Spring 2017

Electrocochleography as a diagnostic tool for Ménière's disease: A comparison between presentation methods and various sound stimuli

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CSD Senior Capstone: May 4, 2017

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Background

Ménière's Disease is a vestibulocochlear disorder characterized by fluctuating low-frequency sensorineural hearing loss (SNHL), episodic vertigo, tinnitus, and aural fullness (Cureoglu, Monsanto, & Paparella, 2016). The symptoms of Ménière's disease are believed to be caused by endolymphatic hydrops (Cureoglu et al., 2016). As shown in Figure 1, cases of endolymphatic hydrops (ELH) occur when there is fluctuation in the amount of fluid (endolymph) in the inner ear structures (Cureoglu et al., 2016). The inner ear includes the structures of the vestibular system and the cochlea. The cause of ELH is unknown (Cureoglu et al., 2016).

Diagnostic Criteria

According to Lopez-Escamez et al. (2015), the diagnosis of Ménière's disease relies on criteria set by the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS). Currently, this diagnosis involves clinical evaluation of symptoms as well as audiometric evaluation (Lopez-Escamez et al., 2015). There is no requirement for any objective measurements to confirm diagnosis (Lopez-Escamez et al., 2015).

What is Electrocochleography?

Electrocochleography (ECoG) is a way of evaluating the function of the cochlea by measuring electrical potentials produced by the cochlea in response to acoustic stimulation (Ferraro & Durrant, 2006). During this process, there is an electrode placed within the ear and additional electrodes placed on the skin, typically on the earlobe and the forehead (Ferraro & Durrant, 2006). ECoG has been used to evaluate cochlear function for some time; previously, ECoG produced extremely variable results and could not be used as a reliable method for diagnosis of Ménière's disease (Gibson, 2009).

Presentation Types:

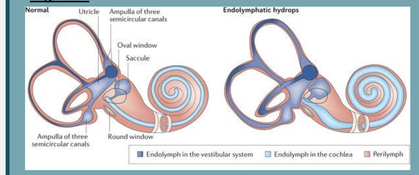
There are several different variations of electrocochleography, each named for the placement of electrode during presentation.

Transtympanic Electrocochleography (TT ECoG)- during this form of presentation the electrode is inserted through the tympanic membrane (Ferraro & Durrant, 2006).

Extratympanic Electrocochleography (ET ECoG)- involves insertion of the electrode into the skin of the bony portion of the ear canal (Ferraro & Durrant, 2006).

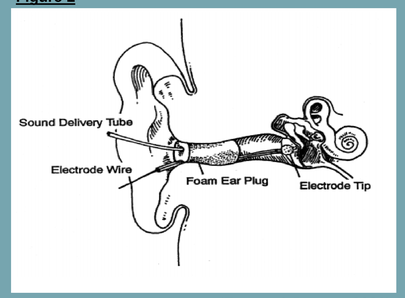
Tympanic Electrocochleography (TM ECoG)- as pictured in Figure 2, this involves placing the electrode on the tympanic membrane, without perforation. This technique is considered a variation of extratympanic electrocochleography by some professionals (Ferraro & Durrant, 2006).

Figure 1



(Nakashima et al., 2016)

Figure 2



(Ferraro & Durrant, 2006)

Study	Subjects	Presentation Method	Stimuli Used	Parameters Measured	Results	Limitations
Noguchi, Nishida, & Komatsuzaki, 1999	Normal Hearing, Ménière's, Other SNHL	TM ECoG	Click, Tone-Burst	AP amplitude, CM	No statistically significant difference in measurements obtained by each method	Compared results of measurements between methods, but not efficacy in differential diagnosis
		TT ECoG	Click, Tone-Burst	AP amplitude, CM		
Haapaniemi, Laurikainen, Johansson, & Karjalainen, 2000	Ménière's	TM ECoG	Click	SP Amplitude, AP Amplitude, SP/AP Ratio	75% of ears showed equal SP/AP ratios between methods. TT ECoG provided measurements that were more easily interpreted	Compared results of measurements between methods, but not efficacy in differential diagnosis
		TT ECoG	Click	SP Amplitude, AP Amplitude, SP/AP Ratio		
Ghosh, Gupta, & Mann, 2002	Normal Hearing, Ménière's, Otitis Media	ET ECoG	Click	SP/AP Ratio	90% sensitivity, 80% specificity	Did not include any other forms of SNHL, which are more likely to present similar to Ménière's disease
		TT ECoG	Click	SP/AP Ratio	100% sensitivity, 90% specificity	
Gibson, 2009	Ménière's, Other SNHL	TT ECoG	Click	SP/AP Ratio	Tone-burst trials resulted in greater accuracy in terms of both sensitivity and specificity.	Controls were matched in severity of SNHL; possibility for undiagnosed ELH. Additionally there were two variables changed between conditions
			Tone-Burst	SP Amplitude		
Martín-Sanz et al., 2012	Normal Hearing, Ménière's	ET ECoG	Click	SP/AP Ratio	85% sensitivity, 80% sensitivity	Did not include any other forms of SNHL, which are more likely to present similar to Ménière's disease

What does it measure?

Electrocochleography measures a number of parameters from the electrical potentials produced by the cochlea. Disruption to the normal function of the cochlea can affect these parameters in different ways. Some parameters include:

Cochlear Microphonic (CM): "An alternating current voltage that reflects the instantaneous displacement of the basilar membrane along some distance within the cochlea" (Ferraro & Durrant, 2006, p. 47).

Summating Potential (SP): "The direct current potential derived mostly from nonlinearities of the CM, probably due to asymmetry of basilar membrane movement" (Gibson, 2009, p. 38).

Action Potential (AP): "The summed response of numerous, at times thousands of, auditory nerve fibers firing synchronously" (Ferraro & Durrant, 2006, p. 48).

The SP and AP can be measured in both amplitude and latency (Ghosh, Gupta, & Mann, 2002). Additionally, Gibson (2009) stated that the amplitude of SP can be measured as a ratio of the AP amplitude (SP/AP Ratio). Several studies have compared the use of these different parameters and their efficacy in diagnosing Ménière's Disease (Ferraro & Durrant, 2006).

Sound Stimuli

There are several types of stimuli that can be used in electrocochleography. The various types of stimuli each have different benefits to them (Ferraro & Durrant, 2006).

Click stimuli

A click stimulus is a very short presentation of broadband noise (Ferraro & Durrant, 2006). This means that there is a wide variety of frequencies presented at once (Ferraro & Durrant, 2006). One benefit of a click is that it stimulates a large number of neurons at one time, which creates well defined waveforms in the measurement parameters (Ferraro & Durrant, 2006). However, the short duration of the click is not ideal for CM and SP measurements, as these parameters are stimulus dependent (Ferraro & Durrant, 2006). In other words, a very brief sound stimulus results in short waveforms that are harder to interpret.

Tone-bursts

Tone-burst stimuli involve frequency specific tones (Ferraro & Durrant, 2006). As a result, this stimulus can reveal frequency specific responses from the cochlea (Ferraro & Durrant, 2006). This is beneficial for progressive disorders and disorders that affect specific frequencies, such as Ménière's disease (Ferraro & Durrant, 2006). However, this stimulus is relatively new, and there are not set standards for presentation protocol across institutions (Ferraro & Durrant, 2006). As a result, there can be widely varied measurements that are difficult to compare (Ferraro & Durrant, 2006)

Conclusions

Based on a review of the literature, TT ECoG offered the most accurate results; however, ET ECoG, especially TM ECoG, provided legitimate accuracy. As a result, TM ECoG can act as a clinical tool in the diagnosis of Ménière's disease that is less invasive than TT ECoG and can be performed without a physician. Additionally, TT ECoG can be used when increased accuracy is necessary. Patient preference regarding the level of invasiveness should play a role in the choice of presentation method. Although click stimuli provided accurate results, tone-burst stimuli are becoming more common and provide accuracy as well as the ability to evaluate specific frequencies. Consequently, clicks could act as the main stimuli in clinical evaluation, with tone-burst presentations being performed if further evaluation is desired. The most effective measurement parameter was SP/AP ratio.

Future Considerations

Considerations should be made by the AAO-HNS for further research regarding the possibility for implementation of electrocochleography as an objective diagnostic tool in the evaluation of Ménière's Disease. Additionally, set standards and protocols should be developed for the diagnostic use of electrocochleography, especially for tone-burst stimuli, so that comparisons can be made across institutions.

References

Cureoglu, S., Monsanto, R., & Paparella, M. (2016). Histopathology of Meniere's disease. *Operative Techniques in Otolaryngology Head and Neck Surgery*, *27*(4), 194-204. doi:10.1016/j.otot.2016.10.003

Ferraro, J., & Durrant, J. (2006). Electrocochleography in the evaluation of patients with Ménière's disease/endolymphatic hydrops. *Journal of the American Academy of Audiology*, *17*(1), 45-68. doi:10.3766/jaaa.17.1.6

Ghosh, S., Gupta, A., & Mann, S. (2002). Can electrocochleography in Meniere's disease be noninvasive?. *The Journal of Otolaryngology*, *31*(06), 371-375. doi:10.2310/7070.2002.34383

Gibson, W. (2009). A comparison of two methods of using transtympanic electrocochleography for the diagnosis of Meniere's disease: Click summating potential/action potential ratio measurements and tone burst summating potential measurements. *Acta Oto-Laryngologica*, *129*(sup560), 38-42. doi:10.1080/00016480902729843

Haapeniemi, J., Laurikainen, E., Johansson, R., & Karjalainen, S. (2000). Transtympanic versus tympanic membrane electrocochleography in examining cochleovestibular disorders. *Acta Oto-Laryngologica*, *120*(545), 127-129. doi:10.1080/000164800454189

Lopez-Escamez, J., Carey, J., Chung, W., Goebel, J., Magnusson, M., Mandalà, M.,…Bisdorff, A. (2015). Diagnostic criteria for Menière's disease. *Journal of Vestibular Research*, *25*(1), 1-7. doi:10.3233/VES-150549

Martín-Sanz, E., Esteban Sánchez, J., González Juliao, M., Zschaeck Luzardo, C., Mato Patino, T., Rodrigañez Riesco, L., … Sanz Fernández, R. (2012). Extratympanic electrocochleography in Ménière's disease. *Acta Otorrinolaringologica (English Edition)*, *63*(6), 421-428. doi:10.1016/j.otoeng.2012.11.003

Nakashima, T., Pyykkö, I., Arroll, M., Casselbrant, M., Foster, C., Manzoor, N., … Young, Y. (2016). Meniere's disease. *Nature Reviews Disease Primers*, *2*, 1-18. doi:10.1038/nrdp.2016.28

Noguchi, Y., Nishida, H., & Komatsuzaki, A. (1999). A comparison of extratympanic versus transtympanic recordings in electrocochleography. *International Journal of Audiology*, *38*(3), 135-140. doi:10.3109/00206099909073015