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Frequency-specific auditory brainstem response testing with age-appropriate sedation

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ABSTRACT

Objective: Auditory brainstem response (ABR) testing is the gold-standard procedure for hearing evaluation in pediatric patients who cannot complete a behavioral hearing test. The amount of audiological information obtained depends on the quality of the patient's sleep during the test. In this retrospective database review, we aimed to assess the amount and the characteristics of the audiological information obtained in ABR testing in pediatric patients with age-appropriate sedation.

Methods: A retrospective chart review was conducted on 501 consecutive ABR sedation sessions performed between January 2014 and June 2016 at the Tel Aviv Medical Center. Oral triclofos was used for the sedation of younger patients (3–24 months) and intravenous propofol for older patients (> 24 months). The dataset included 370 triclofos sessions (in 337 patients) and 131 propofol sessions (in 126 patients).

Results: None of the children developed complications, and all were discharged on the same day of the evaluation. Among the hearing-impaired children, a mean of 10 (1.8 SD) ABR threshold measurements was obtained from propofol-sedated patients and 9.4 (2.8 SD) measurements from those sedated with triclofos ($P = 0.039$). The major characteristics of the hearing loss, including its degree, type, and configuration, were obtained from all propofol-sedated patients and from 95% of those sedated with triclofos.

Conclusions: A comprehensive evaluation of hearing status can be obtained in ABR testing with age-appropriate sedation. An average number of ~10 threshold measurements were obtained during ABR testing with age-appropriate sedation, thus allowing for the evaluation of the degree, type and configuration of the hearing loss.

1. Introduction

Auditory brainstem response (ABR) testing has become the gold-standard for hearing evaluation in infants and young children who cannot perform a behavioral hearing test [1]. Frequency-specific ABR testing includes measurements of hearing thresholds to several frequency-characterized stimuli. This procedure yields significantly more information than traditional testing with a click stimulus alone [2] but requires more testing time.

ABR recording is a non-painful procedure that requires sleep or deep relaxation of the patient throughout the recording time. ABR in infants younger than 3 months of age is generally agreed to be obtainable during natural sleep. However, as sleep patterns change with increasing age and day sleep is harder to achieve during a scheduled appointment, sedation is often needed for the comprehensive assessment of the hearing status in older children.

The amount of audiological information obtained during an ABR session depends on the quality of the patient's sleep. Deep, uninterrupted sleep provides a low background electroencephalographic activity that improves the signal-to-noise ratio, allowing the ABR signal, which has an extremely small amplitude (< 1 μVolt), to be more easily detected. These conditions are expected to enable a faster detection of threshold signals and, hence, to enable the collection of more audiological information at various frequencies during each session.

Previous studies have shown the feasibility of ABR testing with a wide variety of sedation regimens, including oral chloral hydrate [3–8], intravenous propofol [9], oral melatonin [10,11], intranasal dexmedetomidine [12,13], intramuscular ketamine-midazolam-atropine in combination [14], and rectal pentobarbital with oral alimemazine [15]. However, only a few reports have included data regarding the efficiency of these procedures in terms of the amount of audiological information obtained. Janssen et al. [16] reported achieving a mean of 7.8 ABR measures in hearing-impaired children sedated with chloral hydrate. In a study aimed to evaluate the gaps between ABR and

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Abbreviations

ABR	auditory brainstem response
ANSD	auditory neuropathy spectrum disorder
ASA	American Society of Anesthesiologists
CMV	cytomegalovirus
TEOAE	transient evoked otoacoustic emissions

behavioral thresholds, McCreery et al. [17] obtained a mean of 3.2 ABR threshold measures for each ear in infants who were tested during natural sleep (< 3 months) or sedated with either oral chloral hydrate or under general anesthesia.

The current study aimed to assess the amount of audiological information obtained in our ABR test sessions in pediatric patients sedated with either oral triclofos for patients aged 3–24 months or intravenous propofol for patients aged > 24 months. Furthermore, we wanted to assess the informative value of these measurements in terms of the hearing-loss characteristics that could be obtained, such as hearing-loss type, degree, and configuration. Additionally, we sought to assess the qualities of the drug-induced sleep in terms of sleep latency, sleep duration, sleep failures and, above all, sedation safety.

2. Materials and methods

A retrospective chart review was conducted on 501 consecutive ABR test sessions performed during sedation with either oral triclofos or intravenous propofol in healthy pediatric patients (ASA score I-II) between January 1, 2014 and June 30, 2016 (30 months) at the Tel Aviv Medical Center. The study was approved by the Institutional Review Board for Human Experimentation.

2.1. Sedation

All sedation sessions included in the study were performed at the Dana-Dwek Children's Hospital outpatient clinic, Tel Aviv Medical Center, in a specially equipped facility in accordance with the American Academy of Pediatrics guidelines [18,19]. The appropriate sedation for each child was decided in accordance with the prespecified age-appropriate protocol (Fig. 1). Infants younger than 3 months of corrected age were tested during natural sleep. Sedation with oral triclofos (triclofos sodium) was used in infants between 3 and 24 months, and intravenous propofol was used in older children. Prematurely born infants under the age of one year [20] and children with a severe systemic disease (ASA score III-IV according to the American Society of Anesthesiologists physical status classification system) [18,21] were not considered suitable for regular sedation and were either tested during natural sleep or admitted for sedation at the pediatric intensive care unit.

All patients were referred for otoscopic examination prior to the ABR sedation session and underwent a health evaluation at admission, prior to the procedure.

The triclofos sessions were performed by a certified sedation nurse under the supervision of a pediatrician who performed the child's physical examination and prescribed the drug. The propofol sessions were performed by a senior anesthesiologist. The vital signs of all sedation recipients were continuously monitored (including heart rate and pulse oximetry) and recorded every 10 minutes during and after the sedation until full recovery. Any complication that occurred during these sessions was reported according to a prespecified list. To use a low sedative dose, triclofos was administered orally at an initial dose of 50 mg/kg. An additional dose of 30 mg/kg was administered if sleep did not occur after 20–30 minutes or if the child awoke before the ABR recording was completed. The maximal total dose of triclofos was limited to 1000 mg. Additionally, parents of children undergoing triclofos sedation were advised to withhold their child from napping during the 3 hours prior to sedation. Propofol was administered intravenously at a dose of 0.8 mg/kg bolus, followed by continuous infusion at an initial rate of 0.1 mg/kg/min.

2.2. ABR testing

All ABR tests (Eclipse EP25, Interacoustics, Assens, Denmark) were performed by an experienced audiologist. The ABR testing procedure included a combination of click and frequency-specific tests. For the frequency-specific threshold measurements, narrow-band chirp stimuli were used [22–25]. If the air-conduction threshold estimates indicated a hearing loss (> 25 dB nHL), bone-conduction ABR testing was performed using a combination of wide-band and narrow-band chirps. Prior to the frequency-specific threshold measurements, the integrity of the neural waveform response at a high stimulus level (75–85 dB HL) was inspected. In cases of an absent ABR response, cochlear function tests were performed, including cochlear microphonics (via offline separation of the tracings by polarity) and/or transient evoked otoacoustic emissions (TEOAE) (Otoport Advance, Otodynamics, Hatfield, Hertfordshire, UK). These tests were performed to detect cochlear activity that could support the diagnosis of auditory neuropathy spectrum disorder (ANSD).

The tracings were visually inspected online by the examiner. The threshold was determined as the lowest stimulus intensity that produced a repeated response, with a clear response at 5 dB above it and no response at 5 dB below it. The determination of no response required a residual noise level lower than 40 nV in two tracings. The Fmp measures [26] were used to support the response detection but were not a mandatory criterion since Fmp measures tend to remain low at near-threshold tracings [27]. The technical specifications for the ABR recordings are indicated in Appendix A. The ABR device was routinely calibrated once a year according to the manufacturer's instructions.

2.3. Data analysis

The ABR sessions were reviewed using the hearing clinic database (Microsoft Access) and the patients' files. Each patient's registry

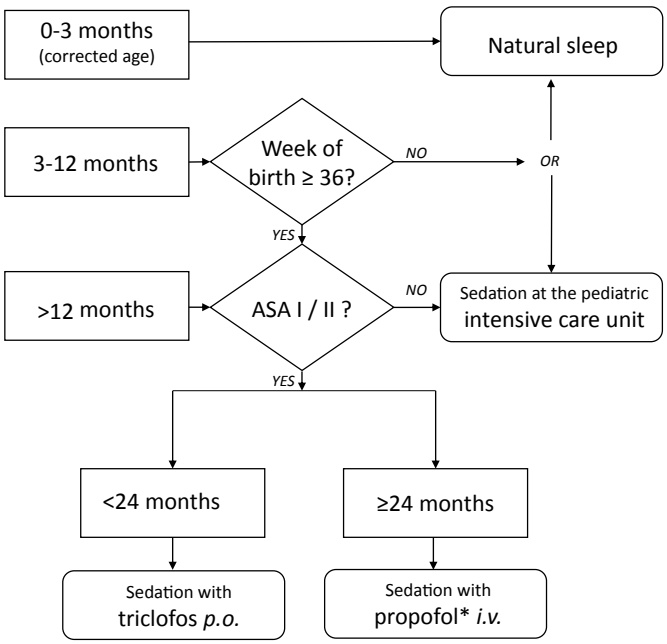

Fig. 1. The age-appropriate sedation flowchart per our protocol. *Propofol sedation was also performed in patients aged 12–24 months if earlier sedation with triclofos failed to achieve the required audiological information.