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Comparison of auditory event-related potentials between children with benign childhood epilepsy with centrotemporal spikes and children with temporal lobe epilepsy

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ABSTRACT

The abnormal brain discharges observed in benign childhood epilepsy with centrotemporal spikes (BECTS) and temporal lobe epilepsy (TLE) are located close to areas responsible for auditory and language processing. This study aimed to analyze the results of auditory event-related potentials (P300) in children with BECTS and TLE in order to assess whether the epileptic activity in centrotemporal and temporal regions may compromise the integrity and physiology of auditory system structures. This was a prospective, comparative, and cross-sectional study. Group I (GI) consisted of 13 children diagnosed with BECTS, group II (GII), 7 children diagnosed with TLE, and control group (GIII), 16 healthy children, with no hearing or academic complaints. After neurological and basic audiological assessments, P300 was applied. The P300 latency and amplitude were compared between groups. Regarding latency, GI showed 324.1 (+31.5) ms, GII 336.3 (+23.5) ms, and GIII 318 (+27.7) ms. Amplitudes were 4.80 (+3.2) μV in GI, 4.7 (+2.5) μV in GII, and 5.8 (+2.4) μV in GIII. Although children with BECTS showed prolonged latencies and reduced amplitudes, these differences were not considered statistically significant. Children with TLE showed statistically significant prolonged P300 latency compared with the control group ($P = 0.037$). We speculate that abnormal electrical discharges in centrotemporal and temporal regions led to the slowing of auditory processing in our sample.

1. Introduction

Anatomical and functional integrity of the auditory pathways, from peripheral to central structures, is essential for proper processing of auditory stimuli and a satisfactory development of language, speech, and learning [1].

Neurological disorders, such as epilepsy, are one of the possible causes of central auditory disorders. Benign childhood epilepsy with centrotemporal spikes (BECTS) and temporal lobe epilepsy (TLE) are two of the most common forms of epilepsy reported in the literature [2–4].

Benign childhood epilepsy with centrotemporal spikes (BECTS) is an electroclinical syndrome characterized as focal, genetically determined, and age-related [5]. There are no visible anatomic lesions, and spontaneous seizure remission usually occurs before adulthood. It usually affects children from 3 to 13 years, with genetic predisposition and male predominance. The diagnosis is made by the association of clinical and electroencephalogram (EEG) findings, which show normal background activity with high voltage sharp waves in the centrotemporal (rolandic) region, followed by slow waves activated by sleep [6].

Temporal lobe epilepsy in children differs from the relatively homogeneous characteristics observed in adults and shows many clinical and electroencephalographic features [7,8]. In childhood, seizure semiology varies with age, and EEG pattern may be less clear. However, in children over 6 years old, the semiology of seizures is very similar to that of adults [7]. In adults, TLE is characterized by focal seizures that can occur within a single clinical event or evolve to secondarily generalized seizures. On EEG, interictal period shows no abnormality or mild to severe background activity asymmetry in temporal regions. Spike and/or slow temporal waves, uni- or bilateral, synchronous or asynchronous, can be seen. Also, these findings are not always located only in the temporal region [6,9].

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Recent studies have reported language, learning, and cognitive deficits in children with BECTS and TLE [10–14]. There are also reports of difficulties in the processing of speech sounds in noisy environments, despite normal hearing thresholds [15]. Auditory processing disorder is a risk factor for language impairments and decreased academic performance, and therefore, it may be related to the deficits experienced by these children [16].

Event-related potentials (ERP) are considered a clinically relevant tool for assessing cognitive function in patients with neurological disorders, including epilepsy [17–19]. Auditory ERP assessment is based on the measurement of neuroelectric activity at each site of the auditory pathway and provides precise observation of auditory processing in time, mostly reflecting the activity of thalamus and cerebral cortex, structures involved in discrimination, integration, and attention functions [20,21].

The P300 is the most-used long latency endogenous potential in clinical practice, and it represents a neurophysiological index of attention-dependent auditory processing [2]. This potential is related to the time that a subject takes to process a given stimulus (understand, evaluate, discriminate, activate selective attention and working memory, and then take a decision) [22,23]. Its component sequence reflects the course of auditory processing activity in milliseconds (ms). The P300 latency is directly related to the speed of information processing [24]. The P300 amplitude, on the other hand, indicates the extent of resources allocated to perform specific neural cognitive processes, meaning that it reflects the number of fibers activated in the task [23].

The P300 provides information about the neurophysiological substrate associated with cognitive processes, such as memory, attention, auditory discrimination, sequential information processing, and decision taking, all necessary for auditory processing [21,25,26]. The P300 waveform does not depend on the physical characteristics of the sensory input, but it is influenced by the cognitive activity performed [18].

The topography of spikes in BECTS and TLE, with epileptic activity in centrotemporoparietal, perisylvian, temporoparietal, and temporal regions, suggests that they may originate near auditory and language cortices. Electrical discharges are close to the final point of the auditory pathway in both types of epilepsy [17,27,28]. However, the mechanisms in which they can affect hearing function still remain to be explored.

Therefore, this study aimed to analyze the results of P300 in children with benign childhood epilepsy with centrotemporal spikes (BECTS) and temporal lobe epilepsy (TLE) in order to provide evidence that structural or electrical abnormalities in the centrotemporal and temporal regions may impair the integrity and physiology of auditory system structures.

2. Material and methods

This was a prospective, cross-sectional study conducted at the Laboratory of Audiology from the Center of Studies and Researches in Rehabilitation (CEPRE) and the Neuroepilepsy Ambulatory Unit/University Hospital, both from the State University of Campinas (UNICAMP/Brazil), in partnership with the Department of Physical Therapy, Speech Pathology and Occupational Therapy of the University of São Paulo (USP). This study was approved by the Ethics in Research Committee (protocol number 354/2010). Written informed consent was obtained for all participants.

We evaluated 36 children, divided into three groups: group I (GI): 13 children with benign epilepsy with centrotemporal spikes, group II (GII): 7 children with temporal lobe epilepsy, and control group (GIII): 16 children with no hearing or learning complaints, no history of epilepsy or other diseases involving the central nervous system (CNS), and no history of abnormalities in language and learning development.

Children from GI and GII underwent clinical neurological examination, conducted by a neurologist, intelligence quotient assessment (IQ) by the Wechsler intelligence scale for children (WISC III) [29], and magnetic resonance imaging (MRI), performed with a 2.0-T scanner (Elscint Prestige) and interpreted by an expert in the area. The BECTS and TLE characteristics were determined according to the International League Against Epilepsy Classification [5], and diagnoses were based on the combination of clinical symptoms, EEG findings, and structural imaging data.

Inclusion criteria for GI and GII were: normal neurological examination, IQ ≥ 80, and normal hearing as assessed by a basic audiological evaluation (normal findings on otoscopy exam, pure tone thresholds ≤15 dBHL, and type A tympanogram in both ears) [30,31]. Group I participants showed normal MRI, and GII children were included regardless of MRI results. These criteria were defined in order to avoid the influence of peripheral hearing disorders or cognitive impairments on auditory electrophysiological testing.

The control group was composed of children from public elementary schools selected by means of a questionnaire answered by their teachers. Inclusion criteria were: no history of epilepsy or other neurological or developmental impairments, no history of otologic diseases or hearing complaints, no academic difficulties, no use of medications, and normal results in the basic audiological evaluation.

2.1. Procedures

Information regarding hearing complaints; otologic problems; global, language, and speech development; academic performance; and history of diseases was collected by a clinical interview carried out with parents.

After this interview and the basic audiological assessment, P300 recording was conducted using the Eclipse EP25 (Interacoustics). Surface electrodes were positioned according to the International 10–20 [32], after cleansing the skin with alcohol, using abrasive paste and then applying of conductive gel. Impedance between electrodes was kept <5 kΩ, according to recommendation of the equipment manufacturer. Auditory stimuli were presented monaurally through insert earphones. The assessment was performed in a sound-attenuated and electrically shielded room, with low light, while children remained seated on a comfortable reclining chair. Children were instructed to keep their eyes closed and to avoid body movements, especially from face and neck regions.

The P300 was obtained through the auditory oddball paradigm, which is based on the identification and discrimination of a rare stimulus (target) presented randomly and less frequently in a series of frequent stimuli (nontarget). A sequence of 300 tone bursts at 75 dBHL was presented, at a rate of 1.1/s, and a bandpass filter of 0.83–33 Hz was used. Target stimulus was a 2000-Hz tone burst presented at a rate of 20% and mixed with the nontarget stimulus, a 1000-Hz tone which corresponded to 80% of the presentations. Children were instructed to mentally count the target stimulus. Reference electrodes were placed on the mastoids (M1 and M2), an active electrode at Fz, and a ground electrode at FPz. An analysis window of 750 ms was used. The presence, latency, and amplitude of P300 wave were measured.

Prior to the recording, a demonstration phase was conducted in order to guarantee that the child understood the task. After the demonstration, the test was started. Children were asked to report the number of rare stimuli at the end of testing for each ear separately. The reported number was compared with the total number of rare stimuli presented by the equipment, to ensure that the child performed the task properly and kept attention on the infrequent stimuli.

Separate averaged evoked potential waveforms were obtained for the rare and frequent tones. The P300 wave was identified as the largest positive peak, ranging from 225 to 396 ms, after the N1, P2, and N2 waves. The P300 amplitude was obtained from the difference in microvolts from positive to negative peaks. Both latencies and amplitudes were compared with those observed in control patients. Two different examiners analyzed the responses separately to avoid errors in the identification of the waves and therefore increase the accuracy of the results.

Homogeneity of groups regarding age and gender was evaluated by means of ANOVA and the equality of two proportion tests, respectively.