Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

Effects of Chronic Otitis Media with Effusion on Amblyaudia

Shahnaz Alamdari[1*], Yones Lotfi[1], Alireza Karimi Yazdi[2], Mohanna Javanbakht[1], Enayatollah Bakhshi[3]

[1]Department of Audiology, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran
[2]Department of Otolaryngology, Head and Neck Surgery, Tehran University of Medical Sciences, Tehran, Iran
[3]Department of Biostatistics, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

ARTICLE INFO

Article History:
Received: 09/06/2018
Revised: 26/09/2018
Accepted: 06/10/2018

Keywords:
Dichotic digit test
Dichotic rhyme test
Auditory processing disorder
Amblyaudia
Free recall attention

ABSTRACT

Background: Chronic otitis media with effusion (CME) primarily affects children. Temporary auditory deprivation is a serious complication of this disease and can result in auditory processing disorder, as demonstrated in past studies. The objective of the current study was to investigate the effects of CME duration on binaural processing and amblyaudia.
Methods: Ninety-four children were examined, including 48 children (29 girls=60%) with different CME durations (from 3 months to more than 9 months) and 46 children (34 girls=73%) with no history of CME or a duration of less than 3 months CME. Persian versions of the dichotic digits and dichotic rhyme tests were applied.
Results: Significant differences between the groups (P<0.001) in dichotic digits difference (DDD) and dichotic rhyme difference (DRD) in free recall conditions were identified. With longer durations of CME, the DDD and DRD average scores were increased in the CME positive group, and the probability of amblyaudia was also enhanced.
Conclusion: A history of CME and the long-term auditory deprivation resulting from it in early childhood can increase the risk of amblyaudia.

Introduction

Otitis media, an inflammatory disease of the middle ear, is the most prevalent childhood disease. This condition mainly affects children, and its prevalence decreases with age [1]. The two main types of this condition are acute otitis media (AOM) and chronic otitis media with effusion (CME). The latter is not usually associated with symptoms and is defined as the accumulation of non-infectious fluid in the middle ear lasting for longer than three months [2]. Nearly, two- thirds of children between one and five years of age have experienced CME at least once during childhood [3].

Temporary auditory deprivation is a common complication of CME, and its most serious effects are long-term auditory processing deficits [4, 5]. During brain development, higher cortical centers receive different inputs from the periphery to form organized neural circuits [6-8]. The impact of sensory input is especially informative during critical periods of brain development. Early exposure to sound causes proper maturation and development of the auditory processing centers [8]. Otitis media reduces the amount of sound that reaches the ear, so changes in early stages would affect how information about sounds is conveyed to higher-order areas for further processing and localization [9].

Auditory processing disorder (APD) is characterized by impairments in auditory abilities, including auditory discrimination, binaural listening, and temporal processing [8]. This disorder affects nearly 2-5% of school-aged children [8]. Multiple studies indicate

Corresponding author:* Shahnaz Alamdari, MSc; Student of Audiology, Department of Audiology, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. **Tel: +98 912 5269118
E-mail: alamdari_sh1@yahoo.com

that auditory deprivation secondary to otitis media can result in impaired language development, auditory processing, auditory memory, listening to background noise, and dichotic testing [10, 11]. Borges et al. (2012) indicated that a history of recurrent otitis media alters central auditory processing functions [12]. Another study by Shetty et al. (2016) showed that recurrent otitis media before the age of 2 years alters the temporal and spectral skills secondary to sensory deprivation, which has negative impacts on speech perception in noise [13]. Moreover, Jafari et al. (2016) found that binaural processing and verbal memory can be affected by recurrent otitis media [14]. Multiple animal studies have shown that monaural deprivation during critical periods of brain development can cause impairments in binaural interaction in the auditory cortex [9, 14].

Amblyaudia is a new subcategory of APD. It is identified by asymmetrical auditory processing between an individual's two ears [15]. Amblyaudia is associated with difficulties in sound localization and spatial hearing, both of which are essential for speech comprehension, particularly in noisy environments [8, 16]. Amblyaudia can also lead to social, language, behavioral, or educational problems [17, 18]. Amblyaudia may not be detected by traditional audiometric tests, because these tests do not place the two ears in competition with each other. At present, dichotic listening tests such as the competing words test, staggered spondaic words (SSW) test, and randomized dichotic digit (RDD) test are used for screening and diagnosing any asymmetry between the auditory pathways [8, 19].

Because of the high prevalence of CME in childhood and the lack of literature on the effects of CME duration on binaural processing scores and amblyaudia occurrence, this study was undertaken by the authors.

The main objective of this study was to evaluate the effects of CME duration on amblyaudia occurrence through valid and reliable auditory dichotic tests, including DDT and DRT [20].

Methods

Participants

This retrospective analytical cross-sectional study evaluated 94 primary school-aged children with histories of different CME durations ranging from less than 3 months to more than 9 months. Forty-eight children with a history of CME lasting more than 3 months were selected from patients at the Imam Khomeini Hospital Complex in Tehran, Iran (study group) based on the simple random sampling method. A total of 29 girls and 19 boys who were within the age range of 7-11 years (mean=8.56 +/- 1.6), monolingual (solely Persian language), and right-handed with normal hearing levels were included in the study. Children with mental or neurologic disorders, a history of head trauma, a history of psychoactive drug use, and children born preterm as well as children who would not cooperate with the researchers were excluded.

Children were assigned to groups of those with a duration of CME of less than 3 months and those who were CME-free, who were 46 healthy children (34 girls, 12 boys) with normal hearing and those with a CME duration of longer than 3 months. They were recruited from local schools and were aged between 7 and 11 years (mean=8.47 +/- 1.2). The two groups were matched according to age, hand preference, and gender.

Audiometry (by Orbiter 982 Madsen) and tympanometry (by Madsen Zodiac) were carried out in both groups before the dichotic digits test was done. Both devices were equipped with headphones calibrated according to appropriate institute standards.

Parents of the children who participated in this study were informed of the research goals and signed informed consent forms according to the ethics of the research committee of the institution (University of Social Welfare and Rehabilitation Sciences research code IR.USWR.REC.1396.258). Assessments were performed in the Imam Khomeini Hospital Complex, Tehran, from October 2017 to March 2018.

Dichotic Testing

DDT is a central auditory test that assesses hemispheric dominance for language and binaural integration skills in children with learning, listening, and reading disabilities. The Persian version of this test was produced by Mahdavi et al. (2017) based on the English version [20]. In this study, monosyllabic words, i.e. numbers from 1 to 10 (except number 4 which has two syllables in Persian) were used as 20 test items, including two pairs of digits in each item (2 digits to each ear). The test was performed at 50 dB SL in reference to the spondee threshold, while the child was wearing headphones (Philips SHL300), and the stimulus was sent by laptop (DELL INSPIRON4050). Children were asked to repeat each expressed test item upon hearing it. Then, the number of words identified correctly was computed separately for each ear. Ear advantage (EA) was calculated by subtracting the left ear score from the right ear score.

The Persian version of the Dichotic Fused Rhymed Words Test included 15 pairs of monosyllabic rhyming words [21]. These paired words were arranged in four lists of 30 items and introduced to each ear simultaneously so that they led to the perception of a single fusion concept. This test was performed while the child was wearing headphones as DDT. DRT reduces the effect of attention on test results, and it is highly valuable in detecting corpus callosum function and evaluating central auditory processing [22].

DDT and DRT were presented in a directed free recall situation to the right and left ears [Dichotic Digit Free Recall right and left (DDFR right, left)], [Dichotic Rhyme Free Recall right and left (DRFR right, left)]. Thereafter, based on correct word or digit recall, the absolute score of each side, the DDD, and the DRD were computed.

Statistical Analysis

The results are expressed as the mean ± standard deviation for continuous variables and as a percentage for categorical variables. Nonparametric statistical analysis was used due to abnormal data distribution according to the Kolmogorov-Smirnov test. The Mann-Whitney U test was likewise used to determine the effect of gender. The Kruskal Wallis test was used because of the abnormal distribution of data. All statistical analyses (Kruskal Wallis test, Mann-Whitney U test) were conducted using the Statistical Package for the Social Sciences (SPSS) version 21.0 software. Statistical significance was set at a level of <5%.

Results

Descriptive information about the DDFR and DRFR scores in CME-free or less than 3 months duration group and the more than 3 months duration group are presented in Table 1.

In Figures 1 and 2, the analytic statistics regarding CME duration based on auditory documents (<3 months, 3-9 months, >9 months) as well as the effects on DDD and DRD are presented. The results revealed a significant difference between the two groups (P<0.001). Moreover, in the dual comparison of results, a significant difference between the group with a CME duration of less than 3 months and the 3-9 months group was seen (P<0.001).

The effect of gender on performance was examined in both groups. There was no significant difference between males and females based on the Mann-Whitney U Test in the DDD (P<0.76) or the DRD (P<0.17).

The present study evidenced an asymmetry in the auditory hearing system based on speech tests and tympanometry in the early childhood of 37 children, but in 11 children with a history of CME, only bilateral tympanometry type B was observed. However, there was a right ear advantage in these 11 people as well as in the

Table 1. Descriptive data of Dichotic Digit Free Recall (DDFR) and Dichotic Rhyme Free Recall (DRFR) in two groups

	CME-free or less than 3 months duration group			More than 3 months CME duration group		
	Number	Mean	Std. Deviation	Number	Mean	Std. Deviation
DDFR Right	46	91.35	6.82	48	81.04	11.79
DDFR Left	46	83.47	7.57	48	50.62	13.34
DDD	46	7.77	4.28	48	30.36	14.35
DRFR Right	46	56.85	6.13	48	59.34	5.34
DRFR Left	46	48.15	6.19	48	40.45	5.05
DRD	46	8.69	5.41	48	19.23	11.17

DDFR Right: Dichotic Digit Free Recall Right; DDFR Left: Dichotic Digit Free Recall Left; DDD: Dichotic Digit Difference; DRFR Right: Dichotic Rhyme Free Recall Right; DDFR Left: Dichotic Rhyme Free Recall Left; DRD: Dichotic Rhyme Difference

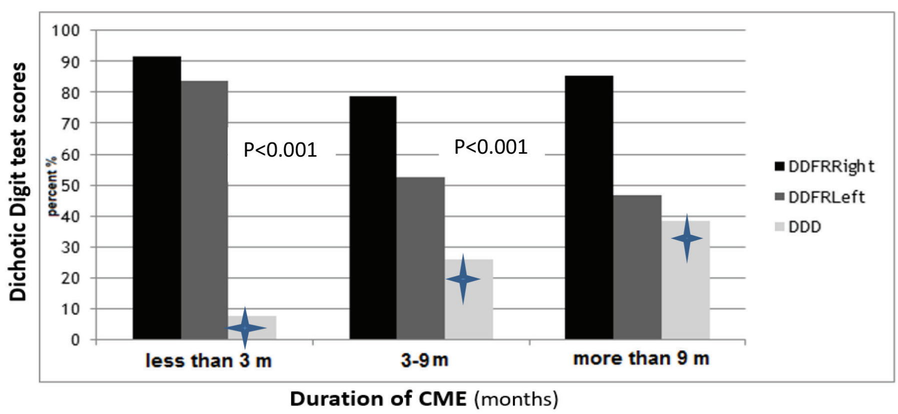

Figure 1: Analytic statistics of dichotic digit test scores as function of the duration of chronic otitis media (COM). DDFR Right: Dichotic Digit Free Recall Right; DDFR Left: Dichotic Digit Free Recall Left; DDD: Dichotic Digit Difference

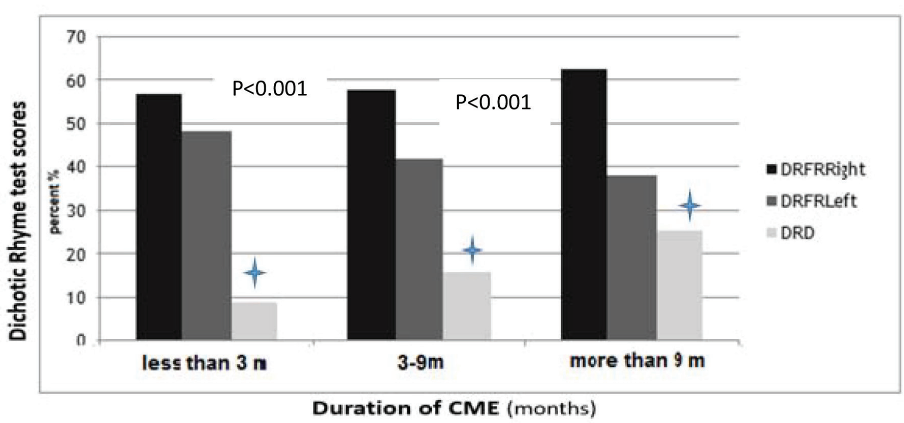

Figure 2: Analytic statistics of dichotic rhyme test scores as a function of the duration of chronic otitis media (COM). DRFR Right: Dichotic Rhyme Free Recall Right; DRFR Left: Dichotic Rhyme Free Recall Left; DRD: Dichotic Rhyme Difference

37 children with hearing asymmetry, and the difference between the two ears was significant (P<0.001). Overall, an increased duration of CME correlated with increased scores of DDD and DRD, and the probability of amblyaudia seemed to be enhanced.

Discussion

Significant difference was observed between the groups in the DDD and DRD in free recall conditions (the CME-free or less than 3 months duration group versus the more than 3 months duration group). The right ear (dominant ear) scores were nearly normal, while the left ear scores fell below the normal cutoff in children in the more than 3 months CME duration group. In other words, an abnormally high interaural asymmetry between the two ears was observed in children in the second group. These results represent a unilateral weakness during the binaural integration of two imbalanced signals.

Based on the 2017 study of Zhuang et al., it seems that conductive hearing loss makes synaptic changes in early developmental periods and disturbs the functional integrity of central auditory structures. This finding is consistent with those of other studies [12, 23].

The central auditory nervous system receives the most fibers in contralateral pathways. Right ear signals travel directly to the left hemisphere. Consequently, the right ear performs better during dichotic tests because of the direct contralateral pathway to the left hemisphere, which is the language-dominant hemisphere in right-handed individuals, whereas left ear signals transverse to the right hemisphere and then cross to the left hemisphere through the corpus callosum (CC).

Jafari et al. (2016) indicated that the ear advantage (EA) is higher in early childhood and degrades with age [14]. If imbalanced signaling exists between the two ears during the critical period, maladaptive patterns of neural connections may result, which will persist even after the peripheral pathology has improved [10, 14]. This statement can explain the results of this study, which showed that long-term CME in childhood can cause significantly weakened neural transmissions from the affected ear in comparison with the unaffected ear. This asymmetry creates a better ear as the dominant ear at higher levels of the central auditory system. Studies have shown that temporary hearing loss (like CME) which occur in the critical period of childhood development can cause some type of auditory asymmetry and amblyaudia [14, 24-26]. The current study showed that auditory asymmetry and amblyaudia can be increased even more by a longer duration of CME.

It seems that longstanding imbalanced inputs from the two ears to the brain may change central auditory processing and set up inappropriate brain circuitry [27]. As Moore’s study showed, children who experienced multiple episodes of CME during their first few years develop disturbances in sound detection in noisy environments [28]. Moosavi et al. (2014) showed that children with a history of CME may suffer from APD signs as well [27]. In support of this hypothesis, the current study results indicate that if CME duration increases, the average DDD and DRD scores as well as the probability of amblyaudia also increases.

In the current study, no gender-related significant difference was observed between the two groups in DDD or DRD. This is in agreement with Jafari et al. (2016) who also observed no significant gender difference between the age groups, except for left DDT measurements [14]. However, ear scores and values of interaural asymmetry were affected by gender in a study by Moncrieff et al. (2016) [23]. They reported that the gender effect was dominant on the dichotic listening with monosyllabic words test material rather than on the dichotic listening with digits materials [23]. There have been reports that males perform better on spatial and motor tasks than females, while females have shown better results in verbal and memory tasks [29]. Further experiments are needed to clarify the effects of gender on behavioral measures.

It should be noted that in the current study, there was a right ear advantage in all children, even in cases of hearing symmetry (based on tympanometry findings in the medical records), and the difference between the two ears was significant. It is likely that there was an asymmetry in auditory inputs before the age of five in all cases (as compared to the CME-free group or the less than 3 months duration group).

Therefore, it seems that in addition to hearing impairment, amblyaudia can be caused by disturbances in the central auditory pathways (regardless of the symmetry or asymmetry of peripheral hearing impairment) [30]. In similar articles [14, 23], no mention was made of a history of symmetry or asymmetry of CME-induced hearing impairment in the pediatric medical records; only the presence of CME in early childhood was considered as a criterion for entry into these studies.

The current study was limited by the absence of exact data on the behavioral threshold and on the degree of threshold asymmetry between the ears. Subsequent studies can resolve this limitation.

Conclusion

The current study showed that when the duration of CME is increased, the risk of amblyaudia in children is also increased. At present, dichotic listening tests are used in screening and diagnosing cases suspected of auditory processing disorders. Based on the current study findings, performing these dichotic tests and appropriate interventions should be considered in children with a history of CME, especially for cases with CME lasting longer than 3 months.

Acknowledgment

The authors express their appreciation to Dr. Afsane Doosti (Department of Audiology, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran) for her helpful comments on this paper. We also thank Dr. Azam Alamdari (Nephrology

Research Center, Tehran University of Medical Sciences, Tehran, Iran) for her help and support.

Conflict of interest: None declared.

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