Editorial

Electrocochleography: Cochlear Implants and the Return to the Operating Room

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Electrocochleography, often abbreviated ECochG, refers to the technique of recording electrical potentials from the cochlea and auditory nerve. The components typically captured and analyzed during this process are the cochlear microphonic (CM), summating potential (SP), and whole-nerve action potentials from the auditory nerve. The recording of these short latency responses from the peripheral auditory system dates back to the late 1940s. During this time a team comprised of an otologist named Julius Lempert and two auditory physiologists, Merle Lawrence and Ernst Glen Weaver, published a paper in 1947 entitled "*The Cochleogram and its Clinical Application. A Preliminary Report*" (Lempert et al, 1947). This report described the authors' experience recording electrical potentials from the exposed round window of patients (i.e., 11 ears) undergoing surgeries for various auditory disorders. This foundational paper set forth their intentions for using these potentials to objectively characterize hearing thresholds and for surgical guidance (i.e., intraoperative monitoring).

Currently, the EcochG refers to the measurement of cochlear and nerve potentials using a brief auditory stimulus and a recording electrode placed in close proximity to the generator sources (e.g., typically the tympanic membrane or promontory). When one is asked what the clinical utility of the EcochG is, most would respond that it is useful in the diagnosis of Ménière's disease. However, reports describing the diagnostic accuracy of EcochG have been mixed. Criteria for Ménière's disease has been provided by the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS) that includes recurrent spontaneous vertigo, fluctuating hearing loss, aural fullness, and tinnitus. While this is the traditional application of EcochG, the recording technique has taken on a new role in the field of cochlear implants.

Recently, EcochG has begun to be used more routinely in patients with cochlear implants. The two primary applications in this population are first, an objective method to estimate the unaided audiogram. Second, the implant itself can be used to measure CMs during cochlear implant insertion to minimize cochlear trauma. These two methods are capable of providing clinicians with important objective data now made possible due to innovative software applications that synchronize the delivery of auditory stimuli with the recordings from the CI electrodes.

Advancements in cochlear implant technology have resulted in residual hearing preservation in some cochlear implant patients. Outcomes can vary when this approach is taken with some patients maintaining all of their pre-implant residual auditory hearing and some suffering a complete loss. In the case of characterizing a patient's residual hearing following implant surgery, pure tone acoustic tone bursts delivered through the ear canal can be used to elicit a CM in the region where the patient continues to have peripheral auditory function. Clinicians now have the ability to activate the electrode in the region where there is preserved hearing and record the CM generated by the remaining hair cells. A CM audiogram can be generated and is essentially the *Cochleogram* that Lembert and colleagues described in 1947 (Lempert et al, 1947). There is now convincing evidence that the CM audiogram recorded via the CI is strongly correlated with behavioral unaided audiometric thresholds and can be recorded in as little as one minute (Koka et al, 2017). This method is especially useful in situations where there is a need to measure residual hearing in the pediatric cochlear implant patients.

The EcochG is also becoming a popular IOM technique during cochlear implant surgery. Cochlear trauma due to electrode insertion has been shown to be one of the primary factors leading to a loss of residual hearing. It is now possible to record the ECochG through the implant in real time as the surgeon inserts the electrode. In this regard, the CM recorded via the CI can be used to monitor cochlear implant electrode location and minimize trauma. In most cases of hearing preservation, the low frequencies are intact and the apical electrodes are used to record and quantify the CM. As the apical electrode is advanced through the cochlea starting at the basal end, auditory stimuli are delivered through an earphone at a frequency that is in the range of that patient's residual hearing (e.g., 500 Hz). The CM amplitude will increase as the electrode moves apically and into the region where there are intact hair cells. Trauma to the intact cochlear structures during electrode insertion will result in a drop in CM amplitude. This new approach using the CI electrode to record CM in real time has been shown to be superior to the round window recordings initially described by Lempert and colleagues and represents an innovative shift in cochlear implant surgery and IOM.

In this month's issue of JAAA, we have an excellent article that examines the effect of various recording and stimulating parameters on the EcochG in a number of experimental conditions. It is exciting to see this response that has been around for decades and continues to be researched and applied to new applications. Understanding the parameters that affect this small electrophysiological response is critical and we encourage you to read the article by Butler and Stuart.

Devin L. McCaslin, Ph.D.
Deputy Editor-in-Chief

Aniket A. Saoji, Ph.D.
Director, Mayo Clinic Cochlear Implant Program

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