Assessment of Central Auditory Processing Functions in Children with History of Otitis Media

ABIR A. OMARA, M.D.; SALWA M. ABD EL-LATIF, M.D. and SOHA M. HAMADA, M.D.
The Audiology Department, Hearing & Speech Institute, Giza, Egypt

Abstract

Background: Central auditory processing disorder (CAPD) refers to difficulties in the perceptual processing of auditory information in the central nervous system. With the emergence of research that shows that 4 to 5 year old children with recurrent childhood otitis media have abnormal responses on auditory brainstem tests, the relationship between otitis media and CAPD is clear.

Objectives: Evaluation of the effects of otitis media in children on central auditory processing functions. Methodology: Thirty children with age range from 7 to 10 years, right-handed with normal hearing level and past history of otitis media participated in this study. The results of low pass filtered speech and time compressed speech tests were compared to those of fifteen children with normal hearing level as a control group.

Results: The study findings showed statistically significant difference between control group and study group as regards low pass filtered speech test with lower percentage in study group. Time compressed speech results revealed that there is significant difference in scoring between control group and study group with lower percentage in study group.

Conclusion: Central auditory processing in children is affected by occurrence of otitis media early in their life as shown in lower scoring of results of low pass filtered speech and time compressed speech tests.

Key Words: Central Auditory Processing (CAP) – Otitis media (OM) – Low pass filtered speech – Time compressed speech.

Introduction

OTITIS media (OM) is the most prevalent disease during childhood, next only to common cold. It is estimated that chronic OM affects 65 million to 330 million people worldwide, and 60% of them (39 million to 200 million) showed clinically significant hearing impairment [1]. Incidence of OM is known to be higher in the first 3 years of life [2].

Adequate sensory experience is critical to the developing nervous system and the maintenance of sensory functions even when such functions are innately determined [3]. Development and maintenance of auditory sense is no exception. In other words, reduced auditory input, early in life, may affect auditory processing later in life. Otitis media (OM) is a common condition that results in hearing loss in early years of life. Sandeep and Jayaram [4] have reported that OM occurring early in life may lead to subtle difficulties in speech identification, particularly under adverse listening conditions. Furthermore, such negative effects may persist for 4 years or even more after an attack of OM.

Chronic OM, persisting for several years, may lead to loss of outer and inner hair cells in the basal turn of the cochlea [8] that in turn, may lead to sensorineural hearing loss [6,7].

Webster and Webster [8] reported a reduction in both the size and number of neurons in the auditory brainstem. It is possible that these anatomical deficits may be functionally evident as deficits in auditory processing. In fact, it has been reported that peripheral hearing loss associated with OM may degrade auditory representation, particularly speech [9]. It is estimated that 26% to 55% of the children with OM have mild to moderate hearing loss in the speech frequency range. Bess [10] and, therefore, the sounds they hear will be degraded [11].

One study that employed specialized speech tests reported that children with OM have Difficulty in processing speech, Welsh et al. [12], for instance, administered monotic speech tests (that employed both Temporally and spectrally distorted speech stimuli) and dichotic tests (that challenged auditory separation and central integration) to a group of children with early onset of OM and reported that
children with early onset of OM had failed results on at least one segment of the test battery.

We aim in this research to study the effect of early otitis media in children on central auditory processing by changing the physical parameters of speech stimuli.

**Subjects and Methods**

This study comprised two groups; group (1): Control group, consists of fifteen children ranging from 7 to 10 years (mean 8.56±1.3) with normal hearing level and group (2): Study group, consists of thirty children with age range from 7 to 10 years (mean 8.22±1.6), right-handed with normal hearing level with past history of repeated attacks of otitis media participated in this study after exclusion of children suffering from; neurological diseases. The results of low pass filtered speech and time compressed speech tests were compared between the two groups.

All subjects of this research were selected from outpatient clinic of Hearing and Speech Institute from April 2012 to August 2012.

The research was approved from ethical committee of general organization of teaching hospitals and institutes.

**Equipment:**

Clinical audiometer Interacoustics model AC40; Immittancemeter Ineracoustics model AZ 26, Assens, Denmark and Compact discs for central auditory processing assessment.

**Procedure**

All subjects in this research were submitted to full medical history taking, otologic examination and basic audiological evaluation (pure tone audiometry, speech audiometry & Immittancetry). Central auditory processing assessment by changing the physical parameters of speech stimuli, using: Low pass filtered speech and time compressed speech tests.

**Central auditory processing tests:**

a- **Low pass filtered speech test:**

The test requires the listener to repeat 25 words that is presented by CD voice. A presentation of 2 lists was completed at 40 dB above the pure-tone average. The words were presented through a 2-channel diagnostic audiometer [4]. The test was administered monaurally. Subjects were instructed to repeat the words.

The percentage of correct speech identification was calculated separately for the right & the left ear.

b- **Time compressed speech test :**

Three lists of time compressed speech is used, with zero%, 40% and 60% compression of tested sentences. Zero% speech is used just as training for the child at beginning of the test. Each ear is tested separately. The listener was required simply to repeat the sentences heard. Each sentence is divided into three parts consisting of a subject, verb and an object. These parts are divided by hash marks on the score form.

Each part is scored separately giving the possibility of three errors per sentence. When the child missed one of the content words in the sentence, it constituted an error. Errors in articles of speech were not considered an error. The words were presented at 40 dB above threshold (SL).

Statistical analysis of the results was done using SPSS system (Statistical package for social sciences) (version16), IBM Corporation, USA. As regards low pass filtered speech and time compressed speech in both control and study groups. Paired sample t-test and independent sample test were used.

**Results**

The subjects involved in this research were classified into two groups; control group, (fifteen children) ranging from 7 to 10 years (mean 8.56±1.3) with normal hearing level and study group, (thirty children) with age range from 7 to 10 years (mean 8.22±1.6), normal hearing level with past history of repeated attacks of otitis media.

As regards the low pass filtered test (Table 1 & Fig. 1) a statistically significant difference was found between the study and control groups for both right and left ear with lower percentage in study group.

Time compressed sentence test showed that, the Zero% compression ratio was presented by 10 sentences only for practice and not incorporated in the statistical analysis. As regards the 40% compression ratio, a statistically significant difference between study and control groups for right ear was detected (Table 2 & Fig. 2) but for the same compression ratio for left ear a difference was detected but was not statistically significant. As regards the 60% compression ratio a statistically significant difference was detected as shown in (Table 2 & Fig. 3) for both right and left ears between study and control groups with lower percentage in study group.

The statistical analysis of results between right and left ears was not significant except for the low pass filtered test for study group.
Table (1): Mean and SD of low pass filtered test score for both study and control groups.

<table>
<thead>
<tr>
<th>Low pass Filtered test</th>
<th>Control Group (Mean±SD)</th>
<th>Study Group (Mean±SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right ear</td>
<td>88.4±5.15</td>
<td>79.8±5.73</td>
<td>&lt;0.05 *</td>
</tr>
<tr>
<td>Left ear</td>
<td>88.8±2.53</td>
<td>82.2±4.94</td>
<td>&lt;0.05 *</td>
</tr>
</tbody>
</table>

Independent sample t-test between control and study group for both RT & LT ears (p<0.05* Sig.).

Fig. (1): Mean score of low pass filtered test for both study and control groups.

Table (2): Mean and SD of time compressed sentence test score for both study and control groups at 40 and 60% compression ratio.

<table>
<thead>
<tr>
<th>Study group</th>
<th>Mean ±SD</th>
<th>Control group</th>
<th>Mean ±SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>Right</td>
<td>69.39±5.27962</td>
<td>Right</td>
<td>84.90±631538</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>73.8±5.27962</td>
<td>Left</td>
<td>79.6±5.27962</td>
</tr>
<tr>
<td>60%</td>
<td>Right</td>
<td>19.86±13.6716</td>
<td>Right</td>
<td>53.91±6.49597</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>17.49±15.2433</td>
<td>Left</td>
<td>53.38±20.3052</td>
</tr>
</tbody>
</table>

Independent sample t-test between control and study group for both RT & LT ears (p<0.05* Sig.).

Fig. (2): Mean score of time compressed sentence test (40% compression ratio) for both study and control groups.

Fig. (3): Mean score of time compressed sentence test (60% compression ratio) for both study and control groups.

Discussion

In this research the central auditory functions in children with normal hearing sensitivity with positive past history of otitis media were evaluated using two central auditory tests (low pass filtered speech and time compressed speech) and the results were compared to those of normal hearing children with no past history of otitis media.

As regards our results of the low pass filtered test, a statistically significant difference was found between the study and control groups with lower percentage in study group.

Time compressed speech test results showed that with the 40% compression ratio, a statistically significant difference between study and control groups for right ear was detected but for the same compression ratio for left ear a difference was detected but was not statistically significant.

As regards the 60% compression ratio a statistically significant difference was detected for both right and left ears between study and control groups with lower percentage in study group.

Our results agreed with Sandeep and Jayaram, [4] who found that, the mean speech identification scores for degraded speech was significantly lower compared to mean speech identification scores for normal speech even in the normal children of their study, although the scores were significantly higher for normal children compared to children with OM for both spectrally and temporally distorted stimuli. However, there was no significant difference in the mean speech identification scores for natural words between the two groups and their explanation...
for that results was that, children may have difficulty in perceiving speech reduced in its redundancy (either because of spectral or temporal distortion). The greater difficulty that children with early OM have in perceiving spectrally distorted speech may be because of their reduced ability to compensate for the loss of signal redundancy in spectrally distorted speech.

The same results of identification of spectrally and temporally distorted speech were achieved by Welsh et al. [12], however their study reported that children with early onset OM failed in at least one segment of their battery (spectrally distorted, temporally distorted, auditory separation and auditory integration) that implies that not all their children had problems in perceiving spectrally or temporally distorted stimuli.

Sandeep and Jayaram, [4] agreed with our results of time compressed test, they found that normal children had poorer speech identification scores for time distorted speech than for spectrally distorted speech while the opposite was true for children with early onset OM. It means that conductive hearing loss in children with early onset OM affected perception of spectral parameters to a greater extent than timing parameters. This has important implications for deciding on intervention strategies for children with early OM, particularly in environments that are less than acceptable (noisy surroundings, public places, etc.). As persons with conductive and cochlear hearing loss benefit from amplification, children with early onset OM can improve perception of spectral information if the intensity of speech input is increased.

The same results were achieved by Anitha, [13], he found that the normal children also had problems in perceiving degraded speech, but the degree of their difficulty was significantly less compared to that of children with early onset OM. Children with OM with normal language development were matched with normal children without OM on language development.

Grave et al. [15], agreed with our results as they found that children with early OM had problems in perceiving spectrally or temporally distorted stimuli as compared to normal children.

Sandeep and Jayaram, [4] found that children who had multiple episodes of OM or for a longer duration had significantly lower speech identification scores for spectrally distorted stimuli than children who had a single episode of OM or OM for less than one month in duration. They found that there was no significant interaction effect between the number of episodes and the duration of OM.

Auditory deprivation, temporary or permanent, and occurring before or after neural maturation, is a specific form of perversion of auditory input that deviates from what is expected and/or needed for the optimization of auditory function in the human. However, the effects of reduced auditory experience are particularly more deleterious when the input restrictions occur within the developmental period although research suggests that even a mature auditory system is not immune to afferent restrictions [9].

Temporal resolution was found to be abnormal in children with OM, but only in instances where hearing loss was of a severe degree [16]. Otitis media in the first 2 years of life has been reported to affect receptive as well as expressive language [17], phonological acquisition [18] and phonological and morphological perception [19].

On the other hand, some authors disagreed with our results there are a number of studies that have reported normal auditory processing and language development in children who had conductive hearing loss secondary to OM in the first 3 years of life. In a prospective study of children who had OM in the period between 7 months and 39 months of age, Gravel et al. [15] reported normal speech perception for words in noise at 8 years and 9 years of age.

Grievink et al. [20] disagreed with our results, they found normal language development in 9 year-old children who earlier had suffered multiple episodes of OM between 2 years and 4 years of age.

The high frequencies are processed in the left hemisphere and they are responsible for the development of sequencing and other language functions, while the right hemisphere seems to ‘get’ the low frequency sounds. When conductive hearing loss occurs, it is often the high frequencies that are lost, this means affection of sequencing and other language functions [21].

Conclusions:

• A statistically significant difference was found between control and study groups as regards low pass filtered speech in RT and LT ears with lower score in study group.

• A statistically significant difference in time compressed speech between control and study groups was found with lower percentage in study group.
except for LT ear with 40% compression ratio that showed non significant difference.

- These findings indicate that central auditory processing functions are altered by history of repeated attacks of otitis media in children.

Recommendations:

- Including the central auditory evaluation tests in the audiological protocol for children with past history of otitis media, as the prevalence of central auditory affection affect their quality of hearing as it affects understanding of speech.

- The classrooms are very noisy, and have poor acoustics. It is possible that the teachers’ speech will be degraded under these conditions, and children with a history of early onset OM may have difficulty in perceiving speech under such circumstances. This, in turn, may affect their learning and academic achievement. The teachers and the parents of those children should be informed of the possibilities of central affection of that child as compared to normal children with the possible management of that problem.

References


