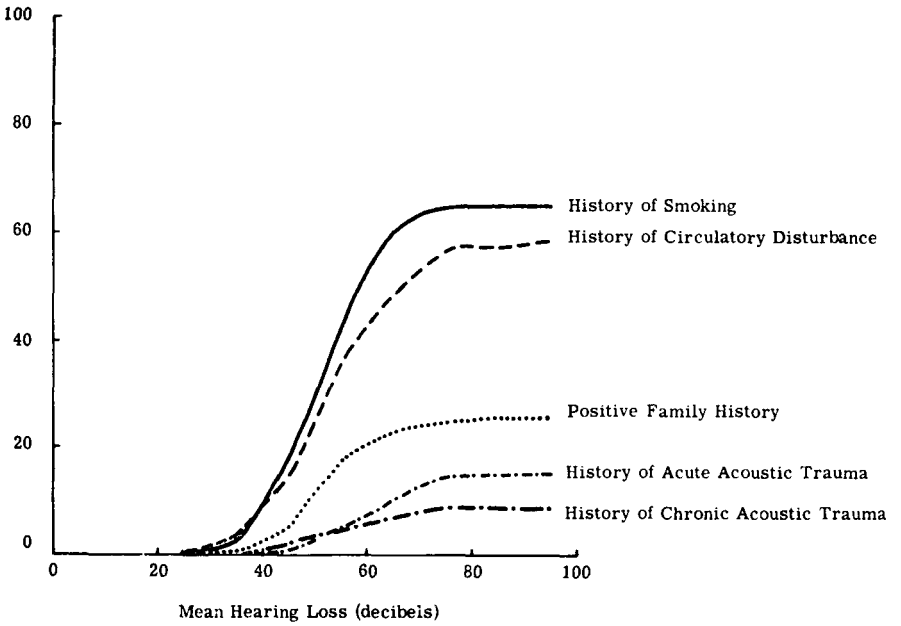


FIG. 4.

RELATIONSHIP BETWEEN DEGREE OF HEARING LOSS AND ASSOCIATED FACTORS

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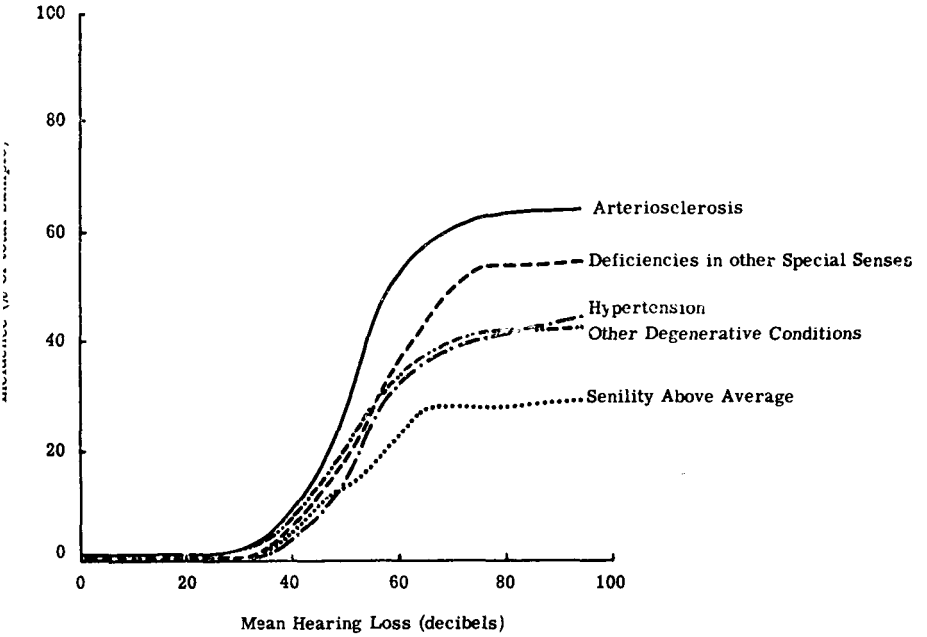


FIG. 5.

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Association with Smoking

Only 30 per cent. of the random sample gave a history of regular smoking compared with 65 per cent in the presbyacusis group. "Regular smoking" was defined as a consumption of more than ten cigarettes, or their equivalent, a day. It would appear that those who smoke regularly have an increased liability to presbyacusis as against non-smokers. No relationship was demonstrated between the amount of tobacco consumed and either the age of onset or the severity of the hearing loss.

Association with Nitrous Oxide Anæsthesia

Of those with a hearing loss of over 50 db. 27 per cent. had had nitrous oxide anæsthesia at one time or another. This is not in excess of the figure for the general population and does not serve to support the possibility that nitrous oxide anæsthesia is a vital factor in presbyacusis. Furthermore, if the isolated occurrence of anæsthetic anoxia were a vital incident in the development of presbyacusis one would expect the consequent hardness of hearing to be reasonably closely related to it in time; in fact in none of this group was this the case.

Association with Cardiovascular Disturbances

Over 70 per cent. of those with presbyacusis were found to also have arteriosclerosis.

Of those without arteriosclerosis 11 per cent. had a mean hearing loss of less than 50 db., 59 per cent. had a mean loss of between 50 db. and 70 db. and 30 per cent. a loss of more than 70 db. Of those with moderately severe arteriosclerosis 12 per cent. had a hearing loss of less than 50 db., 79 per cent had a hearing loss of between 50 db. and 70 db. and 10 per cent. a loss of more than 70 db. Of those with severe arteriosclerosis only 4 per cent. had a hearing loss of less than 50 db. whilst 83 per cent. had a hearing loss between 50 db. and 70 db. and 13 per cent. had a loss of more than 70 db. Thus the relative severity of the hearing loss appears to increase with the degree of arteriosclerosis.

The relative incidence of tinnitus and vertigo was found to follow a similar pattern.

Fifty-nine per cent of the presbyacusis sample were found to have a history of circulatory disturbance. For the purposes of this study circulatory disturbance was taken to comprise congestive cardiac failure, cor pulmonale, cerebro-vascular accidents, and peripheral arterial insufficiency.

With regard to blood pressure 31·5 per cent. of the presbyacusis sample were found to have systolic pressures below 150 mm. of mercury, 55·4 per cent. between 150 mm. and 200 mm. and 14·9 per cent. over 200 mm. This suggests that the incidence of presbyacusis is higher

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amongst those with a high systolic blood pressure than amongst those with a low or normal one.

Of those in the same sample with a systolic blood pressure below 150 mm., 21 per cent. had mean hearing losses below 50 db., 58 per cent. had mean losses between 50 db. and 70 db., and 21 per cent mean losses of over 70 db. Of those with a systolic blood pressure between 150 mm. and 200 mm., eight per cent. had mean hearing losses below 50 db., 78 per cent. had mean losses between 50 db. and 70 db. and 14 per cent. had mean losses of over 70 db. Of those with a systolic blood pressure of over 200 mm. none had mean hearing losses of less than 50 db., 75 per cent had mean losses of between 50 db. and 70 db., and 25 per cent. losses of over 70 db. Thus it appears that the higher the systolic blood pressure is raised the greater is the likelihood both of presbyacusis occurring and of the hearing loss being relatively profound. A similar picture was found in regard to diastolic blood pressure levels.

From a comparison of hæmoglobin and hearing loss levels in the random sample it appeared, leaving other factors aside, that hearing loss increases in severity in direct relation to the degree of coincidental anæmia. Thus of those with hæmoglobins over 90 per cent., all had relatively slight hearing losses (below 70 db.); whilst of those with hæmoglobins below 70 per cent all had relatively severe hearing losses (above 70 db.). It would appear, therefore, that moderate degrees of anæmia—such as are not uncommon amongst the elderly—may at least aggravate the degree of hearing loss.

Associations with Defects in Other Special Senses

Fifty-five per cent. of the presbyacusis sample were found to have had deficiencies in other special senses associated with their deafness. By deficiencies in other special senses is meant deterioration in sight, taste or smell occurring for the first time after the age of 50. This is a high figure and it prompts the question whether there may not be a factor operating which is common to the deterioration of all the special senses or indeed to degeneration of the nervous system in general.

Association with other Degenerative Phenomena

Forty-three per cent. of the presbyacusis sample had associated deficiences in other systems. There is thus commonly an association between presbyacusis and deficiencies in other special senses and less commonly with degenerative conditions elsewhere in the body.

The incidence of above average senility in relation to the age in years of the subjects in the sample was 29 per cent., suggesting that there is no particular connection between the age of onset of presbyacusis and the degree of general senescence.

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The results indeed emphasize the lack of association between above average senility and above average hearing loss. It is quite clear that the level of presbyacusis does not run parallel to the level of general senility.

Both the incidence and the severity of hearing loss amongst elderly people bear a direct relationship to the number of contributory factors operating up to a maximum of four beyond which there is no further deterioration. This may be because at this point the labyrinths are not capable of deteriorating any faster or more profoundly in response to further non-acute assaults, no matter how many they may be. Thus of those with a hearing loss of less than 40 db. the great majority have three or less factors operating and none has more than four, whereas for those with a loss of over 70 db. the great majority have four or more factors operating and none less than three.

This is of great interest as it to some extent confirms that the age of incidence, the rate of progress and the ultimate severity of presbyacusis may be dependent on a number of relatively independent factors each of which is common in elderly people and each of which happens to have a deleterious effect on auditory acuity.

Results of Therapeutic Trials

With regard to those who were given the diuretic 15 per cent. showed a further loss in hearing, 55 per cent. no change and 30 per cent. a gain.

Of those who were given Vitamin B 21·7 per cent. showed a further loss, 34·8 per cent no change and 43·5 per cent. a gain in hearing.

Of those taking the androgen-œstrogen preparation 13·3 per cent. showed a further loss, 46·7 per cent. no change and 40 per cent. a gain in hearing.

Finally with regard to those who were given the vasodilator, 14·3 per cent. showed a further loss, 64·3 per cent. no change and 21·4 per cent. a gain in hearing.

Of those subjects who showed a loss or gain the majority had average changes of between 10 db. and 20 db. on their original audiographs.

Beyond tending to confirm that presbyacusis cannot be attributed to any one primary cause and that it is not consistently improved by any one type of therapy the results of this part of the investigation were not dramatic. For each drug used the broad pattern of results is similar—a small group deteriorated, the largest group remained substantially unchanged and an intermediate group were improved.

The Overall Picture

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

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per se, but to the presence or absence of several other factors of which regular smoking, circulatory disturbance, 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 ætiology. It can equally well be associated with arteriosclerosis or hypertension, or acoustic trauma, 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 coincidently.

It is, therefore, not a condition in its own right at all, but 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 one 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—100 per cent. of the samples investigated in this study—sooner or later develop one of the several conditions common to their age which bring cochlear damage 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, disturbances of other special senses and exposure to acoustic trauma or nitrous oxide anæsthesia. The effect of a diuretic, Vitamin B, an androgen-œstrogen 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

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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 anæmia are the chief.

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