Literature Review: Newborn Hearing Screening May Predict Autism Spectrum Disorder

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Abstract

In the past few years, there has been growing evidence to support an underlying auditory brainstem pathology related to ASD. Improving our understanding of the underlying pathophysiology of ASD leads to the potential identification of novel biomarkers and the development of targeted interventions in the future. This literature review identifies literature articles that investigated the association between the results of the newborn hearing screening and the incident of ASD later in life. By critically analyzing these studies and their results, potential need for future hearing screening with higher intensity stimuli to allow more accurate predictions of ASD risk is indicated.

Key words: Autism Spectrum Disorder,
Newborn Hearing Screening, Early Diagnosis.

Literature Review

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder, that is defined as persistent deficits in social communication and social interaction across multiple contexts in addition to restricted, repetitive, patterns of behaviour, interests, or activities(1). Symptoms cause clinically significant impairments in social, occupational, or other important areas of current functioning. According to estimates by the Centers for Disease Control and Prevention, about 1 in every 54 children is identified with ASD. It is more common in males with a ratio of 4:1 male to female(2). Although most behavioural signs of ASD are noticed by the age of 18 months, diagnosis is not typically made until the child is 3-4 years of age. However, early identification and intervention are critical for improving ASD symptoms manifestation and reducing economic costs(2). Atypical responses to auditory stimuli are common in individuals with autism spectrum disorder. Multiple brain regions have been studied for clues to the pathophysiology of ASD. Neuroanatomically, ASD is known to be associated with smaller brain stem volume, grey matter reduction, and a reduction in superior olivary neurons (projected towards the lateral lemniscus)(3,4).

Newborn hearing screening is used to identify newborns with permanent hearing loss as early as possible. It is done within the first month of life. It is done using the automated otoacoustic emission (AOAE) test where a soft earpiece is placed in the baby's ear and quiet clicking sounds are played through it; the earpiece picks up the response from the inner ear and the computer analyzes the results(5). If the AOAE results are inconclusive, a second AOAE test is scheduled, or another type of hearing test called the auditory brainstem response (ABR) test is arranged. The ARB test should always be considered due to its non-invasiveness and reliability in measuring neuronal abnormalities(5).

The ABR test involves placing 3 small sensors on the baby's head and neck. Soft headphones are placed over the baby's ears and gentle clicking sounds are played. This test takes between 5 and 15 minutes and it measures the auditory evoked potential extracted from ongoing electrical activity in the brain elicited by the basilar region of the cochlea. When interpreting the ARB results, the number of neurons firing (amplitude), speed of transmission (latency), the time between peaks (interpeak latency), and the difference in wave V latency between the 2 ears (interaural latency) are measured(6). The ARB produces measurements of 5 waves of electrical activity within the brainstem; the first wave occurs in the auditory nerve while the fifth wave occurs in the lateral lemniscus (in the brainstem)(7).

In the Department of Psychiatry and Behavioural Sciences at Duce Center for Autism, researchers have been able to recognize the importance of advanced and improved ASD detection and diagnoses. They suggest that digital assessments can demonstrate more accurate and early autism detection. In one study, a device was programmed to detect a child's response to hearing their name being called. In the study, 104 16-31 months-old children participated; 22 of them were diagnosed with ASD and 82 had typical development. Children diagnosed with ASD were more likely to have a prolonged latency to orient themselves, especially when a movie was playing in the background. Only 8% of them oriented to name calling on the first attempt, in comparison to 63% of the toddlers in the other group(8).

In a study conducted in 1991, brainstem auditory evoked potentials in 109 children with infantile autism, 38 children with autistic condition, 19 children with mental retardation, and 20 normal children; brainstem transmission time was found to be significantly longer in children with infantile autism and those with an autistic condition. This investigation predicted a correlational relationship between the autistic characteristics in those children with abnormally functioning brainstem. This led to the understanding that abnormal language, cognition, and social development in autism spectrum disorder are accounted for by the neurological damage of the brainstem(9).

Furthermore, in an investigation at the Speech and Hearing Center at Sheba Medical Center in Israel, clinical assessments, as well as ARB results of a group of 26 children with ASD with a mean age of 32.5 months and a group of 26 children with language delays with a mean age of 30.3 months were analyzed. The comparison between the two groups revealed significantly prolonged absolute latencies and interpeak latencies in both groups, but more-so in the ASD group. For example, 13 of the 26 participants in the ASD group showed significant prolongation in absolute latencies of two or more of the ARB waves in at least one ear. However, only 2 of the 26 participants with a language delay showed a similar pattern. This study provides evidence for pathology in the brainstem in children with language delays and more significantly, in children diagnosed with ASD(10).

The neural encoding of both verbal and non-verbal stimuli in individuals with ASD was analyzed using brainstem auditory evoked potentials to allow for measured sound conduction via the central auditory pathways. Click and speech stimuli in both the ASD group and typical development groups were used to measure neural encoding. Click stimuli resulted in no significant results in absolute wave latency between both groups. However, the higher interpeak intervals of waves III-V were observed in the ASD group. Regarding BAEPs elicited by speech stimuli, the ASD group showed shorter wave V resulting in a statistically significant difference between the two group's absolute latencies(11). This is also proved by a similar study which suggested that approximately 20% of ASD children exhibit abnormal neural encoding in the brainstem. In this study, the difference in results between speech stimuli and click stimuli was attributed to the complexity of language(12).

An analytical case-control study looked at 2-6-year-old children diagnosed with ASD and compared them to children with a language delay not associated with other pathological conditions. Statistically, a significant difference was found between the two groups: children with ASD showed abnormally prolonged ARB amplitude. Higher amplitudes of wave I than wave V were seen in the ASD group more frequently than in the control group (35% vs 10% respectively)(13). When 139,154 (including 321 infants later diagnosed with ASD) newborns' ARB data was extracted from the Universal Newborn Hearing Screening, significant prolongations of the ARB phase and latency were noticed in the ASD newborns compared to the non-ASD newborns(7). A similarly prolonged ARB was also identified in infants in the neonatal intensive care unit (NICU) who were later diagnosed with ASD(7).

Conclusion

Based on the studies discussed, ASD was found to be associated with longer latencies in waves III, V, I-III, and I-V. These correlations were found to be significant, but exhibit heterogeneity probably associated with several factors such as age and ARB protocol characteristics. Despite those significant findings, there is great variability in the magnitude and direction of associations across studies. However, due to insufficient behavioural symptoms before 12 months of age, ASD has been difficult to differentiate. Nevertheless, the study of biomarkers may provide evidence before ASD symptoms emerge. The early diagnosis of ASD can dramatically influence developmental outcomes and functioning through early interventions. To date, there have been varying research studies conducted to investigate autism spectrum disorder detection in children before the common age of diagnosis (3-4 years) through measuring auditory brainstem responses. Further research to address and identify heterogeneity across ARB and ASD associations studies must be done in the future. Prospective designs to address outstanding conceptual limitations are vital to informing the etiologic and prognostic significance of ARBs in ASD early diagnosis.

References

1.   American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. Arlington, VA: American Psychiatric Association, 2013.

2.   National Center on Birth Defects and Developmental Disabilities, Centers for Disease Control and Prevention. 2020. Retrieved from https://www.cdc.gov/ncbddd/autism/data.html

3.   Hashimoto T, Tayama M, Murakawa K, Yoshimoto T, Miyazaki M, Harada M, Kuroda Y. Development of the brainstem and cerebellum in autistic patients. J Autism Dev Disord. 1995; 25(1):1–18.

4.   Rodier PM. Converging evidence for brain stem injury in autism. Dev Psychopathol. 2002; 14(3):537–557.

5.   Akinpelu OV, Peleva E, Funnell WR, Daniel SJ. Otoacoustic emissions in newborn hearing screening: a systematic review of the effects of different protocols on test outcomes. Int J Pediatr Otorhinolaryngol. 2014;78(5):711-7.

6.   Burkard, R. F., Eggermont, J. J., & Don, M. Auditory Evoked Potentials: Basic Principles and Clinical Application. Philadelphia, Lippincott Williams & Wilkins; 2007.

7.   Miron O, Beam AL, Kohane IS. Auditory brainstem response in infants and children with autism spectrum disorder: A meta-analysis of wave V. Autism Res. 2018;11(2):355-363. doi:10.1002/aur.1886

8.   Campbell K, Carpenter KL, Hashemi J, et al. Computer vision analysis captures atypical attention in toddlers with autism. Autism. 2019;23(3):619-628. doi:10.1177/1362361318766247

9.   Wong V, Wong SN. Brainstem auditory evoked potential study in children with autistic disorder. J Autism Dev Disord. 1991; 21(3):329-40.

10.   Roth, DE., Muchnik, C., Shabtai, E., Hildersheimer, M. and Henkin, Y. (2012). Evidence for atypical auditory brainstem responses in young children with suspected autism spectrum disorders. Developmental Medicine & Child Neurology, 54: 23-29.

11.   Kamita MK, Fagundes-Silva LA, Magliaro FC, Kawai RY, Fernandes FD, Matas, CG. Brainstem auditory evoked potentials in children with autism spectrum disorder. Jornal de Pediatria. 2020; 96(3), 386-392, ISSN 0021-7557.

12.   Russo NM, Skoe E, Trommer B, Nicol T, Zecker S, Bradlow A, Kraus N. Deficient brainstem encoding of pitch in children with Autism Spectrum Disorders. Clinical Neurophysiology. 2008; 119(8), 1720-1731. ISSN 1388-2457.

13.   Santos, M., Marques, C., Nóbrega Pinto, A., Fernandes, R., Coutinho, M.B. and Almeida e Sousa, C. (2017), Autism spectrum disorders and the amplitude of auditory brainstem response wave I. Autism Research, 10: 1300-1305.