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Normative data for TM electrocochleography measures

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Abstract

Objective: Establish normative data for tympanic electrocochleography (TM ECochG) parameters in normal hearing adults without Ménière's disease's (MD) symptoms. Describe TM ECochG variables that help to distinguish normal from MD ears.
Material and methods: We enrolled 100 subjects (N = 200 ears), 59 females, aged between 19 and 71 years from 09/2010 to 04/2014. Inclusion criteria: normal otomicroscopy, hearing thresholds ≤25 dB nHL from 250 to 4000 Hz, normal tympanogram, no symptoms of MD according to the AAO-HNS 1995 criteria and Gibson's score <7. We excluded subjects with dizziness, aural fullness or other symptoms of endolymphatic hydrops. The following parameters were analyzed: SP/AP amplitude ratio, SP/AP area ratio and the difference between AP latency with rarefaction and condensation stimuli.
Results: There was no significant difference between right and left ears (Intraclass correlation coefficient < 0.6). SP/AP amplitude ratio varied between 0.084 and 0.356 and SP/AP area ratio between 0.837 and 1.671 (percentiles 5 and 95). The AP latency difference to rarefaction and condensation clicks was between 0.0 and 0.333 ms.
Conclusion: Normative data for TM ECochG parameters were established in 100 normal hearing subjects without MD. These data can be used to distinguish normal from pathological findings and in follow-up of MD patients.

Keywords: Electrocochleography; Ménière disease; Hearing; Dizziness; Tinnitus

1. Introduction

Electrocochleography (ECochG) is one of the diagnostic tools used in patients with Ménière's disease (MD). The wide spectrum of symptoms and the clinical course of MD continue to make diagnosis and management challenging to clinicians. Besides the AAO HNSF criteria (1995), the criteria suggested by Gibson (2009) and The International Criteria (Lopez-Escamez et al., 2015), vestibular tests, VEMP and ECochG are useful not only for diagnosis but also to determine the evolution of the disease (Young, 2013; Ferraro, 2010; Ferraro and Durrant, 2006).

The most widespread used measure in ECochG remains the summating potential-to-action potential (SP/AP) amplitude ratio, whose sensitivity for the diagnosis of MD varies between 60% and 92% (Margolis et al., 1995; Ferraro et al., 1985; Devaiah et al., 2003). Notwithstanding, other measures have been proposed to enhance diagnostic accuracy like the SP/AP area ratio, the action potential latency difference to rarefaction and condensation clicks and the tone-burst evoked

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SP (Ferraro and Tibbils, 1999, Baba et al., 2009; Al-Momani et al., 2009, Ohashi et al., 2009; Margolis et al., 1995).

Ferraro and Tibbils (1999) proposed a method for measuring the SP and AP areas in tympanic electrocochleography (TM ECochG). They found that including both SP/AP amplitude and area ratios in the diagnostic criteria significantly increased the sensitivity to MD. As a follow up to this study, Devaiah et al. (2003) reviewed the charts of 138 patients with MD. Among 20 patients with possible MD, eight passed the exclusion criteria. The TM ECochG recordings of 8 patients and 13 controls were reviewed and SP/AP amplitude and SP/AP area curves were measured as described in the previous publication (Ferraro and Tibbils, 1999). The authors concluded that the SP/AP area curve ratio significantly improves the ECochG sensitivity in possible Ménière's disease.

A large retrospective chart review conducted by Baba et al. (2009) identified in a 15-year period 198 patients (209 ears) with Ménière's disease, diagnosed according to the Committee on Hearing and Equilibrium of AAO HNSF criteria and compared them to 16 volunteers (controls). They analyzed transtympanic (TT) ECochG records and measured the SP and AP areas as proposed by Ferraro and Tibbils (1999). An image of the waveform of the AP and SP complex was captured by an image scanner, and the outline of the captured image was then traced with the computer mouse to calculate the area using the NIH Image software. These authors concluded that the SP/AP area ratio might not necessarily have higher sensitivity in the diagnosis of endolymphatic hydrops than the SP/AP amplitude ratio in TT ECochG.

Oh et al. (2014) used extratympanic (ET) ECochG in 60 Ménière patients and 30 controls. They also captured an image of the waveform of the AP and SP complex, outlined the captured image with the computer mouse and calculated the area using the ImageJ software, a time consuming procedure. They found no statistically significant difference in the mean SP/AP area ratio between patients with definite, probable, or overall Ménière's disease, as compared to controls.

Contrasting with the previous studies, Al-Momani et al. (2009), comparing 178 suspected MD patients and twenty volunteer subjects with normal hearing thresholds who produced normative ECochG values for the study, found that the SP amplitude to click stimuli, the SP/AP amplitude ratio, and the SP/AP area ratio were the most sensitive and specific measures associated with a diagnosis of MD. More importantly, when the SP/AP area and amplitude ratios were included together (versus the area or amplitude ratio alone) the sensitivity value improved from approximately 60% to 92%, while specificity remained high at 84%.

Margolis et al. (1995) recorded data on rarefaction and condensation clicks in 28/53 subjects using tympanic electrode (Margolis et al., 1995). At 88 dB nHL the mean AP latency difference between rarefaction and condensation clicks was 0.15 ± 0.13. The 95th percentile was determined at 0.38 ms. The authors recommended that the AP latency difference to condensation and rarefaction clicks should be included among the indicators of endolymphatic hydrops.

There is still no consensus about the best ECochG method for evaluating MD: TT ECochG or TM ECochG or ET ECochG, nor about the type of stimulus, intensity and the most practical approach to establish the area measures. Some manufacturers have recently included software algorithm upgrades that calculate automatically the areas when the clinician determines the baseline, onset and end of AP and SP as well as AP and SP peaks. So measurements are now user-friendlier and can be performed easily within the manufacturer's software.

While the SP/AP area ratio, AP latency difference to rarefaction and condensation clicks and the tone-burst evoked summating potential are used in clinical practice for more than 10 years, there is a lack of normative data for these measures as most papers were focused on symptomatic patients (Devaiah et al., 2003; Baba et al., 2009; Ferraro and Tibbils, 1999; Al-Momani et al., 2009). The largest sample of normal controls (n = 30) was reported by Oh et al. (2014). In this study no data on the action potential latency difference to rarefaction and condensation click were reported.

The aim of this study is to establish normative data for SP/AP amplitude ratio, SP/AP area ratio and the AP latency difference to rarefaction and condensation clicks in a population of normal hearing adults without symptoms of MD, following the criteria proposed by the AAO HNS 1995 (1995) and Gibson (2009).

2. Material and methods

2.1. Study population

In this retrospective chart review from September 2010 to April 2014 we enrolled 100 subjects (N = 200 ears) aged between 19 and 71 years (mean age 43.6 ± 11.8 years), 59 females. Inclusion criteria were: normal otomicroscopy, pure tone thresholds ≤25 dB nHL from 250 to 4000 Hz, normal tympanogram. Only subjects without any symptoms of MD according to the criteria of the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology − Head and Neck Surgery Guidelines AAO-HNS 1995 (1995) and with a Gibson's score <7 (Gibson, 2009) were eligible. We excluded subjects with middle or external ear abnormalities as well as patients with dizziness, aural fullness or other symptoms of possible endolymphatic hydrops not included among the AAO-HNS criteria.

2.2. Ethics

This study was approved by the Institution Ethics Committee (number 835.965/2014).

2.3. ECochG recording

After careful otomicroscopic inspection and cleansing of the external ear canal, 10% xylocaine spray was filled into the ear canal to reduce patient's discomfort. After 10 min the ear canal was irrigated with warm 0.9% saline solution and