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Otolaryngological Consequences of Pressure-Related Injuries: A Prospective Study of Auricular Barotrauma

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Abstract | **Original Research Article**

Background: Pressure-related injuries, including blast exposure and barotrauma, may result in a wide spectrum of otolaryngological lesions. The ear is particularly vulnerable to sudden pressure changes, leading to auditory and vestibular symptoms that may represent a medical emergency. ***Objective:*** To assess the otolaryngological consequences of pressure-related injuries, with particular emphasis on auricular barotrauma, and to describe the diagnostic and therapeutic management based on a prospective clinical study. ***Methods:*** A prospective study was conducted in the Otolaryngology Department of the Specialty Hospital of Rabat, Morocco, between September 2021 and September 2022. Fifty patients presenting to the ENT emergency department following a pressure-related injury were included. Clinical examination, otoscopic findings, and pure-tone audiometry were analyzed, along with therapeutic outcomes. ***Results:*** All patients presented with auricular barotrauma secondary to a direct blast mechanism. Tinnitus was the most frequent symptom (94%), followed by hearing loss (30%) and vertigo (6%). Otoscopic examination was normal in 90% of cases, while tympanic membrane perforation was observed in 6%. Audiometry was normal in 86% of patients; 14% showed mild unilateral conductive hearing loss. Clinical evolution was favorable in 90% of cases, with persistent hearing impairment in 10%. ***Conclusion:*** Auricular barotrauma is the most common ENT manifestation of pressure-related injuries. Although prognosis is generally favorable, careful clinical, audiological, and long-term follow-up is required to detect persistent sequelae and prevent complications.

Keywords: Barotrauma; Blast injury; Tympanic membrane; Hearing loss; Otolaryngology emergencies.

INTRODUCTION

Pressure-related injuries include blast injuries, barotrauma, and acute acoustic trauma. Blast injuries result from an explosion causing a sudden and intense pressure wave, whereas barotrauma is defined as tissue injury secondary to pressure variation within body compartments, particularly those containing air such as the middle ear and paranasal sinuses [1, 2].

In otolaryngology, these mechanisms may affect the auditory and vestibular systems, leading to otalgia, hearing loss, tinnitus, vertigo, and otorrhagia. Rhinological and laryngeal involvement may also occur, particularly in cases of ostial obstruction or severe pressure gradients [3, 4]. Acute pressure-related ENT injuries are considered medical emergencies requiring prompt assessment.

The aim of this study was to evaluate the otolaryngological consequences of pressure-related injuries, based on a prospective series of patients managed in the ENT emergency department, and to review diagnostic and therapeutic strategies.

MATERIALS AND METHODS

Study Design and Population

A prospective study was conducted including 50 patients who presented to the ENT emergency department of the Specialty Hospital of Rabat between September 2021 and September 2022.

Inclusion Criteria

Patients were included if they met the following criteria:

- Exposure to a minor pressure-related injury (auricular blast)
- Presence of otalgia, tinnitus, otorrhagia, or hearing disturbance following exposure

Exclusion Criteria

Patients with tympanic membrane perforation secondary to pre-existing middle ear disease were excluded.

Clinical and Paraclinical Assessment

All patients underwent:

- Detailed clinical history
- Otoscopic examination
- Pure-tone audiometry performed as soon as clinically possible and repeated at day 30

Additional vestibular or imaging investigations were reserved for selected cases based on clinical findings.

Management and Follow-Up

Management was conservative in most cases and included local antibiotic therapy, water precautions, and clinical surveillance. Surgical treatment was indicated in cases of persistent tympanic membrane perforation.

RESULTS

Mechanism of Injury

All cases were related to auricular barotrauma caused by a direct blast mechanism, including slap injuries, direct trauma by a ball, or sudden pressure increase during diving.

Clinical Presentation

The most frequent functional symptoms were:

- Tinnitus: 94% (n = 47)
- Hearing loss: 30% (n = 15)
- Rotatory vertigo: 6% (n = 3)

Otoscopic Findings

Otoscopic examination revealed:

- Normal tympanic membrane: 90%
- Tympanic membrane perforation: 6%
- Myringitis: 4%

Image 1: Otoscopy showing left hemotympanum with hyperemic edges

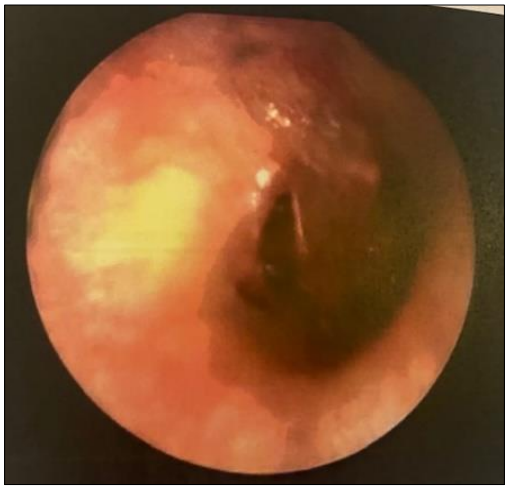

Image 2 : Otoendoscopy of the right ear showing a large tympanic membrane

Audiometric Findings

Pure-tone audiometry showed:

- Normal hearing: 86%
- Mild unilateral conductive hearing loss: 14%

Follow-up audiometry at day 30 demonstrated improvement in hearing thresholds in 90% of patients, with persistent hearing loss in 10%.

Therapeutic Management

Local antibiotic therapy was prescribed in 10% of cases, associated with water avoidance and surveillance. One patient underwent delayed type I tympanoplasty six months after trauma.

DISCUSSION

Pressure-related injuries constitute a frequent cause of otolaryngological emergency consultations, particularly due to the vulnerability of air-containing structures to sudden pressure variations. Among ENT organs, the ear is the most commonly affected, owing to the anatomical and functional characteristics of the external auditory canal, tympanic membrane, and middle ear cleft. In the present study, all patients presented with auricular barotrauma secondary to a direct blast mechanism, highlighting the predominance of minor, non-explosive pressure injuries in civilian practice.

Mechanisms and Pathophysiology

Auricular barotrauma results from a sudden increase in intrameatal pressure exceeding the adaptive capacity of the tympanic membrane and middle ear system. Direct blows to the ear, such as slaps, ball impacts, or water entry during diving, generate an abrupt pressure gradient that is transmitted to the tympanic membrane, leading to hyperemia, ecchymosis, or perforation [1-5]. The unilateral and isolated nature of tympanic involvement observed in our series is consistent with this localized mechanism.

The high prevalence of tinnitus (94%) in our patients reflects the sensitivity of the cochlear structures to pressure waves. Even in the absence of visible tympanic lesions or measurable hearing loss, cochlear microtrauma may occur, resulting in transient or persistent tinnitus [7-19]. This finding has been widely reported in studies on blast and acoustic trauma, where tinnitus often represents the earliest and most frequent symptom [2-7].

Clinical and Otoscopic Findings

Otoscopic examination was normal in the majority of patients (90%), despite the presence of functional symptoms. This dissociation between clinical symptoms and otoscopic findings is well recognized in pressure-related injuries and underscores the importance of systematic functional evaluation [6-8]. Tympanic membrane perforation was observed in 6% of cases, a rate comparable to that reported in the literature for minor blast injuries [8, 9].

Myringitis and tympanic hyperemia, although less frequent, represent early inflammatory responses to pressure stress. Otorrhagia, when present, should always raise suspicion of tympanic membrane rupture and warrants careful otoendoscopic evaluation [5].

Audiological Assessment

Pure-tone audiometry remains a cornerstone in the assessment of auricular barotrauma and should be performed as soon as the clinical condition allows. In our series, 14% of patients exhibited mild unilateral conductive hearing loss, consistent with tympanic membrane or ossicular chain involvement. The predominance of conductive over sensorineural hearing loss reflects the relatively low-energy nature of the pressure trauma in this population [10-15].

Follow-up audiometry at one month demonstrated hearing improvement in 90% of cases, confirming the generally favorable prognosis of minor auricular barotrauma. However, persistent hearing loss in 10% of patients emphasizes the need for continued monitoring, as delayed recovery or permanent sequelae have been described, particularly in cases of repeated trauma or associated inner ear injury [11, 12].

Diagnostic Strategy and Complementary Examinations

While clinical examination and audiometry are sufficient in most cases, additional investigations may be required in selected patients. Vestibular assessment is indicated in the presence of vertigo or imbalance, which was observed in 6% of our cohort. Temporal bone computed tomography should be reserved for suspected ossicular disruption, perilymphatic fistula, or inner ear involvement, especially following high-energy trauma [10-14].

Routine imaging is not recommended in uncomplicated cases, as it does not alter management and exposes patients to unnecessary radiation.

Therapeutic Management

Management of auricular barotrauma is primarily conservative. In our study, local antibiotic therapy was prescribed in a minority of patients (10%), mainly in cases with tympanic membrane perforation or external auditory canal injury, to prevent secondary infection. Water precautions and clinical surveillance constitute the mainstay of treatment, as spontaneous healing of tympanic membrane perforations occurs in the majority of cases within weeks [8, 9].

Surgical intervention is rarely required and should be delayed for at least 3 to 6 months to allow for spontaneous closure. In our series, only one patient required delayed type I tympanoplasty, which aligns with published data reporting low surgical rates in traumatic perforations [6-9].

Prognosis and Complications

The overall prognosis of auricular barotrauma is favorable, with spontaneous resolution in most cases. Nevertheless, potential complications justify close follow-up. Persistent tinnitus, observed in a small proportion of patients, may significantly affect quality of

life despite normalization of hearing thresholds [7-19]. Chronic tympanic membrane perforation, although uncommon, may predispose to recurrent infections and conductive hearing loss.

Secondary cholesteatoma represents a rare but serious long-term complication, particularly in cases of marginal or non-healing perforations, and mandates prolonged surveillance [11-13]. Definitive hearing loss should only be diagnosed after at least one year without audiometric improvement, as delayed recovery has been documented [12-15].

Limitations

This study has certain limitations, including the relatively small sample size and the absence of long-term audiological follow-up beyond the early post-traumatic period. Additionally, inner ear lesions may have been underestimated due to the limited use of advanced vestibular testing and imaging.

Conclusion

The diagnosis of ENT consequences of pressure-related injuries, particularly auricular barotrauma, relies on careful clinical examination, otoendoscopy, and audiological evaluation. Although outcomes are favorable in most cases, systematic follow-up is essential to detect persistent sequelae and prevent long-term complications.

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