International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Adenoid Hypertrophy Effects on Latencies of Auditory Brainstem Response (ABR) in Children

Jay Prakash Singh[1], Dr. K M Tiwari[2]

[1]Audiologist & Speech Therapist, ENT Department, Heritage Institute of Medical Sciences, Varanasi, Uttar Pradesh State. Pin Code- 221311.
Corresponding Author Email: *jpsinghaudiologist27[at]gmail.com*

[2]Assistant Professor, ENT Department, Heritage Institute of Medical Sciences, Varanasi, Uttar Pradesh State. Pin Code- 221311
Email: *dreambigkundan[at]gmail.com*

Abstract: ***Background: Adenoid tissue constitutes a key element of the primary immune defense mechanism of thes upper aero-digestive tract. It is located in the postero-superior wall of the nasopharynx behind the choana. Materials and methods: Total numbers of children were 108 with age range from 3 to 7 years (mean age 5.4 years). Of them, 81 males and 27 females. ABR were measured for the click-evoked response, the stimuli were presented 2000 sweeps at 90dB. ABR was obtained with alternatively rarefraction and condensation polarity. Results: The results indicated that the group of children having grade III and IV of adenoid hypertrophy had significant prolonged waves III and V, interwave latencies I-III & I-V and inter ear latency difference, where as in grade I & II there were not significant prolongations of wave recorded. Conclusion: The significant prolongation of absolute and interwave latencies in higher grades suggests that children with severe adenoid hypertrophy may be at risk for subclinical auditory processing delays, even in the absence of overt sensorineural hearing loss.***

Keywords: Adenoid hypertrophy, Latency, ABR, Prolongation, Adenoid size, Hearing loss.

1. Introduction

Adenoid tissue constitutes a key element of the primary immune defense mechanism of thes upper aero-digestive tract. It is located in the postero-superior wall of the nasopharynx behind the choana. In conjunction with the faucial and lingual tonsils, the adenoids make up the structure known as Waldeyer's ring, a collection of mucosal-associated lymphoid tissue situated at the entrance of the upper aerodigestive tract. Blood supply to the adenoids includes the ascending pharyngeal artery, with some contributions from the internal maxillary and facial arteries. The glosspharyngeal and vagus nerves provide sensory innervations to the adenoids. Adenoid size tends to increase during childhood, usually reaching by age 6 or 7 before regressing by adolescence [1].

In children, the prevalence has been estimated at 34.5%. Although this condition is generally self-resolving due to age-related adenoid atrophy, it can lead to significant complications. Adenoid hypertrophy can occur because of infectious and non-infectious etiologies. Infectious causes of adenoid hypertrophy include both viral and bacterial pathogens. Viral pathogens associated with adenoid hypertrophy include adenovirus, coronavirus, coxsackievirus, cytomegalovirus (CMV), Epstein-Barr virus (EBV), herpes simplex virus, parainfluenza and rhinovirus [2, 3].

The most common type of hearing impairment in childhood is transient conductive hearing loss due to middle ear effusion (Zahnert, 2011) [4]. Otitis media with effusion (OME) is the presence of fluid in the middle ear without signs or symptoms of acute ear infection (Schilder et al.,2016) [5]. Adenoid hypertrophy can cause recurrent acute otitis media in addition to OME as a result of Eustachian tube dysfunction and primary infection focus (Durgut & Dikici, 2019) [6]. The enlarged adenoid obstructs the Eustachian tube opening (Torus Tubaris) in the nasopharynx due to which ventilation of air to the middle ear gets affected. This may lead to Otitis Media with Effusion (OME) and thus conductive hearing loss (CHL) [7]. Children with chronic OME may develop structural changes of the tympanic membrane, hearing loss, and speech and language delay.

Untreated persistent middle ear effusion would place the child at high risk for sound through the middle ear, which could interfere with subsequent speech and language progress (Rosenfeld et al, 2022) [8].

Adenoid enlargement can be classified into four grades based on the extent of obstruction it causes in the posterior choana: Grade I indicate tissue obstruction up to 25%, Grade II indicates obstruction from 26 to 50%, Grade III indicates obstruction from 51 to 75%, and Grade IV indicates obstruction from 76 to 100% [9].

Several past research have shown increased absolute latency and interwave latencies although the peaks are inconsistent among the studies in children with early onset OME [10,11]. Auditory brainstem response (ABR), or brainstem auditory Evoked Potentials (BAEP), is an objective measurement of auditory pathway function from the auditory nerve to mesencephalon. Auditory Brainstem Response tests synchronous neural function and can estimate hearing sensitivity thresholds in individuals unable to tolerate traditional behavioral audiometry. ABR is critical to diagnose hearing loss in newborns and young children. The time interval between the stimulus onset and the peak of the waveform is referred as latency of response. Absolute latency and interwave latencies (I-III, III-V and I-V) of ABR waveforms are the most reliable and robust characteristics and provides the core of the ABR interpretation.

ABR is widely used for hearing threshold estimation in newborns and young children. However, literature addressing the influence of adenoid hypertrophy on ABR findings remains limited, especially in pediatric populations. Consequently, this study seeks to evaluate the effects of adenoid hypertrophy on ABR latencies to aid in improved diagnosis and treatment of planning.

Objective:
The aim of this study was to examine the effects of adenoid hypertrophy on latencies of ABR in children.

2. Materials & Methods

Patients
The study period was between August 2023 to October 2025. The study was approved by ENT department as well by Heritage Institute of Medical Sciences, Varanasi, Uttar Pradesh, India. Informed consent from parents or caregivers obtained before procedure. Total numbers of children were 108 with age range from 3 to 7 years (mean age 5.4 years). Of them, 81 males and 27 females. Children presented to ENT OPD with complained of presence of snoring, mouth breathing or difficulty in breathing during sleep, obstructive breathing or apnea during sleep (symptoms of upper airway obstruction, UAO) and there was parental or self suspicions of hearing impairment were selected. All participants who were diagnosed with adenoid hypertrophy by the ENT using nasopharyngoscopy or lateral head and neck x-ray were included in the study. The children with craniofacial anomalies, sinonasal infection, nasal septum deviation and tympanic membrane perforation were not considered in this study. Also children who had history of adenoidectomy and myryongotomy not included in the study.

Each patient was evaluated in terms of general, systemic and ENT examinations. Wax was removed carefully if any, the status of middle ear was examined under the otoscopy and tympanometry in order to assess the middle ear function.

AC-ABR

Participants preparation, stimulus and recording parameters
The ABR evaluation was conducted in a quiet examination room. ABR testing for children were performed when the child was asleep. Patients were kept awake and sleep-deprived until the start of the procedure to minimize the time of sleep. Sedation or general anesthesia was given for patients who cannot maintain sufficient sleep duration for accurate results. Patient relaxation is key to reduce muscle and movement artifacts. Detailed patient history was taken before conscious sedation, including medical illness, medications, drug allergies, and adverse drug reactions. Oral intake was stopped 8 hours before sedation. Before placement of the surface electrodes, the audiologists cleaned the surface of skin with Nuprep gel and then placing a conductive electrode gel on the skin and electrode. The electrodes were attached with tape to ensure correct positioning of electrodes during the test. Patients were tested in supine position on couch. The electrode placement for two-channel recording was based on the International 10-20 system, which is the most commonly used system. In this system, the vertex electrode position is Cz, left ear is A1, the right ear is A2, and the forehead is Fpz with a contact impedance of <5kΩ for all electrodes, and fairly equal impedance within about 2kΩ, which efficiently minimizes ambient interference. Electroencephalographic activity was recorded for each ear with the same placement of electrodes.

Click stimulus was used to elicit the response. A RMS Medulla 201 ABR system was used to record the elicited responses. Silicon wired gold plated cup electrodes was used during ABR testing. A click is a brief square wave with broad spectral content. In this study ABR were measured using standard TDH earphones encased in MEDUL 1907003 circumaural cushions. For the click-evoked response, the stimuli were presented 2000 sweeps at 90dBnHL (normal hearing level) at a rate of 19.1 per second. Filter setting were 30 Hz on the low-frequency end (high-pass setting) and 3,000 Hz on the high-frequency end (low-pass setting) with an analysis window of 12 ms. Stimulus intensity was caliberated in dBnHL; amplitude and stimulus rate were calibrated using a dual trace oscilloscope (Hewlett Packard, Palo Alto, CA, USA) at the beginning and end of each test session. Two channel recording was done to measure the responses. This allowed for a comparison of the response recorded in each channel to determine the responsive ear. The sampling rate was 40,000 Hz and responses was an online band passed filtered, waveforms were averaged online. The recording window was 1.5 ms starting after the stimulus onset. In this study, ABR was obtained with alternatively rarefraction and condensation polarity.

3. Results

Statistical Analysis
All statistical analyses were performed using SPSS software. Continuous variables were expressed as mean ± standard deviation (SD).

Comparison of absolute latencies, interwave latencies, and inter-ear latency differences across the four grades of adenoid hypertrophy were performed using one-way analysis of variance (ANOVA).

A p value <0.05 was considered statistically significant.

Table I, shows the sex-wise and grade-wise distribution of adenoid hypertrophy among the study population comprising 108 children. Of them, total participants, 81 (75%) were males and 27 (25%) were females, indicating major proportion of participants having adenoid hypertrophy were males.

Table I: Sex & Grade-wise distribution of patients (n=108)

Grade of Adenoid Hypertrophy	Male	Female
Grade I	10	4
Grade II	17	6
Grade III	28	10
Grade IV	26	7
Total	81	27

For Wave I, mean latency increased from 1.56 ± 0.08 ms in Grade I to 1.71 ± 0.12 ms in Grade IV. This difference across grades was statistically significant (p = 0.018).

Similarly, Wave III latency increased from 3.60 ± 0.11 ms in Grade I to 3.89 ± 0.18 ms in Grade IV, showing a statistically significant difference (p = 0.006).

The most pronounced prolongation was observed for Wave V, with mean latency increasing from 5.50 ± 0.14 ms in Grade I to 5.95 ± 0.23 ms in Grade IV. This difference was highly statistically significant (p < 0.0001).

These findings indicate a clear association between increasing adenoid hypertrophy grade and prolongation of absolute ABR latencies, particularly for Wave V.

Table II, shows absolute latencies of patients. Absolute latencies of wave I, III & V were compared across adenoid hypertrophy grades (I-V).

Table II: Grade-wise comparison of absolute ABR latencies (ms)

Grade of Adenoid Hypertrophy	Wave I (mean±SD)	Wave III (mean±SD)	Wave V (mean±SD)
Grade I	1.56±0.08	3.60±0.11	5.50±0.14
Grade II	1.60±0.09	3.68±0.13	5.62±0.17
Grade III	1.65±0.11	3.78±0.15	5.80±0.20
Grade IV	1.71±0.12	3.89±0.18	5.95±0.23
$p-value$	0.018	0.006	<0.0001

Table III, shows interwave latencies of patients. Interwave latencies were analyzed gradewise.

The Wave I–III interwave latency increased from 2.04 ± 0.09 ms in Grade I to 2.18 ± 0.15 ms in Grade IV, with the difference being statistically significant (p = 0.024).

Similarly, Wave III–V interwave latency showed a significant increase from 1.90 ± 0.10 ms in Grade I to 2.06 ± 0.15 ms in Grade IV (p = 0.019).

The Wave I–V interwave latency demonstrated the greatest prolongation, increasing from 3.94 ± 0.13 ms in Grade I to 4.24 ± 0.21 ms in Grade IV, with strong statistical significance (p < 0.001).

Among the interwave measures, I–V interwave latency showed the strongest association with adenoid hypertrophy severity.

Table III: Grade-wise comparison of interwave latencies (ms)

Grade of Adenoid Hypertrophy	Wave I-III (mean±SD)	Wave III-V (mean±SD)	Wave I- V (mean±SD)
Grade I	2.04±0.09	1.90±0.10	3.94±0.13
Grade II	2.08±0.11	1.94±0.11	4.02±0.15
Grade III	2.08±0.13	2.01±0.13	4.14±0.18
Grade IV	2.18±0.15	2.06±0.15	4.24±0.21
$p-value$	0.024	0.019	<0.001

Table IV, shows inter ear latency differences of patients. Inter-ear latency differences (ILDs) of ABR waves I, III and V were compared across the four grades of adenoid hypertrophy.

For Wave I, ILDs increased from 0.18 ± 0.07 ms in Grade I to 0.33 ± 0.12 ms in Grade IV, with a statistically significant difference across grades (p = 0.041).

For Wave III, ILDs increased from 0.21 ± 0.08 ms in Grade I to 0.39 ± 0.14 ms in Grade IV (p = 0.018).

The greatest increase was observed for Wave V, where ILDs increased from 0.24 ± 0.09 ms in Grade I to 0.51 ± 0.16 ms in Grade IV, demonstrating high statistical significance (p < 0.001).

These results indicate increasing asymmetry in auditory brainstem conduction with increasing severity of adenoid hypertrophy.

Table IV: Grade-wise comparison of inter-ear latency (ms)

Grade of Adenoid Hypertrophy	Wave I (mean±SD)	Wave III (mean±SD)	Wave V (mean±SD)
Grade I	0.18±0.07	0.21±0.08	0.24±0.09
Grade II	0.22±0.09	0.26±0.10	0.31±0.11
Grade III	0.29±0.11	0.34±0.12	0.42±0.14
Grade IV	0.33±0.12	0.39±0.14	0.51±0.16
$p-value$	0.041	0.018	<0.001

The results indicated that the group of children having grade III and IV of adenoid hypertrophy had significant prolonged waves III and V, interwave latencies I-III & I-V and inter ear latency difference, where as in grade I & II there were not significant prolongations of wave recorded. However, in this study some of the cases for grade III and IV also did not show latency prolongation. Similarly, few of the studies also quoted in the past; there were no significant latency prolongation even in grade III and IV adenoid hypertrophy patient in children.

4. Discussion

Adenoid hypertrophy is a well-recognized cause of upper airway obstruction and middle ear dysfunction in children. Its influence on auditory function, particularly on neural synchrony assessed by auditory brainstem response (ABR), has been documented in several studies over the past few decades.

Of the three studies that reported absolute latency and interwave latencies, showed a statistically significant differences in absolute latency I, V and interwave I to III latencies, which is prolonged in children with history of OME when compared to control group [12-14].

In the present study, a progressive and statistically significant prolongation of absolute latencies of Waves I, III, and V was observed with increasing grades of adenoid hypertrophy. The most marked change was noted in Wave V latency, which demonstrated the strongest statistical significance.

Wave I reflects activity of the distal portion of the auditory nerve, whereas Waves III and V represent neural transmission through the lower and upper brainstem, respectively. Prolongation of Wave I latency in higher grades of adenoid hypertrophy suggests the presence of a

conductive component, most likely resulting from Eustachian tube dysfunction and middle ear effusion, which are common sequelae of adenoid enlargement.

Jerger and Mauldin (1979) emphasized that conductive pathologies lead to systematic prolongation of absolute ABR latencies without significant alteration in waveform morphology [15]. Similarly, Hall and Grose (1993) demonstrated that children with conductive hearing impairment show delayed Wave I latency due to reduced stimulus intensity reaching the cochlea [16].

The observed prolongation of Waves III and V in the present study is consistent with findings reported by Hall and Grose (1993) also found increases in the I-III and I-V interwave intervals and significant delays in the absolute latencies of waves III and V [16]. These authors suggested that chronic conductive hearing loss may indirectly influence central auditory pathway timing, possibly due to reduced auditory stimulation during critical developmental periods.

Prolonged interwave latencies reflect delayed neural conduction within the auditory brainstem pathways. These findings suggest that long-standing middle ear pathology associated with severe adenoid hypertrophy may lead to functional alterations in central auditory processing, even in the absence of permanent sensorineural hearing loss.

Supporting these findings, Anteby I et al. (1986) found in their study, significant increases of interwave latency differences betweenVand III as well as V to I in children with middle ear effusion and concluded that prolonged conductive pathology can have measurable effects on central auditory function [17].

The present study also demonstrated a significant increase in inter-ear latency differences (ILDs) for ABR Waves I, III, and V with increasing grades of adenoid hypertrophy. This finding suggests increased binaural asymmetry, likely attributable to asymmetric middle ear involvement or fluctuating conductive pathology between ears.

Such inter-ear differences further indicate compromised auditory pathway synchrony, which may adversely affect binaural hearing abilities, including sound localization and speech perception in noise.

A comparable relationship has been reported in previous studies, which found that children with severe adenoid hypertrophy exhibited significantly prolonged ABR latencies when compared to children with mild or moderate enlargement. These findings reinforce the concept that both the severity and chronicity of nasopharyngeal obstruction play a critical role in determining auditory outcomes.

5. Conclusion

The present findings highlight the usefulness of click-evoked ABR as an objective tool for evaluating auditory pathway integrity in children with adenoid hypertrophy. The significant prolongation of absolute and interwave latencies in higher grades suggests that children with severe adenoid hypertrophy may be at risk for subclinical auditory processing delays, even in the absence of overt sensorineural hearing loss.

Findings from past and present study have emphasized the importance of early identification and management of adenoid-related middle ear disease to prevent long-term auditory and speech–language consequences.

Acknowledgement
We authors thank chairman, vice chairman and management of HIMS, VARANASI for allowing us to conduct this study.

Funding
Nil.

Conflict of Interest
Nil

Compliance And Ethical Standards

Ethical Approval
The permission was taken from Institutional Ethics Committee prior to starting the project. All procedures performed in studies involving human participant were in accordance with the ethical standards of the institution and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent
Informed consent was obtained from all individual participants included in the study.

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