International Journal of Pediatric Otorhinolaryngology 95 (2017) 51–56

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: http://www.ijporlonline.com/

Acoustic absorbance measurements in neonates exposed to smoking during pregnancy

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ARTICLE INFO

Article history:
Received 29 November 2016
Received in revised form
30 January 2017
Accepted 31 January 2017
Available online 4 February 2017

Keywords:
Ear
Middle
Acoustic impedance tests
Infant
Newborn
Tobacco smoke pollution

ABSTRACT

Objective: To analyze acoustic absorbance using wideband tympanometry in neonates exposed to passive smoking during pregnancy.
Method: A study comprising 54 neonates in the control group (CG – unexposed) and 19 in the study group (SG – exposed) was carried out. Subjects were submitted to the wideband tympanometry test and subsequent analysis of absorbance of 17 frequencies.
Result: Low frequencies had a lower level of absorbance compared to high frequencies for both ambient and peak pressures, with no difference between the groups.
Conclusion: No effect of passive smoking on acoustic absorbance measurements in neonates was observed.

1. Introduction

Recent studies have shown that exposure to cigarette smoke during pregnancy can constitute a risk factor for hearing of the neonate, and may also lead to serious complications such as low birth weight, prematurity, placenta problems and risk of bleeding [1–5].

Neonates exposed to passive smoking have reduced cochlear physiology, evidenced by lower response levels of otoacoustic emissions (OAE), prompting the present study to ascertain whether middle-ear measurements are similarly affected. Acoustic absorbance measurement is a procedure for detecting minor changes in the middle-ear and consequent otitis media.

Absorbance measurements are performed using ambient pressure or peak pressure. In the study by Keefe and Simmons [6] (2003) comparing absorbance at peak and ambient pressures in 18 ears of individuals aged over 10 years with conductive hearing loss, absorbance at peak pressure was more accurate for clinical diagnosing conductive loss than ambient pressure, which can be useful for screening.

The prevalence of middle-ear impairments such as secretory otitis media (with effusion) in school children exposed to passive smoking was considered statistically significant in the study of Erdivanli et al. [7] (2012). In a study by Durante et al. [5] 2013, 16 children were excluded from the sample for having been exposed to cigarette smoke at home by parents, and had type B tympanometric curves at a 226 Hz probe tone.

The dearth of studies on passive smoking in the neonatal age group and the principle of new approaches in wideband tympanometry among neonates led to the hypotheses of the present study that neonate exposed to passive smoking during pregnancy have typical absorbance outcomes at peak and ambient pressures compared to the control group, for having been subject to the effects of cigarette substances on the ear canal and, more specifically, in the middle ear.

The objective of this study was to analyze acoustic absorbance using tympanometry by wideband stimuli in neonates exposed to tobacco smoke during pregnancy, according to group (study and control), frequencies (226–8000 Hz), pressure (ambient or peak) and ear (left and right).

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http://dx.doi.org/10.1016/j.ijporl.2017.01.036
0165-5876/

2. Casuistic and method

This study was approved by the Research Ethics Committee of the Irmandade da Santa Casa de Misericórdia de São Paulo hospital under protocol 771.404. All subjects took part after their legal guardians had received explanation about the study and signed the Free and Informed Consent Form.

2.1. Casuistic

The sample comprised 73 neonates recruited from the Pediatric sector of the Irmandade de Misericórdia da Santa Casa de São Paulo hospital. The participants were hospitalized in the open ward of the Institution and allocated into one of two groups according to the maternal smoking habits in the gestational period.

The Control Group (CG) comprised 54 neonates (32 females and 22 males) unexposed to passive smoking, and the Study Group (SG) comprised 19 neonates (9 females and 10 males) exposed to passive smoking by the mother during pregnancy.

The inclusion criteria for both groups were: term neonate; no indicators of hearing risk [8]; underwent test at 28 days of life or earlier; mother not in use of other drugs, such as cocaine, alcohol or other substances considered toxic; presence of transient evoked otoacoustic emissions (TEOAE) with noise signal ratio $\geq$ 6 dB for at least three frequencies.

The inclusion criterion for the study group was: mother active smoker (maternal smoking during pregnancy).

The exclusion criterion was non-completion of the full study protocol.

2.2. Equipment

A *Titan* (*Interacoustics)* device and the IMP440 C*linical* module was used, with the optional 3D wideband tests and *Wide Band Tympanometry (WBT) research* module. The module automatically extracts the values of the measurements taken and transforms them into spreadsheet data. This spreadsheet is used with Excel, allowing peak and ambient absorbance values for each subject to be analyzed. The frequencies 226 Hz, 257 Hz, 324 Hz, 408 Hz, 500 Hz, 630 Hz, 794 Hz, 1000 Hz, 1260 Hz, 1587 Hz, 2000 Hz, 2520 Hz, 3175 Hz, 4000 Hz, 5040 Hz, 6350 Hz and 8000 Hz were selected, giving a total of 17 frequencies per test ear at ambient pressure, and 17 at peak pressure. The frequencies were chosen based on the literature [9,10].

2.3. Procedures

All tests were performed with the neonate in a natural sleep state while placed within a cot alongside the mother in the rooming-in ward of the hospital during the post-partum hospital stay. After visual inspection of the external auditory canal, the most snug-fitting insert for the neonate's ear size was selected and the probe carefully introduced so as not to wake the baby. The test first was the one most conveniently positioned. Upon placement of the probe into the test ear and confirmation of the side placed (right or left ear), "Start" is clicked and the measurement automatically acquired. The acoustic absorbance measurement took an average of 10 s to perform per ear.

Data extraction was carried out using the "140331 *WBT absorbances and averaged tymp"* spreadsheet. Extraction produces an Excel spreadsheet allowing peak and ambient absorbance values by frequency to be displayed for each subject.

The Wilcoxon, Mann-Whitney, Chi-squared, Fisher and McNemar tests were employed for inferential analysis of results. The level of significance adopted in this study was 5% (p-value $\leq$ 0.005).

3. Results

The number of cigarettes smoked per day by mothers during pregnancy, ranging from 1 to 25, is shown in Fig. 1.

Wideband tympanometric analyses covered a total of 17 frequencies per ear and per pressure, i.e. 17 frequencies for ambient pressure and 17 for peak pressure were tested for the right ear. The same procedure was followed for the left ear.

The absorbance value was a real number between "zero" and "one" and can be converted into a percentage (%), i.e. a displayed value of 0.30, represents 30% absorbed energy (absorbance). "Zero" indicates all energy is reflected, whereas "one" indicates all energy is absorbed.

3.1. Analysis of acoustic absorbance of right ear at ambient pressure by frequency and group

A comparison of the groups for all frequencies is provided in Fig. 2. None of the frequencies showed a statistically significant difference ($p > 0.062$).

Greater absorption in level of responses can be seen for low frequencies for the study group compared to the control group, but the mean absorbance values for both groups are the lowest found among the 17 frequencies assessed. For medium frequencies, the study group had a higher level of absorbance than the control group up to the frequency of 2520 Hz. For acute frequencies, an inversion of values was only observed at 8000 Hz, where the control group had a greater absorbance value than that of the study group. The highest absorption levels can be seen at higher frequencies (6350 Hz and above) compared to the other frequencies assessed.

3.2. Analysis of acoustic absorbance of left ear at ambient pressure by frequency and group

Overall comparison of the 17 frequencies for the left ear at ambient pressure (Fig. 3) revealed no statistically significant difference on intergroup comparison ($p > 0.094$).

A minor difference between the groups was evident for low frequencies. For these frequencies, the absorbance response level of the study group remains similar to that of the control group up to the frequency of 630 Hz. The difference was only 0.01 for two of the frequencies analyzed. Also, for medium frequencies, the level of absorbance in the control group was close to that of the study group. However, levels for most of these frequencies exceeded 0.01 in the study group. For high frequencies, the control group had higher absorbance levels than the study group only for the highest frequency tested of 8000 Hz.

3.3. Analysis of acoustic absorbance of right ear at peak pressure by frequency and group

Comparison of absorbance values at peak pressure between groups for the 17 frequencies are given in Fig. 4. The study group had a higher absorbance value only at the frequency of 5040 Hz ($p = 0.020$). No difference was detected between the groups for the other frequencies ($p > 0.082$).

The response level for high frequencies differed more compared to low and high frequencies, as did the highest level of absorbance.

3.4. Analysis of acoustic absorbance of left ear at peak pressure by group

Comparison of mean acoustic absorbance values of the left ear for the 17 frequencies at peak pressure in the groups studied (Fig. 5) revealed no statistically significant difference for any of the