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CASE REPORT

Pneumolabyrinth after Paediatric Head Injury

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Abstract: Pneumolabyrinth is a rare clinical finding that has been documented following head injury and middle ear surgery. We report a case of pneumolabyrinth complicating head injury in an 11 year old male. The condition was diagnosed using high resolution CT imaging and the child was successfully managed conservatively. This case report represents only the fourth documented case of paediatric pneumolabyrinth and the first with a comprehensive audiological follow-up.

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Introduction

'Pneumolabyrinth', air within the vestibule and cochlea, was first described by Mafee et al in 1984, as a sequela to iatrogenic fracture of the stapes footplate at mastoidectomy.[1] The identification of air within the inner ear on CT imaging is considered to indicate the presence of a pathological connection between the inner ear structures and the middle ear and mastoid air cell system.[2,3] Air may enter the inner ear via a temporal bone fracture involving the otic capsule, via a perilymphatic fistula at the oval or round window, or it may occur secondary to barotrauma or displacement of a stapes prosthesis (Table 1). Various otological and vestibular symptoms may then develop as a direct consequence of the ingress of air. We describe a rare case of a post-traumatic pneumolabyrinth in a child, complete with comprehensive audiological follow-up. In addition, the aetiology and pathological consequences of this phenomenon are discussed.

Case Report

An 11 year old boy presented following a head injury resulting from a skateboard accident, complaining of true vertigo and left sided hearing loss. There had been no loss of conscious level but mild retrograde amnesia was recorded. Initial examination in the emergency room reported bloody rhinorrhoea and left otorrhoea, though the fluid was not sent for CSF analysis. The child was reviewed the following day by a paediatric otolaryngologist. Neurotological examination revealed a small left tympanic membrane perforation, second degree nystagmus beating to the right side and a left House Brackmann grade two facial nerve palsy suggestive of an injury involving the left otic capsule. Pure-tone audiometry demonstrated a severe to profound hearing loss on that side and normal thresholds on the right side. High resolution CT imaging confirmed a left petrous temporal bone fracture with involvement of the otic capsule (Figure 1). In addition, air was also seen within the vestibule and cochlea. Caloric function tests were not performed. The left otorrhoea resolved after 48 hours and the vertigo and facial palsy both gradually settled over three to four weeks. Regular audiological assessment was undertaken and at 6 months good improvement in low frequency threshold was seen (Figure 2). However, a severe to profound loss persisted at high frequencies.

Discussion

Pneumolabyrinth in children is a rare phenomenon which has only been described on three occasions previously. All cases to date have followed trauma,

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Table 1. Documented cases of pneumolabyrinth in children and adults

Author	Age	Aetiolgy	Ix	Site	Mx	Hearing Outcome
Mafee[1]	61	Post- mastoidectomy	CT scan	OW fistula	Surgical	NK
Gross[2]	2	Trauma	CT scan	Otic capsule #	Conservative	NK
Weissman[3]	25	Trauma	CT scan	Otic capsule #	NK	NK
Pashley[4]	4	Trauma	Laminography	RW +OW fistulas	Surgical	Returned to previous level at 3 months, but fluctuated
Nurre[5]	57	Trauma	CT scan	Otic capsule #	Conservative	Dead ear at 2 years
Yanagihara[6]	11	Trauma	Exploratory Tympanotomy	RW fistula	Surgical	Limited low frequency improvement at 1 year
Yanagihara[6]	17	Trauma	Exploratory Tympanotomy	RW fistula	Surgical	Good recovery at low frequency, moderate at high frequency at 1 year
Yanagihara[6]	48	Trauma	Exploratory Tympanotomy	RW +OW fistulas	Surgical	No improvement
Lipkin[7]	26	Trauma	CT scan	Perilymphatic fistula	Surgical	40-50dB improvement postop
McGhee[8]	62	Barotrauma	CT scan	RW fistula	Surgical	NK
Isaacson[9]	47	Post-stapedectomy	CT scan	OW fistula	Conservative	Closure ABG at 4 months
Scheid[10]	56	Post-stapedectomy	CT scan	OW fistula	Conservative	Moderate to profound loss

***Ix** = diagnosing investigation, **Mx** = management, **NK** = not known, **#** = fracture, **OW** = oval window, **RW** = round window, **SCC** = semicircular canal. Nishizaki, 1998[11] – No clinical details of case given*

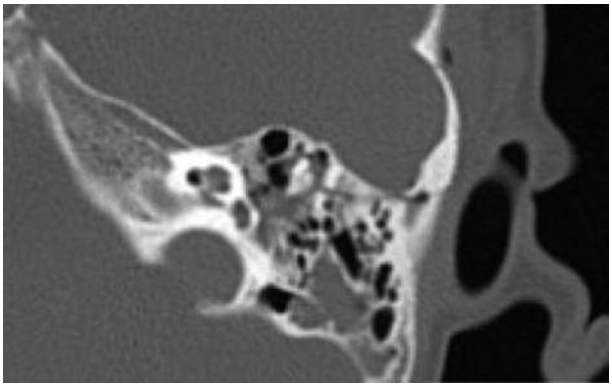

Figure 1. CT image of left temporal bone fracture and pneumolabyrinth

with our case representing the second to be described following temporal bone fracture (Table 1). The case described by Gross et al, of a 2 year old child with an otic capsule violating temporal bone fracture, did not however include audiological follow-up.[2]

Increasingly, temporal bone fractures are described with respect to their relationship to the important structures within the temporal bone, as opposed to the traditional classification based upon the orientation of the fracture line with respect to the long axis of the petrous ridge (longitudinal or transverse).[12] The involvement, or sparing, of the otic capsule has

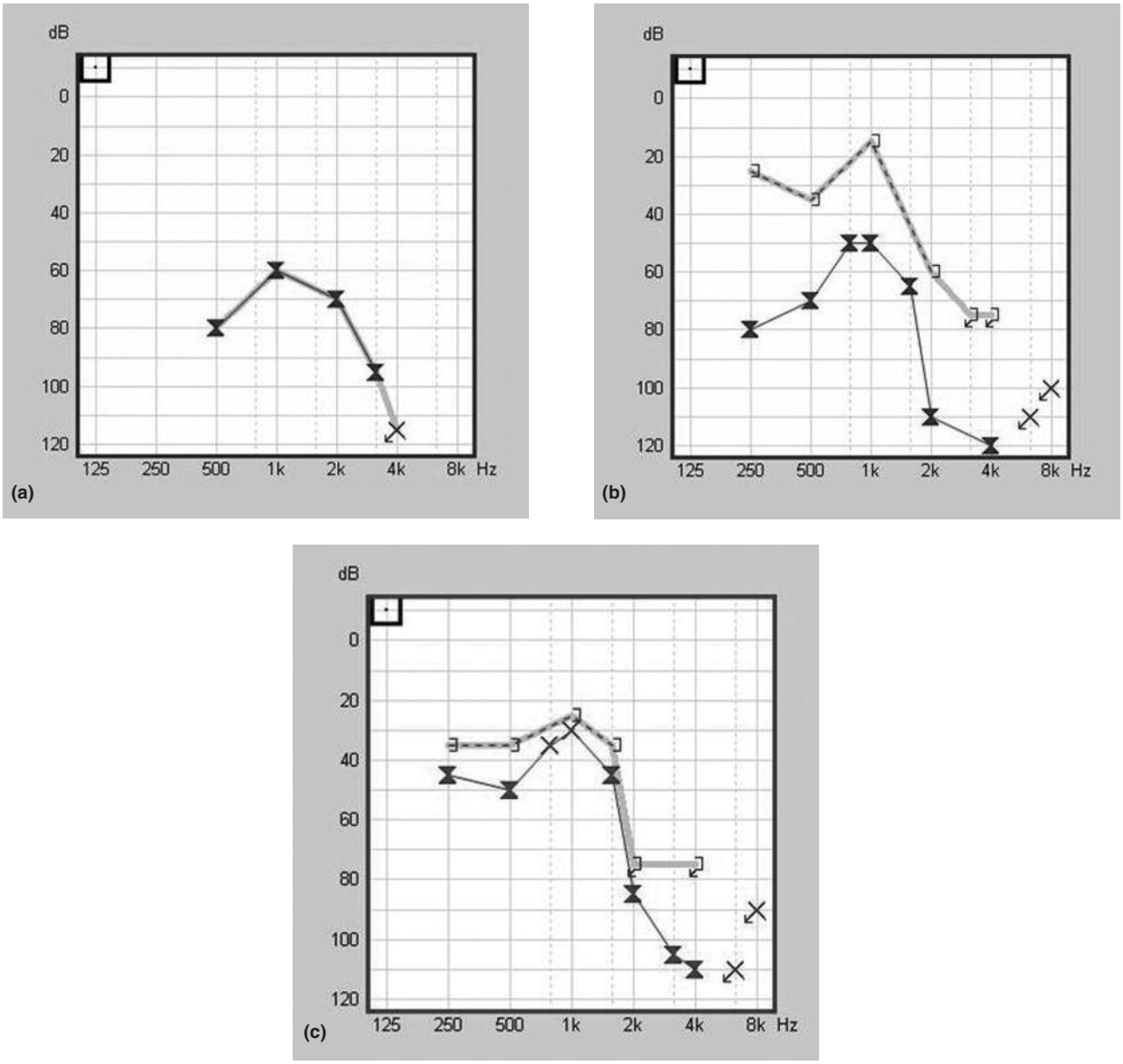

Figure 2. Serial pure-tone audiometry following pneumolabyrinth **(a)** Audiogram of left ear at time of initial presentation, **(b)** Audiogram at one month, **(c)** Audiogram at 6 months

important clinical and management implications. Fractures involving the otic capsule, as described here, are more likely to be associated with serious complications such as facial nerve palsy, cerebrospinal fluid (CSF) leak and sensorineural hearing loss (SNHL). Although clinically suspected, no biochemical confirmation of CSF or perilymph leak was obtained in our case, with the otorrhoea resolving with conservative management within two days. However, a delayed onset partial facial nerve palsy occurred and recovered spontaneously, and there was a severe SNHL.

It has been postulated that the SNHL, consistently found in pneumolabyrinth, is due to the mass effect of the air upon the basement membrane with subsequent disruption of the travelling wave.[13,14] However, the exact pathogenesis underlying the symptomatology of pneumolabyrinth remains unknown. Nishioka et al demonstrated in an animal model that air can enter the scala tympani through a rupture of the round window membrane, providing the middle ear pressure exceeds a critical level. Once an air bubble had formed in the perilymph, a marked increase in the threshold for an action potential in the auditory nerve was demonstrated.[13] This change was subsequently found to be reversible upon removal of the air bubble. Likewise, Kobayashi et al demonstrated complete, or near complete, recovery of cochlear function following perfusion of air into the scala tympani of an animal model. They postulated that the extent of this recovery refuted the possibility that an anoxic effect upon the inner ear was responsible for the changes in cochlear function.[14] In a second set of experiments, Kobayashi et al demonstrated that the location of the air within the cochlea was important with regards to the magnitude and reversibity of the decrease in cochlear function. The observed effect upon cochlear potentials was larger and irreversible if air was perfused into the scala vestibuli.[15] Partial recovery of the hearing threshold was demonstrated in our case. When all described cases of pneumolabyrinth, in both adults and children, are considered, some improvement in hearing threshold is seen in the majority of cases, with the extent of any recovery being entirely unpredictable (Table 1).

The treatment options in pneumolabyrinth are conservative (as in our case) or surgical, with middle ear exploration and closure of the abnormal connection. The choice of management strategy is largely dependent upon the mode and severity of injury and the patient's general condition. Surgical intervention has been advocated where the SNHL is progressive or fluctuant and if vertigo persists.2,10 In a review of 820 temporal bone fractures, Brodie et al found that 95 of 122 (78%) CSF fistulae closed spontaneously within one week, with a 3% risk of meningitis. This compared to a meningitis risk of 23% for those whose fistulae persisted for longer than seven days, and surgical closure in this group was therefore advocated.[16]

Conclusion

We describe a case of pneumolabyrinth following head injury with documented subsequent spontaneous improvement in hearing. Though rare, the otologist must be aware of this condition so that timely decisions can be made about when to intervene surgically, and accurate information about prognosis given to patients following temporal bone trauma.

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