References


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Hearing loss and cortical atrophy in a population-based study on non-demented women

SIR—Age-related hearing loss (ARHL) is common and may cause difficulties in perception and understanding speech. ARHL is influenced by ageing, genetic factors, noise and other environmental factors [1]. Age-related brain atrophy is related to reductions in the number of neurons, and decreased cortical synaptic density. Brain atrophy may potentially damage hearing capacity through the impairment of primary and secondary auditory centres which are located in the temporal lobe. To our knowledge, no study has examined the relationship between brain atrophy and ARHL. In a population-based sample of non-demented women, we examined whether there is an association between ARHL and brain atrophy, and whether this relationship is influenced by cognitive function.

Methods

Population

This study is part of the representative Gerontological and Geriatric Population Study in Gothenburg [2], and the Prospective Population Study of Women [3]. In 1992–93, 70-year-old women were examined (n = 299). Pure tone audiometry was performed in 163 randomly selected participants [4], of whom 80 had a brain computerised tomography (CT) scan. In 2000–01, 70-year-old women were examined (n = 523). Pure tone audiometry was performed in 42 randomly selected women, of whom 31 had a brain CT scan. Since there were no differences of hearing capacity and brain atrophy between these two groups, they were pooled. One hundred and eleven in the study population were comprised of 70-year-old women. None were demented according to criteria of the Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition [5].

Five right ears with pronounced hearing impairment of peripheral origin, not related to ageing, were excluded from the study. Three had conductive hearing loss (two chronic otitis media, and one otosclerosis), and two had severe, unilateral sensorineural hearing loss (one Ménière’s disease,
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one sudden deafness). In all these cases, the otological condition was unilateral, and the contralateral, non-affected ear was included in the study. One woman lacked hearing in the right ear, leaving 111 left ears and 105 right ears for analyses. The study was approved by the Ethics Committee of Goteborg University. All subjects gave informed consent to participate, in accordance with the provisions of the Helsinki Declaration.

Audiometry

Pure tone audiometry was performed in a quiet office room by trained clinical audiologists. Madsen OB 70 audiometers, calibrated according to internationally accepted ISO standards, were used. Before testing, an otoscopic examination of the external meatus was done and occluding cerumen was removed. The pure tone test included measurements of air conduction thresholds at octave and half-octave intervals between 0.25 and 8 kHz using the ascending method [6].

Computerised tomography (CT) of brain

CT scans (without contrast enhancement) were rated by radiologists and neurologists blinded to the subjects’ clinical characteristics [7, 8]. Cortical atrophy of occipital, parietal, frontal and temporal lobes was categorised using a three-point scale according to the extent of sulcal widening (normal, moderate and severe) [8, 9]. Lateral ventricle size was measured in three linear distances: (i) the bifrontal span, (ii) the width of the head of the caudate nucleus, and (iii) the minimum width of the bodies at the waist. Ratios for (i), (ii), and (iii) were determined by dividing the obtained values by the internal diameter of the skull at the level of the measurement, giving the following ratios: bifrontal ratio, bicaudate ratio, and cella media ratio.

Mini mental state examination (MMSE)

Cognitive function was assessed by Mini mental state examination (MMSE) [10] which assesses global cognitive function including orientation, registration, attention, calculation, visual-spatial, recall and language. It scores from 0 to 30, lower scores implying worse cognitive function.

Statistical analysis

As few women had severe cortical atrophy, cortical atrophy was analysed as a dichotomous variable (present/absent). A paired sample t-test was used to examine differences of hearing capacity between left and right ear. An independent sample t-test was used to study the differences of hearing capacity between women with and without cortical atrophy. The association between hearing capacity and lateral ventricle index was tested by Spearman’s rank correlation coefficient (bicaudate ratio and cella media ratio) or Pearson’s correlation coefficient (bifrontal ratio). As cognitive impairment may influence performance on hearing tests, the relationship between hearing capacity and cortical atrophy was further studied by stratifying the sample by MMSE score (≤28 and >28). Two-tailed tests of significance were used.

Results

Among the 111 70-year-old women, 72 had cortical atrophy (34 one lobe, 17 two lobes, 13 three lobes, 8 four lobes). The pure tone thresholds were poorer in the left ear than in the right ear at frequencies 6 and 8 kHz with a difference of 2.2 dB (P = 0.05) and 2.7 dB (P = 0.03), respectively.

Women with cortical atrophy at any lobe had poorer hearing capacity of the left ear at the frequencies 6 kHz (mean value: 42.3 versus 50.1 dBHL) and 8 kHz (mean value: 49.0 versus 60.2 dBHL) than women without cortical atrophy. Women with atrophy of three or four lobes had poorer hearing of the left ear than those with atrophy of one or two lobes, and women without atrophy at frequencies 2, 4, 6 and 8 kHz (Figure 1). The findings for the right ear were in the same direction, but non-significant. Women with isolated temporal lobe atrophy (n = 17) had similar hearing capacity as women with isolated atrophy of the other three lobes (n = 17). Hearing capacity was not related to lateral ventricle index, (i.e. bicaudate ratio, bifrontal ratio and cella media ratio).

The mean MMSE score for the total group was 28.3 ± 1.4 (range 21–30). The relationship between cortical atrophy and hearing capacity was stronger in women with better
The associations were more pronounced for the left ear than for the right. One explanation could be that brain atrophy might be more severe in the right hemisphere than in the left, but we could not test this hypothesis, as we had no measurement of atrophied side. Another explanation is ear asymmetry with slightly poorer high-frequency thresholds of the left ear [11]. It has been suggested that the right cochlea is more sensitive to noise than the left [12]. Hearing loss was associated with cortical, but not central, atrophy, which seems logical as the cochlear sensory cells are more equivalent to grey than to white matter.

Cognitive function may alter capacity to perform hearing tests. Cognitive decline has been related to problems to perceive stimuli to the left ear during dichotic listening [13], and central auditory speech-processing deficits has been suggested to precede onset of Alzheimer’s disease by many years [14]. However, the observed association between hearing loss and cortical atrophy was most pronounced in those with high cognitive function.

Among the strengths of the study are the population-based sample, and comprehensive examinations. Limitations include, first, the sample size which is relatively small. The findings therefore need to be confirmed in larger studies. Second, although inter-rater reliability was good, subjective rating of cortical atrophy on CT scan is a crude method, which likely underestimated the associations. Third, the cross-sectional design precludes conclusions about the directions of the associations. Fourth, there are differences between men and women regarding hearing loss and brain atrophy [6,15,16]. We only examined women, and thus, cannot generalise our findings to men. Finally, multiple

cognitive function (MMSE 29–30, n = 56) than in other women (MMSE ≤28, n = 55) (Table 1). In those with better cognitive function, cortical atrophy at any cerebral lobe was related to poorer hearing of the left ear at frequencies of 1, 2, 4, 6 and 8 kHz. In those with poorer cognitive function, cortical atrophy was related to hearing capacity of the left ear at the frequency 8 kHz.

**Discussion**

We found a relationship between general cortical atrophy and poorer hearing in the high-frequency range of the left ear in a population-based sample of 70-year-old women. The relation between pure tone thresholds and brain atrophy was correlated to the extension of cortical atrophy, but not to specific location (temporal lobe). Most correlations were found in women with high cognitive function.

There are possible explanations for our findings. First, the relationship may represent expressions of common, age-related degenerative processes, as poor hearing was related to general cerebral atrophy, not to individual lobes. Second, although pure tone audiometry is supposed to reflect peripheral hearing, and not believed to be influenced by central auditory processing, we cannot exclude the possibility that a small part of the observed differences of pure tone thresholds in our study may reflect influences of central auditory processing, as primary and secondary auditory centres are located in the temporal lobe. Finally, the cross-sectional design of our study cannot elucidate the direction of the associations. It is thus possible that hearing loss may accelerate cerebral atrophy through impaired social contact and auditory stimulation.

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**Table 1.** Pure tone thresholds (means and SDs, dB HL) in women with and without cortical atrophy by stratified MMSE score

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Without atrophy</th>
<th>With atrophy</th>
<th>Without atrophy</th>
<th>With atrophy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 22 (22)*</td>
<td>n = 34 (32)</td>
<td>n = 17 (16)</td>
<td>n = 38 (35)</td>
</tr>
<tr>
<td>Left ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>13.6 ± 6.4</td>
<td>16.9 ± 9.0</td>
<td>20.6 ± 13.4</td>
<td>17.0 ± 7.0</td>
</tr>
<tr>
<td>0.25</td>
<td>15.7 ± 8.0</td>
<td>18.1 ± 9.3</td>
<td>23.2 ± 13.1</td>
<td>20.0 ± 9.1</td>
</tr>
<tr>
<td>1</td>
<td>14.8 ± 7.9</td>
<td>20.2 ± 10.2*</td>
<td>23.2 ± 10.9</td>
<td>22.2 ± 10.2*</td>
</tr>
<tr>
<td>2</td>
<td>19.6 ± 9.7</td>
<td>25.4 ± 12.6*</td>
<td>24.4 ± 12.2</td>
<td>26.6 ± 12.5</td>
</tr>
<tr>
<td>4</td>
<td>26.8 ± 13.5</td>
<td>36.9 ± 16.2*</td>
<td>35.3 ± 16.2</td>
<td>35.1 ± 15.4</td>
</tr>
<tr>
<td>6</td>
<td>38.4 ± 16.1</td>
<td>48.8 ± 18.4*</td>
<td>47.4 ± 17.8</td>
<td>51.2 ± 16.8</td>
</tr>
<tr>
<td>8</td>
<td>46.6 ± 17.4</td>
<td>57.7 ± 18.2*</td>
<td>52.0 ± 19.2</td>
<td>62.5 ± 14.9*</td>
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<tr>
<td>Right ear</td>
<td></td>
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<tr>
<td>0.25</td>
<td>14.8 ± 7.0</td>
<td>15.6 ± 8.5</td>
<td>20.3 ± 8.6</td>
<td>15.3 ± 6.2*</td>
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<tr>
<td>0.5</td>
<td>16.1 ± 8.3</td>
<td>17.5 ± 9.1</td>
<td>23.1 ± 10.3</td>
<td>18.4 ± 7.2</td>
</tr>
<tr>
<td>1</td>
<td>17.1 ± 9.3</td>
<td>19.5 ± 9.9</td>
<td>24.4 ± 11.7</td>
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<td>2</td>
<td>21.1 ± 13.1</td>
<td>25.0 ± 14.1</td>
<td>26.9 ± 14.2</td>
<td>26.4 ± 11.6</td>
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<tr>
<td>4</td>
<td>30.2 ± 15.2</td>
<td>35.6 ± 18.5</td>
<td>32.2 ± 16.9</td>
<td>33.1 ± 13.8</td>
</tr>
<tr>
<td>6</td>
<td>39.1 ± 15.5</td>
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<td>43.1 ± 14.8</td>
<td>45.6 ± 16.1</td>
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<tr>
<td>8</td>
<td>49.9 ± 15.9</td>
<td>54.8 ± 16.7</td>
<td>51.1 ± 21.0</td>
<td>55.5 ± 15.7</td>
</tr>
</tbody>
</table>

Note: Independent sample t-test was used to study difference of hearing capacity between women with and without atrophy. * P<0.05.

* Numbers in the parentheses are for the right ear.
The relation between brain atrophy and poorer hearing

Women with cortical brain atrophy had poorer hearing in the high-frequency range of the left ear.

The relation between brain atrophy and poorer hearing was correlated to the extension, not to the location, of the cortical atrophy.

The relation between brain atrophy and poorer hearing was stronger in women with high cognitive function.

Key points

- Women with cortical brain atrophy had poorer hearing in the high-frequency range of the left ear.
- The relation between brain atrophy and poorer hearing was correlated to the extension, not to the location, of the cortical atrophy.
- The relation between brain atrophy and poorer hearing was stronger in women with high cognitive function.

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comparisons were made, which may lead to false positive findings. The finding that all significant associations were in the expected direction supports our conclusion, but further confirmation is needed.

In conclusion, our study suggests a possible association between general brain atrophy and hearing loss, but causality cannot yet be inferred due to cross-sectional study design.

Key points

- Women with cortical brain atrophy had poorer hearing in the high-frequency range of the left ear.
- The relation between brain atrophy and poorer hearing was correlated to the extension, not to the location, of the cortical atrophy.
- The relation between brain atrophy and poorer hearing was stronger in women with high cognitive function.

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Conflicts of interest

No conflicts of interest exist.

References


Tissue Doppler annular velocities, NT-proBNP and exercise capacity in healthy elderly

SIR—The effect of ageing on myocardial function has been evaluated in previous studies using conventional echocardiographic parameters and invasive investigations.

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