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Electrophysiologic Assessment of Central Auditory Processing by Auditory Brainstem Responses in Children with Autism Spectrum Disorders

In addition to aberrant features in the speech, children with Autism Spectrum Disorder (ASD) may present unusual responses to sensory stimuli, especially to auditory stimuli. We investigated the auditory ability of children with ASD by using Auditory Brainstem Responses (ABR) as they can directly judge both hearing status and the integrity of auditory brainstem pathways. One hundred twenty-one children (71: ASD; M 58/F 13, mean age; 41.8 months, 50: control group; M 41/F 9, mean age; 38 months) were induded in the study. As compared with the values in the control group, the latency of wave V, wave I-V, and wave III-V inter-peak latencies were significantly prolonged ($p<0.05$) in the ASD group. The findings indicate that children with ASD have a dysfunction or immaturity of the central auditory nervous system. We suggest any children with prolonged III-V inter-peak latencies, especially high functioning children should be further evaluated for central auditory processing to set up a more appropriate treatment plan.

Key Words : *Autism Spectrum Disorder (ASD); Central Auditory Processing; Auditory Brainstem Responses (ABR)*

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INTRODUCTION

Autism spectrum disorder (ASD), a major neuropsychiatric condition in children, is generally recognized as a developmental condition in origin but very little is known about its etiology. There are no universal agreements with regard to abnormalities of the brain structure, and no biomarkers have been detected for confirmation of clinical diagnosis. Diagnosis is mainly made on the basis of a variety of clinical features such as qualitative disturbance in communication, social interaction, and restricted interests or activities. Earlier studies, which focused on the language skills of children with ASD, showed aberrant features in their speech such as unresponsiveness to questions, echolalia, choosing inappropriate words, poor ability of binaural separation, and having a left ear advantage (1-5). It was also suggested that some children may not be able to decode auditory language (1). Central Auditory Processing Disorder (CAPD) is a complex and heterogeneous group of auditory-specific disorders usually associated with a range of problem within the processes responsible for generating the auditory evoked potentials and other behaviors such as auditory localization or lateralization, auditory discrimination and auditory pattern recognition (6). CAPD may underlie, or interact with other neuropsychiatric conditions. Since characteristics of the auditory function have many clinical and neuropsycholgical similarities with those of ASD, it would be interesting if we are able to clarify whether they share the fundamental pathophysiology or a common clinical and genetic propensity.

To answer this question, we evaluated the characteristics of auditory ability of children with ASD by using Auditory Brainstem Responses (ABR), as they can directly judge both hearing status and the integrity of auditory brainstem pathways.

MATERIALS AND METHODS

One-hundred and twenty-one children (71: ASD; M 58/F 13, mean age 41.8 months, 50: control group; M 41/F 9, mean age 38 months) were involved in the study, and they were consecutively recruited from the Pediatric Neurology Clinic, Kyungpook National University Hospital, Daegu, Korea between 1 January 2002 and 31 December 2005.

A full neurological examination was done, when possible. Brain magnetor resonance imaging (MRI) was done only when the subjects had abnormal medical history or physical findings in the ASD group. Along with the application of DSM-VI-TR, neuropsychological tests such as the Childhood Autism Rating Scale, Social Maturity Scale, and Speech/Language evaluation were conducted.

Their auditory ability was also assessed as an initial evalu-

ation by using ABR. We measured the absolute latencies of these I to V waves, the inter-wave intervals of I-V and III-V, and amplitude ratios with using 90 dB to 20 dB in 10 dB steps for stimulus intensity, 13/sec of click rate, 200 μsec of duration, and Cz-ipsilateral medial earlobe for derivations (NAVIGATOR, Bio-logic, U.S.A.).

Statistical values were expressed as mean±standard deviation (SD). These results were analyzed statistically using the Student's t-test or nonparametric tests, as indicated. Comparisons among groups for differences in estimated means were conducted with analysis of variance (ANOVA). All reported p values were two-tailed. A p value less than 0.05 was considered significant.

RESULTS

The demographic features of the study subjects are shown in Table 1. In the ASD group, 30 out of 71 children were socially impaired (below 70 on Social Maturity Scale). One third of the subjects (31.0%) showed the typical features of ASD such as impairments in social interaction, impairments in communication, and restricted, stereotyped behavioral patterns on the Child Autism Rating Scale and met the DSM-VI-TR criteria for autism. In the control group, their social skills were within the normal range as expected. Six out of 71 children (8.5%) showed abnormal findings of ABR for amplitude and latency values in the group of children with ASD. One of the children had significantly low wave amplitudes on one ear. As shown in Table 2, mean latency values of wave I, III, and V in the ASD group were 1.40±0.17 msec for the left, 1.44±0.11 msec for the right, 3.90±0.13 msec for the left, 3.92±0.15 msec for the right, and 5.91±0.44 msec for the left, 5.94±0.39 msec for the right, respectively. In the control group, the wave I, III and V latency values were 1.36±0.15 msec for the left, 1.42±0.21 msec for the right, 3.85±0.17 msec for left, 3.87±0.19 msec for right, and 5.67±0.25 msec for the left and 5.73±0.36 msec for the right, respectively. The latency values of wave V were significantly prolonged in the ASD group in comparison with those of the control group (p<0.05).

As shown in Table 3, I-V Inter-peak latency values were 4.51±0.42 msec for the left and 4.49±0.34 msec for the right, and III-V inter-peak latency values were 2.01±0.28 msec for the left, 2.02±0.31 msec for the right in the ASD group (4.26±0.21, 4.26±0.21, 1.71±0.12, 1.77±0.24 for autism, respectively). In the control group, I-V Inter-peak latency values were 4.34±0.29 msec for the left, 4.31±0.35 msec for the right, and III-V inter-peak latency values were 1.82±0.33 msec for the left, 1.86±0.27 msec for the right, respectively. As compared with the values of the control group, I-V, and III-V inter-peak latency values were significantly prolonged in the ASD group (p<0.05). Twelve out of 71 (16.9 %) took brain MRI. Among them, one had an arachnoid cyst and one had hamartomas in pons and cerebellum.

DISCUSSION

Autism is a developmental disorder characterized by disturbances in social interaction, communication, and restricted interests or activities. Although there is little evidence of a marked reduction in autistic features, it has been determined

Table 1. Demographic features of the subjects

	ASD (N=71)	Control group (N=50)
Gender (male/female)	58/13	41/9
Age (mean±2SD)	41.8±15.1 (months)	38.0±9.3 (months)
Social Quotient		
Below 70	30 (42.3%)	0 (0%)
70 or above	41 (57.7%)	100 (100%)
CARS		
Below 28	49 (69.0%)	15/50 (100%)*
28 or above	22 (31.0%)	

*The test was administered to 15 out of 50 children.
ASD, autism spectrum disorder; CARS, Childhood Autism Rating Scale.

Table 3. Wave I-V and III-V interpeak latency values (90 dB)

	I-V		III-V	
	Left (msec)	Right (msec)	Left (msec)	Right (msec)
ASD (N=71)	4.51±0.42*	4.49±0.34*	2.01±0.28*	2.02±0.31*
Autism (N=22)	4.26±0.21	4.26±0.21	1.71±0.12	1.77±0.24
Control group (N=50)	4.34±0.29	4.31±0.35	1.82±0.33	1.86±0.27

*p<0.05.
ASD, autism spectrum disorder.

Table 2. Mean latency values of wave I, wave III, and wave V (90 dB)

	Wave I (msec)		Wave III (msec)		Wave V (msec)	
	Left	Right	Left	Right	Left	Right
ASD (N=71)	1.40±0.17	1.44±0.11	3.90±0.13	3.92±0.15	5.91±0.41*	5.94±0.39*
Autism (N=22)	1.36±0.08	1.43±0.21	3.88±0.17	3.89±0.12	5.59±0.18	5.66±0.51
Control (N=50)	1.36±0.15	1.42±0.21	3.85±0.17	3.87±0.19	5.67±0.25	5.73±0.36

*p<0.05.
ASD, autism spectrum disorder.

that early interventions have had positive effects in significantly improving social behavior, self care, and academic skills (7). It also suggests that an early diagnosis and a better understanding of the patient's condition play an important role in arranging potential interventions. ASD is also a pervasive language disorder that involves auditory and visual language. Children with ASD usually show two general types of language deficits, either Phonologic-Syntactic (production of speech sound-grammar) or Semantic-Pragmatic (meaning-communicative usage of language). It is believed that young autistic children can also possess a language disorder (5). Central auditory processing problems may underlie or interact with other difficulties such as speech-language disorder and ASD (8-10). We agree that there are a lot of clinical and neuropsycholgical similarities between ASD and CAPD. Due to the issues mentioned above, we had to clarify whether they are the same condition in the sense of being part of a wider spectrum or if they share common clinical and genetic propensities for making appropriate intervention plans.

Research on the higher-order auditory processes can be conducted by using more objective measures such as ABR, middle, and late evoked responses as well as visual scanning procedures. Many earlier studies assessed the neurolinguistic characteristics of children with autism by using neurophysiological measures, but the results obtained were contradictory (11-17). Particularly, Maziade et al. observed the prolongation of the early brain evoked response inter-peak latency, I-III in autistic probands (11); however, Wong et al. reported that children with infantile autism or autistic conditions had a significantly longer brainstem transmission time than those with normal by using ABR (18). Our study also showed a significant prolongation of the latency values of wave V, I-V, and III-V inter-peak latency values in the ASD group, even though the values of the pure autism group was not statistically significant. It is interesting to note that neuroanatomical and neuropathological studies on autism reported hypoplasia of some brainstem nuclei, reduction in Purkinje cells, hypoplasia of the cerebellar vermis, neuronal immaturity, increased cell packing density in the amygdala and hippocampus (19-21). Considering the fact that ABR informs us regarding the processing of acoustic stimuli, particularly in brainstem, these findings provide clinical evidence of brainstem abnormalities and suggest that the brainstem may be partly responsible for deviant language, cognitive, and social development in children with ASD. We believe that children with ASD possess a dysfunctioning or an immature central auditory nervous system that includes the brainstem.

We also believe that ASD and CAPD, for the most part, are the same condition in the sense that they share common clinical and genetic propensities. In addition, children with ASD in our study seem to have left ear advantage because mean latency values of wave I, III, and V of the left ear were shorter than those of the right, even though this was not statistically significant (Table 2). Earlier studies using ABR reported that children with CAPD exhibited poor ABR morphology during binaural stimulation (22, 23); however, we could not find similar results in either ASD or control groups.

Since ABR allows us to assess the processing of acoustic stimuli at the preconcious level prior to language and it may be an important prognostic indicator, any children with prolonged wave V, I-V, and III-V inter-peak latency values, especially high functioning children, should be evaluated for CAPD. Therapeutic and educational interventions should be individualized and tailored to the child's specific strengths and deficits, including their central auditory processing ability. Optimal outcomes may be achieved through the interdisciplinary efforts of parents, physicians, psychologists, educators, speech and language pathologists, social workers, and audiologists.

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