Peripheral Auditory Assessment in Minor Head Injury: A Prospective Study in Tertiary Hospital

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Abstract Hearing loss is a common problem encountered in ENT practice. Hearing loss following head injury is a major medical problem in both adults and children, which may go unnoticed when it does not affect speech frequencies. Sensorineural hearing loss at high frequencies is a common finding in minor head injury. Patients with history suggestive of mild head injury (MHI) according to Glasgow coma scale score were evaluated. The most common cause of MHI was road traffic accidents involving two wheeler riders without helmets. Higher the frequencies affected, and severe the hearing loss, poorer was the prognosis. Distortion product oto-acoustic emissions assessment at 3000 and 4000 Hz were found to be significant and has a higher predictive value in assessing outer hair cell damage.

Keywords Road traffic accidents · Hearing loss · Minor head injury · DPOAE

Introduction

Hearing loss is a common problem encountered in ENT practice. Hearing loss following head injury also is well known since ancient times. According to a World Road Statistics (2007), more than 95,000 people died in road accidents in India [1]. The numbers of road traffic

accidents (RTA's) have increased with minor head injuries being very common and usually go unreported. Mild traumatic brain injury [2] is one of the most common neurological disorders. Studies done in Delhi [3], Bangalore [4] documented that about one-third of two wheeler riders admitted to a neuro-surgery ward were alleged to be under the influence of alcohol at the time of accident.

Hearing impairment following head injury can be due to central or peripheral causes, middle ear or cochlea being the most common site of peripheral injury. Clinical and animal experimental studies have shown that there are various sites of pathology ranging from hair cell damage and degeneration of the organ of corti [5], ischemia of the eighth nerve to damage of central auditory pathways (due to compromise of blood supply to the inner ear) either partly or totally [6]. The animal experiments show that the deafness is due to injury of the organ of corti, identical with that which results from a shock pulse in the air as a bomb blast or a pistol shot. There was violent displacement of the basilar membrane and organ of corti, and both reversible and irreversible cellular injuries were present. Schuknecht and Davison [7] estimated hearing loss in cats subjected to head injury. The earliest detectable histological changes consisted of anatomical derangement of outer hair cells and their supporting cells. In mild injuries the outer hair cells which are normally tall and rectangular appeared shorter and wider and the nuclei were smaller and the chromatin was condensed. In severe lesions there was a loss of external hair cells and the beginning of cytological changes in the Dieters cells and the supporting cells, further progressive stages of injury consisted of flattening of the organ of corti and finally its complete disappearance. Progression of hearing loss can be attributed to the synergistic effects between trauma, noise exposure [8], medication [9] and meningitis.

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This study was done to assess the hearing loss in patients with Mild Head Injury [MHI] and to define its natural history and progression/regression by serial assessment of hearing. Outer hair cell function was assessed by Distortion product oto-acoustic emission (DpOAE) testing.

Materials and Methods

This prospective study was done in the Department of ENT at the Christian Medical College Vellore, India. A pilot study was done for a period of 3 months to look at the profile of hearing levels of patients presenting to the Accident and Emergency department (A & E Dept) with history suggestive of MHI. Following the pilot study we arrived at a sample size of 60 for the main study. Subsequently 60 consecutive patients with history suggestive of MHI were included in the study.

Inclusion Criteria

All patients with history suggestive of MHI Glasgow coma scale scoring system [GCS] [10, 11] 13–15 and improving and age between 6 and 60 years. Patients discharged from casualty after observation period of 24 h. History of loss of consciousness of less than 20 min.

Exclusion Criteria

Patients with past history of ear disease, previous head injury or noise trauma. Patients having family history suggestive of autoimmune disease and hearing loss.

Each patient was evaluated in the A & E Dept. A thorough Neurological examination was done and assigned a score according to GCS [10, 11] scale. A detailed neuro-otological examination was done in ENT Department. Radiological investigations such as X-Ray skull (Antero- posterior and lateral view) and CT scan were done to detect skull fractures. Routine Blood investigations were done and vital signs were monitored during the entire observation period. Facial nerve function was graded according to House Brackmann scale [12]. Patients were specifically asked for symptoms of hearing loss, tinnitus and vertigo. Patients were called to audiology lab and a detailed hearing assessment was done, after taking an informed consent.

Pure tone audiometry [PTA] was done using GSI-61, MA-53 audiometers. Audiometers were calibrated daily with subjective calibrations with normals. Hearing thresholds of 15–25 dB across the frequencies were considered to be as normal. A Siemens SD-30 impedance audiometer was used to obtain immittance measurements. The test was performed using a probe tone frequency of 226 Hz.

Distortion product oto-acoustic emission testing was done with the Smart DPOAE package of INTELLIGENT HEARING SYSTEMS in patients with normal immittance. Distortion product oto-acoustic emissions were recorded using a test protocol where primaries were fixed at $L_1 = 65$ dB SPL, $L_2 = 55$ dB SPL with an f_2/f_1 ratio of 1.22. The f_2 frequencies were carefully selected to correspond closely to audiometric test frequencies of 1000, 2000, 4000 Hz DPOAE testing was done at 1000, 2000, 3000, 4000, and 6000 Hz. A DPOAE response was considered to be present if the SNR > 6.13 dB.

Repeat evaluation was done after a period of three and 6 months. A detailed oto-neurological evaluation was done in all three visits and patients were specifically asked for symptoms of hearing loss tinnitus and vertigo.

Results and Analysis

Data was entered on an Excel spread sheet Statistical analysis was done using SPSS version 11.0. Important outcomes with differences were tested using Wilcoxon Signed Ranks Test and McNemar Test.

Of the 60 patients seen 83% were males in the age group of 20–40 years (Fig. 1).

A vast majority (75%) of the RTA's was two wheeler accidents and none wore helmets at the time of accident. In about 40% of our patient's consumption of alcohol would have contributed to the RTA (Table 1).

Of the 60 patients, 7 patients were found to have normal audiograms and presence of DPOAEs.

Out of 60 patients 73% were asymptomatic, 15% complained of vertigo, 10% complained of hearing loss, and 2% complained of tinnitus (Table 2; Fig. 2).

Fig. 1 83% were males. 66% were between ages of 20 and 50 years

Table 1 Mode of injury

Road traffic accidents	Fall from height	Hit by a brick	Bull gore injury
54	4	1	1

Road traffic accidents were the major cause of Head injury

Table 2 Symptoms

Asymptomatic	Hearing loss	Vertigo	Tinnitus
44	6	9	1

Fig. 2 Hearing loss on evaluation **Fig. 3** PTA on evaluation**Table 3** Classification of fractures

Normal	Frontal	Temporal	Occipital	Parietal	Facial bone
45	5	4	1	3	2

Out of 60 patients (120 ears tested) 38% had normal hearing, 40% had sensorineural hearing loss, 7% had conductive hearing loss, and 15% had mixed hearing loss. A total of 62% had hearing loss, the most common frequencies affected were 4000 and 8000 Hz (Fig. 3).

Out of 60 patients a total number of 15 patients were found to have skull fractures, with fracture of the frontal bone being the most common (Table 3).

Of five patients with frontal bone fractures bilateral hearing loss was noticed in all the patients, of which mixed hearing loss improved but did not become normal.

In patients who sustained temporal bone fractures, mixed fractures were seen in two patients, one patient had longitudinal fracture, and one had transverse fracture.

Sensorineural hearing loss was found in four ears, mixed hearing loss was found in one ear, conductive hearing loss was noticed in one ear, and two ears were found to be normal. Our study revealed no acute facial nerve injuries along with temporal bone fractures [13].

Sensorineural hearing loss was noticed in the patient who sustained a fracture of the occipital bone. Out of the three patients who sustained parietal bone fractures two patients were found to have normal hearing, the third patient had sensorineural hearing loss in one ear which became normal and mixed hearing loss in the other ear that improved.

Bilateral sensorineural hearing loss was detected in patients who sustained facial bone fractures.

Delayed facial nerve paresis was seen in one patient who presented with history of bull gore injury which recovered within 3 months.

Nine patients complained of vertigo. Dix-Hallpike positional test was positive in three patients for whom Epley's repositioning maneuver was done and rests of the patients were treated with labyrinthine suppressants.

One patient complained of tinnitus.

It was seen that DPOAE was absent in 38.6% at 1000 Hz, 36% at 2000 Hz, 29.8% at 4000 Hz in patients even with normal PTA thresholds after MHI.

Fig. 4 Progression of hearing loss in high frequency region

Fig. 5 DPOAE at 3000 and 4000 Hz

In case of Mild hearing loss (Fig. 4) on PTA, there was absence of emissions in 70% at 1000 Hz, 69% at 2000 Hz, 83% at 4000 Hz (Fig. 5). This may suggest that damage to outer hair cells becomes more pronounced when there is manifest hearing loss on PTA at the first visit suggesting sub clinical irreversible damage to outer hair cells. In few cases with normal hearing, DPOAEs were absent throughout the evaluation time period suggesting irreversible damage to outer hair cells.

As the hearing improved oto-acoustic emissions were detectable, however in cases where the hearing loss progressed, emissions could not be recorded. Changes in DPOAEs were found to be statistically significant only at 3000 Hz (P value 0.002) and 4000 Hz (P value 0.003), in MHI.

Discussion

Road traffic accidents were the most common cause of Minor head injury as seen in most of the studies. The

incidence of RTA's in young adults, in our study, was similar to the study done by Ludwig Podoshin [14] and M. R. Abd AL-Hady [15]. Whereas in the study done by Griffith [16] the majority were seen in late teens.

Two wheeler accidents were found to be the commonest cause of RTA causing minor head injury in our study, where as George G Browning [17] reported that assault/fight was the major etiology causing minor head injury.

Symptoms of hearing loss were found in only 10% of patients which is in agreement with Schuknecht [7] and Makashima [18] due to the involvement in high frequency region.

But the symptom of vertigo was found to be 15% which is low compared with Toglia [19] (61%) and Rosalyn [20] (95%).

Frequency of tinnitus also is low which is in agreement with Griffith [15], who reported no complaints of tinnitus.

The incidence of hearing loss in our study is 62% which is in agreement with Griffith [15] (56%) and males being most affected.

The commonest type of hearing loss was sensorineural loss confined to high frequencies. Higher the frequency affected and severe the hearing loss the prognosis was poor. The degree of hearing loss determined the outcome, and it was found in our study that patients who had moderate to severe hearing loss at the time of injury had a poorer prognosis.

Limitations

19 out of 60 patients were lost to follow-up. Of the remaining only 68% patients came for first follow-up and 30% for the second evaluation.

Conclusion

This study has shown that hearing should be evaluated in all patients with Minor head injury even if they do not complain of hearing loss. In our study we observed that of the two wheeler riders none were wearing helmets and more than 60% were under the influence of alcohol. In case of mild hearing loss hearing recovered. There was variable recovery in patients having moderate and moderately severe hearing loss suggesting sub clinical irreversible damage to outer hair cells in MHI. Testing DPOAE in patients with MHI may help in detecting sub clinical injuries to cochlea.

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