Otoacoustic Emissions: An Invaluable Screen of Neonatal Hearing

Scott A. Davenport¹, and Andrea L.O. Hebb¹,²*

¹Department of Psychology, Saint Mary’s University, Canada
²Divisions of Neurosurgery, Otolaryngology—Head & Neck Surgery and Department of Radiation Oncology, Dalhousie University, Canada

Abstract

Otoacoustic emissions (OAEs) including evoked otoacoustic emissions test (EOAE), automated auditory brainstem response (a-ABR), transitory evoked otoacoustic emissions (TEOAEs) and brainstem auditory evoked potential (BAEP) are invaluable in assessing hearing in the newborn and non-verbal children and young adults. The following article briefly outlines the implementation of OAEs in clinical settings and highlights future research potential.

INTRODUCTION

Otoacoustic emissions (OAEs) are low-level signals emitted inside the cochlea and recorded in the auditory canal. OAEs were theorized over 60 years ago by the biophysicist Thomas Gold [1]; although his proposal of an active cochlear process was not widely accepted until the 1970s. The first human OAEs were to be recorded and tentatively explained by Kemp who used a low-level click as the stimulus and recorded the cochlear echoes [2, 3]. Since Kemp’s observation and subsequent experiment(s) OAEs have been studied extensively and implemented as a routine neonatal screening test for hearing loss. In addition, neonatal hyperbilirubinemia, familial auditory neuropathy, end-stage renal disease, and neurofibromatosis type II (NF2) are some of the conditions which may precipitate hearing loss in children and in which OAEs have been utilized [3-7]. The purpose of the ensuing discussion is to demonstrate the effectiveness of OAEs (and the various tests inspired by the mechanism) as a versatile component of screening and experimentation.

Comparison of tests

Hospital based universal neonatal hearing screening programs are at present widely used; the most effective ones are evoked otoacoustic emissions test (EOAE), followed by an automated auditory brainstem response (a-ABR) for all infants failing the EOAE [3, 6, 8]. The accuracy and efficacy of these tests for detecting hearing loss in high-risk neonates has not been fully elucidated. Examinations have often been hampered by excessive environmental electrical “noise”, electro-myogenic interference (from behavioural distress), and cochlear immaturity [6, 8]. Subsequently, visual reinforcement audiometry (VRA) is typically recommended, however, in the case of developmental delay, cognitive motor or visual disabilities brainstem auditory evoked potential (BAEP) may be recommended [6]. Comparing the BAEP, a-ABR, and auditory transitory evoked otoacoustic emissions (a-TEOAE); measuring the variables of sensitivity, specificity, positive and negative predictive value and odds ratio demonstrated that overall the BAEP was the better test. The BAEP had higher sensitivity and specificity, accuracy in its predictions, and a much lower false positive rate than the EOAE and a-ABR [6].

OAE use

Hearing loss is a common deficit, with severe to profound loss occurring in 1-3 infants per 1000 in Canada [9]. Otoacoustic emissions (OAEs) are often used in combination with detailed medical histories to reveal the etiology of hearing loss in infants [7, 10]. For example, otoacoustic emission recordings are typically normal in familial auditory neuropathy with absence of auditory brainstem responses [7]. The OAE is a normal physiologic response generated by the outer hair cells of the cochlea. A hearing sensitivity of 30 dB HL is indicated by a pass on an OAE test [11].

Hyperbilirubinemia

Hyperbilirubinemia has devastating effects on the auditory system. Even short term increases in bilirubin levels can induce temporary or permanent changes in evoked potentials [4]. Baradaranfar et al. conducted a study on newborn babies with jaundice [4]. Thirty-five infants were tested, 26 had normal ABR, 9 with abnormal ABRs, 5 had no ABR waves at all and 4 had increased I-III and III-V intervals and latency in all waves. Twenty-six infants had normal hearing, 4 mild to moderate...
hearing loss, and 5 suffered from severe to profound hearing loss. OAEs could be recorded in 1 infant with mild to moderate hearing loss and 4 with severe to profound hearing loss. Overall, 26 had normal tests and in 5 infants, abnormal results were localized to the retro-cochlear region indicative of auditory neuropathy [4].

Kidney Disease

Abnormalities in auditory systems are frequent in children with end-stage renal disease (ESRD); there is not yet any consensus for the effect of renal failure and hemodialysis on auditory complications [5]. In a study conducted by Naderpour et al., children were tested in three groups: 25 ESRD patients undergoing hemodialysis, 25 non-dialytic patients with chronic renal failure, and 25 age and sex-matched control subjects [5]. ABR testing was abnormal in 11 dialysis patients with normal results in all 25 non-dialytic patients with chronic renal failure cases and controls. OAE testing was abnormal in all dialytic patients with abnormal ABR testing. Sensorineural hearing loss was rare among non-dialytic patients with chronic renal failure but very common in ESRD children undergoing long-term dialysis [5].

Neurofibromatosis type II (NF2)

Children with NF2 have an increased risk for hearing loss. Otoacoustic emissions are forms of energy (sound) generated by the outer hair cells of the cochlea and can be used to assess cochlear hearing loss. Evoked otoacoustic emissions (EOAEs) have been used to assess outer hair cell and cochlear hearing loss function in non-verbal neurofibromatosis NF2 patients [12-15]. Although typically used in infants, EOAEs have been used to assess cochlear function in adult non-verbal NF2 patients [unpublished observation, 13].

Canadian Research

Robert V. Harrison (2018) has repeatedly demonstrated OAE measurement as an important clinical and research tool. In terms of newborn hearing screening, OAEs testing is used even more than the standard behavioural audiogram [16]. OAEs can be used to test outer hair cell integrity [17]. While ipsilateral and contralateral OAE suppression can be used to test some aspects of auditory brainstem functioning; the full potential of OAE in clinical testing has not yet been reached [16].

CONCLUSION

OAEs and other objective tests (BAEP, aABR) are invaluable non-invasive screening tests that are applicable to many conditions including but not limited to neonatal hyperbilirubinemia, familial auditory neuropathy, end-stage renal disease and NF2. The irrefutable exemplary implementation of OAEs into the field of medicine and research only bolsters the potential for a wider variety of applications. OAEs are a valuable resource for screening and experimental research on mechanisms underlying hearing loss.

REFERENCES


