Original Article

Hearing Impairment in Senile Dementia of Alzheimer’s Type*

WANG Ning-yu¹, YANG Hui-jie¹, SU Jing-fei¹, KONG Feng¹, ZHANG Ming-xia¹, DONG Hui-qing², ZHANG Xin-qing², JIA Jian-ping², HAN De-min³

¹ From Department of Otorhinolaryngology, Chaoyang Hospital Affiliated to Capital University of Medical Sciences, Beijing 100020, China;  
² From Department of Internal Neurology, Xuanwu Hospital Affiliated to Capital University of Medical Sciences, Beijing 100053, China;  
³ From Department of Otorhinolaryngology and Cephalocervical Surgery, Tongren Hospital Affiliated to Capital University of Medical Sciences, Beijing, China  
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【Abstract】Objectives To evaluate peripheral auditory dysfunction in senile dementia of Alzheimer’s disease (AD) and its relationship with cognitive dysfunction. Methods Pure tone thresholds, word recognition scores (WRS), acoustic immittance and auditory brain-stem responses (ABR) were tested to evaluate the auditory function in 43 AD patients and 50 normal subjects. The test reliability in these subjects was examined before the test results were evaluated for their correlation with the Mini Mental State Examination (MMSE) score. Results There were no statistically significant differences in peripheral auditory functions between the two ears in the tested subjects or between the two groups when the audiometric results of the right ear were compared ($P > 0.05$). Also, there were no statistically significant differences between the two groups when audiometric test reliability, acoustic impedance and ABR results were compared ($P > 0.05$). Conclusions The pure tone audiometric threshold and WRS in AD patients are similar to those in comparable non-AD senile subjects. Peripheral auditory dysfunction is not related to cognitive dysfunction.  

Keywords senile dementia of the Alzheimer’s type; pure tone audiometry; word recognition score; mini-mental scale questionnaire; cognition dysfunction

Senile dementia (Alzheimer’s disease, AD) is a primary retrograde degenerative disease of the central nervous system, which results from diffuse brain atrophy, especially in the frontal and temporal lobes. It is manifested by progressive intelligence decline and behavior/personality changes, as well as cognitive dysfunctions including impairments in memory, orientation and abstract thinking. Neuropsychological tests are fundamental in the diagnosis of AD. Whether hearing impairment affects cognitive function and can be tested as part of the neuropsychological diagnostic procedures for AD has interested both otorhinolaryngologists and neurologists. Indeed, much controversy remains regarding the relationship between peripheral auditory hypofunction and cognitive dysfunction and between hearing deterioration and intellectual decline. The objective of this study is to evaluate the pure tone threshold and word recognition in patients with AD and to ascertain their relations to cognitive functions.
Materials and methods

1.1 Clinical Materials

1.1.1 Forty-three cases of AD were recruited from patients at the Department of Neurology, Beijing Xuanwu Hospital, and at Beijing Gerontology Medical Research Center. These patients were already subjects in the AD audiology study project at the Beijing Key Laboratory in Brain Aging. The researchers involved in the project were from 8 task groups including specialists in neurology, neuropsychology, electro-neurophysiology, neuropharmacology, neuropathology, neuro-imaging, neuro-otology and epidemiology. Due to the long time requirement and great complexity of the project, a Dementia-Special-Unit Ward was created within the Department of Neurology with 15 dedicated beds. All relevant study designs within the project were thoroughly contemplated, and standardized diagnostic procedures and study processes were employed by all involved task groups to ensure accurate and reliable study outcomes. The following inclusion criteria were used for selecting AD subjects:

1) suspected or mild AD per clinical evaluation;
2) 60 years of age or older;
3) no history of irritability, otitis media or use of ototoxic medications;
4) no history of hearing aid use;
5) normal otological examination with no evidence of conductive deafness;
6) ability to be co-operative in audiometric tests.

1.2 The control group included 50 normal senile subjects whose living environment was comparative to that of the AD patients. They were recruited from a group of long-term study subjects maintained by the Epidemiology Study Centre in the Department of Public Heath, Beijing Gerontology Medical Research Center. Except for normal neuropsychological examination, the inclusion criteria were the same as those for selecting AD subjects.

1.2 Methods

1.2.1 Diagnosis of Dementia and AD. The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM—IV) was used for diagnosis of dementia. The diagnosis of AD was based upon the standards set by American National Institute of Neurologic Disorders and Stroke/Alzheimer’s disease and Related Diseases Association (NINAD/ADRDA). Vascular dementia (VD) was ruled out using the Hachinski’s ischemic scale.

1.2.2 Cognitive Function Evaluation. The MMSE was used in this study for evaluation of the patient’s comprehensive cognitive functions including memory, logic thinking and space/time orientation.

1.2.3 Auditory Function Evaluation

Before audiometric testing, the otologist collected the ear disease history and performed otological examination. Tympanometry tests were performed using an Amplifon 770, together with ipsilateral and contralateral acoustic reflexes at 0.5, 1 and 2 kHz, to rule out middle–ear disorders.

Hearing threshold. Air–conduction thresholds at 0.25, 0.5, 1, 2, 4 and 8 kHz were tested using the up–down method on an Amplifon A460 with TDH49 earphones. Test procedures were explained to the subject prior to testing. The threshold at 1 kHz was retested for confirmation at the end of the test. The test was typically completed within 20 minutes. Test reliability was categorized as excellent, good, fair and poor based upon the subject’s performance and behavior. The test–retest reliability of the threshold at 1 kHz was also for this purpose, with a consistent threshold indicating excellent test reliability, a 5 dB change good reliability, a 10 dB change fair reliability and > 10 dB change indicating poor reliability, respectively.

WRS. WRS of each ear was tested by asking the subject to repeat words delivered to the ear through an earphone. Subject’s responses were judged through a sound monitoring system. The test materials were phonetic balanced word lists including 50 single–syllable words. The WRS of each ear was scored based upon responses to 50 words. For auditory threshold 40 dB HL, testing words were delivered at 40 dB above the air–conduction threshold at 2 kHz. For subjects with air–conduction thresholds at 2 kHz 40 dB HL, the words were delivered at the comfortable loudness level. The same Amplifon A460 audiometer was used for WRS tests.

ABR. An Amplifon MK12 was used for ABR tests. The subject assumed a supine position during the ABR test. Silver disc electrodes were used, with the recording electrode placed at the forehead, the reference at the ipsilateral earlobe and the ground at the contralateral earlobe. TDH49 earphones were used for stimulus delivery. Inter–electrode impedance was maintained below 5 kΩ. The 2–1–2 tone pips were used with alternating polarities. Repetition rate was at 21/s with the filter set between 100 and 3000 Hz. Sensitivity was set at 0.07 mV.
Time window was 10 ms and 2000 sweeps were collected for each averaged waveform. Latencies and inter-peak latencies of waves I, III and V, as well as interaural latency differences of wave V, were analyzed. Wave V amplitudes were also measured. The ABR threshold was used to confirm the reliability of the pure tone audiometry.

1.2.4 Statistical Methods

Both audiometric and neuropsychological examinations were completed within one month.

PTA1 = averaged air-conduction pure tone threshold at 0.5, 1 and 2 kHz.

PTA2 = average air-conduction pure tone threshold at 0.5, 1, 2 and 4 kHz.

The null hypothesis for statistical analyses were that there were no differences between the normal control and AD groups in PTA1, PTA2 and WRS and that the audimetric results were not correlated to the MMSE scores. A P<0.05 was considered statistically significant.

All data were stored on a computer. The statistical software SPSS 8.0 was used for t-test, x²-test, covariance and other tests.

Results

No statistically significant differences in test results were found between the AD and control groups or between the two ears, except for MMSE. Because of this, analysis of the audimetric results was based on data from the right ear only. Again, while the control group showed better auditory function than the AD group (see Table), the differences were not statistically significant (P>0.05). The null hypothesis was therefore confirmed.

Mildly abnormal immittance compliance was seen in 15 cases, unilateral in 9 and bilateral in 5 cases. There were no other evidence of conductive deafness in these cases, however, and they were evenly distributed in both groups.

There were no statistically significant differences between the two groups in the measurements of audimetric reliability, acoustic immittance and ABR threshold (P>0.05). The ABR threshold–PTA differences were between 10 and 20 dB and not statistically significant.

The average Hamilton Depressive Rating Scale score of the AD group was 26.2 ± 7.4, indicating the prevalence of moderate to severe depression in this group. Hamilton Depressive Rating Scale scores > 17 indicate moderate to severe depression. An MMSE score <24 indicates dementia. The average MMSE score of the AD group in this study (17.9±3.1) was lower than that of the control group (26.3±2.5) (P<0.001).

Discussion

A review of the literature on AD shows that the intra-group confounding factors have not been well controlled in most previous studies on the relationship between the auditory and cognitive dysfunctions in AD patients. Different diagnostic standards and

### Table. The comparison of the results of the AD group and the normal control group

<table>
<thead>
<tr>
<th>Items</th>
<th>Normal control (n=50)</th>
<th>AD group (n=43)</th>
<th>Pvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>73.3 ± 6.6</td>
<td>72.7 ± 6.4</td>
<td>0.675*</td>
</tr>
<tr>
<td>Sex(Female %)</td>
<td>66.0</td>
<td>69.7</td>
<td>0.698*</td>
</tr>
<tr>
<td>ED (yrs)</td>
<td>5.2 ± 2.1</td>
<td>4.8 ± 3.3</td>
<td>0.091*</td>
</tr>
<tr>
<td>MMSE</td>
<td>26.3 ± 2.5</td>
<td>17.9 ± 3.1</td>
<td>0.001*</td>
</tr>
<tr>
<td>PTA1 Right ear</td>
<td>23.2 ± 10.6</td>
<td>26.3 ± 8.5</td>
<td>0.077*</td>
</tr>
<tr>
<td>Left ear</td>
<td>22.3 ± 6.9</td>
<td>25.8 ± 9.4</td>
<td>0.083*</td>
</tr>
<tr>
<td>PTA2 Right ear</td>
<td>26.2 ± 11.8</td>
<td>29.1 ± 8.7</td>
<td>0.169*</td>
</tr>
<tr>
<td>Left ear</td>
<td>28.7 ± 13.2</td>
<td>29.3 ± 9.6</td>
<td>0.105*</td>
</tr>
<tr>
<td>WRS (%) Right ear</td>
<td>87.6 ± 16.8</td>
<td>85.5 ± 15.5</td>
<td>0.107*</td>
</tr>
<tr>
<td>Left ear</td>
<td>85.1 ± 17.3</td>
<td>84.9 ± 16.7</td>
<td>0.123*</td>
</tr>
</tbody>
</table>

Notes: *: Bilateral t-test of the independent sample, P<0.05; #: Bilateral four-fold-table x²-test, P < 0.05; ED: Education degrees.
neuropsychological evaluation questionnaires have been used in these studies. As a result, opinions on the relationship between auditory and cognitive dysfunctions in AD patients remain conflicting and often contradictory.

The current study was designed as a case–control study with an intention to control potentially confounding factors and sampling errors. Well–established and validated neuropsychological examination questionnaires were used and administered by experienced experts. When administering questionnaire examinations, efforts were made to make sure that the subject understands the test contents and requirements. One well–trained and experienced audiologist performed all audiometric tests to minimize technical variations.

The results from this study show that, although the audiometric results of the AD group were slightly poorer than those of the control group, the difference was not statistically significant. These results support the hypothesis that cognitive dysfunction in AD is not related to peripheral auditory dysfunction.

From the findings in this study, we believe that the following points warrant attention in evaluating auditory and cognitive dysfunctions in AD patients:

I. Auditory dysfunction may reduce the patient’s scores in cognitive tests and undervalue his cognitive ability, leading to the illusive dementia diagnosis. In our study, MMSE have been administered by experienced neuropsychological experts who are well aware of the potential errors caused by hearing decline. However, even this arrangement does not guarantee complete elimination of such errors, which should be regarded as widespread and potentially misleading.

II. Sampling errors can affect study results. For example, high proportion of subjects with hearing decline in the AD group may constitute an inappropriate sampling. This is especially problematic in the case of comparing unmatched control and AD groups. An example would be comparing volunteer AD patients to control subjects from a well–defined study population. Both AD and control subjects in this series are from well–defined study populations, with minimal possibility of mismatch sampling error.

Because the diagnosis of AD was based upon clinical evaluation rather than histopathological evidence in this study, misdiagnosed cases were possible. However, studies on correlation between clinical AD diagnosis and post–mortem autopsy findings indicate that the current diagnostic standards for AD are highly accurate. We thus feel the possibility of errors from misdiagnosed cases is negligible.

III. It is possible that AD may affect peripheral auditory neuromechanisms including the cochlear nucleus, in addition to damaging the cortex and other central structures involved in processing auditory signals. The effects of AD on the auditory system may be evaluated through audiometric testing.

References