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Middle Ear Barotrauma in Hyperbaric Chamber Inside Attendants

Hiperbarik İç Yardımcılarında Orta Kulak Barotravması

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Abstract

Aim: Hyperbaric oxygen therapy (HBOT) facilities and their use in various medical fields are increasing. Hyperbaric chamber inside attendants (HCIAs) are exposed to several occupational hazards, of which middle ear barotrauma (MEB) is the most common. This study aimed to prospectively investigate MEB incidence and severity in hyperbaric chamber inside attendants.

Material and Method: The HCIAs underwent an otoscopic examination by an otolaryngologist before and after the HBOT session, and their demographic characteristics, medical history, and otological symptoms were recorded. The appearance of the tympanic membrane in those who develop MEB is graded according to the Teed classification system. The data collected in the study were analyzed using statistical software.

Results: The research involved 56 HCIAs who underwent otoscopic examinations before and after HBOT sessions. The study revealed that 21.5% of the participants experienced MEB, with no significant correlations between MEB and demographic variables. According to the data, 25% of HCIAs who experienced MEB reported no pain.

Conclusion: No evidence in the literature suggests that MEB causes permanent damage to HCIAs. However, MEB in HCIAs may be more prevalent than previously thought. This study indicates that many MEB cases may be missed if HCIAs are not thoroughly screened and assessed. While MEB may not have a clinical impact, it is important to understand the risk of occupational MEB that HCIAs may be exposed to.

Keywords: Hyperbaric oxygen therapy, middle ear barotrauma, hyperbaric chamber ĭ nside attendants

Öz

Amaç: Hiperbarik oksijen tedavisi (HBOT) olanakları ve çeşitli tıbbi alanlardaki kullanımı artmaktadır. Hiperbarik iç yardımcıları (HCIA'lar) çeşitli mesleki tehlikelere maruz kalmaktadır ve bunların arasında en yaygın olanı orta kulak barotravmasıdır (MEB). Bu çalışma, hiperbarik iç yardımcılarında MEB insidansını ve şiddetini prospektif olarak araştırmayı amaçlamaktadır.

Gereç ve Yöntem: HCIA'lar, HBOT seansından önce ve sonra bir kulak burun boğaz uzmanı tarafından otoskopik muayeneye tabi tutuldu ve demografik özellikleri, tıbbi geçmişleri ve otolojik semptomları kaydedildi. MEB geliştirenlerde timpanik membranın görünümü Teed sınıflandırma sistemine göre derecelendirildi. Çalışmada toplanan veriler istatistiksel yazılım kullanılarak analiz edildi.

Bulgular: Araştırmaya HBOT seanslarından önce ve sonra otoskopik muayeneye tabi tutulan 56 HCIA dahil edildi. Çalışma, katılımcıların %21,5'inin MEB yaşadığını ve MEB ile demografik değişkenler arasında anlamlı bir korelasyon olmadığını ortaya koydu. Verilere göre, MEB yaşayan HCIA'ların %25'i ağrı hissetmediğini bildirmiştir.

Sonuç: Literatürde MEB'in HCIA'larda kalıcı hasara yol açtığına dair bir kanıt bulunmamaktadır. Ancak, HCIA'larda MEB daha önce düşünülenden daha yaygın olabilir. Bu çalışma, HCIA'lar kapsamlı bir şekilde taranıp değerlendirilmediğinde birçok MEB vakasının gözden kaçabileceğini göstermektedir. MEB'in klinik bir etkisi olmasa da, HCIA'ların maruz kalabileceği mesleki MEB riskinin anlaşılması önemlidir.

Anahtar Kelimeler: Hiperbarik oksijen tedavisi, orta kulak barotravması, hiperbarik iç yardımcıları

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INTRODUCTION

Barotrauma refers to injuries caused by pressure, such as direct pressurization of the body or the inability of a gas-filled body cavity to equalize pressure when there is no communication with the environment.[1] Middle ear barotrauma (MEB) occurs when a pressure difference between the middle ear and the external environment cannot be equalized. Symptoms include ear pain, tinnitus, and temporary conductive hearing loss. Clinical manifestations of MEB include accumulation of fluid or blood in the middle ear, hemotympanum, or rupture of the tympanic membrane (TM). Depending on the severity of the injury, symptoms may take up to four weeks to resolve.[2]

Hyperbaric Oxygen Therapy (HBOT) is recommended for the treatment of various conditions, including gas embolism, decompression illness (DCI), carbon monoxide poisoning, necrotizing fasciitis, acute traumatic ischaemic injury, and wound healing.[3] HBOT is a procedure in which the individual breathes intermittently near 100% oxygen in a hyperbaric chamber at a pressure higher than sea level.[4] HBOT can be provided in single or multi-place chambers.

During HBOT in a multi-place chamber with a capacity for many patients, patients are accompanied by Hyperbaric Chamber Inside Attendants (HCIAs) who provide technical support, medical care, and emergency intervention. These HCIAs can be nurses, doctors, or paramedics and are responsible for preparing both the patient and equipment before the session and monitoring the patient during the session.[5] HCIAs risk developing barotrauma due to pressure changes and compressed air in the chamber. This can cause harm to various systems and organs in the body. MEB is the most common occupational injury in HCIAs.[6] This study aimed to conduct a prospective investigation into the frequency and severity of MEB among HCIAs. The aim was to demonstrate that the risk may be greater than estimated.

MATERIAL AND METHOD

At the start of the study, ethical approval was obtained from the Noninvasive Clinical Research Ethics Committee of 'BLINDED FOR REVIEW' on 30.11.2021 with registration number 21. All HCIAs were medically screened according to the UHMS Guidelines for Multiplace Inside Attendants Medical Fitness to Work 2018.[7] HCIAs between 18 and 65 years old who were willing to participate were included in the study. Pregnant women, individuals with a history of ear surgery, active upper respiratory infections or ear infections, those who were unable to align the ear at the initial examination, and individuals who experienced confinement anxiety were excluded from the study. Healthcare workers working as HCIAs in the HBOT unit of our hospital between December 2021 and April 2022 participated in the study. All participants were fully informed about the study and gave verbal and written consent. Demographic data, including race, age, sex, weight, height, and medical history, were recorded. A history of atopy and smoking habits of HCIAs was also recorded.

The HBOT unit has a multi-place chamber known as the Hypertech® Quadro Care, which has a capacity of 11+2 patients. The study was carried out during sessions when HCIAs had to monitor patients.

Each participant's tympanic membrane was photographed and recorded after undergoing otoscopic examination by the same otolaryngologist using a Heine® otoscope. The otolaryngologist checked the participants for any septum nasal deviations before the HBOT session. HCIAs were trained before treatment on the importance of MEB and pressure equalization; they were instructed to perform repetitive Valsalva maneuvers during compression and to raise the alarm in case of ear pain or discomfort. The same physician and technician monitored HCIAs outside the pressure chamber for side effects during compression and treatment. HCIAs were instructed to swallow or sip water if the Valsalva maneuver failed to equalize the ear. HBOT sessions were conducted for 90 minutes at a pressure of 2.5 ATA (250 kPa) with 5-minute air breaks every 20 minutes. Our compression rate was 0.75 meters per minute. All HCIAs breathed 100% oxygen from the last 15 minutes of the isobaric phase until leaving the pressurized chamber. During the sessions, other patients were being treated in the same room. At the end of the hyperbaric treatment, participants were asked if they experienced any otological symptoms such as pain, pressure, dizziness, hearing loss, or tinnitus. Immediately following the hyperbaric HBOT session all participants underwent a second otoscopic examination by the same otolaryngologist, and the otoscopic images were photographed again for comparison with the first photograph. The appearance of the TM was graded according to the Teed classification system.[8] The TEED scale is used for the classification of ear barotrauma. Grade 1 is a slight injection of the TM; Grade 2 is a partial hemorrhage of the TM; Grade 3 is a total hemorrhage of the TM; Grade 4 is a blue and bulging hemotympanum; and Grade 5 is a perforated TM.[9]

The study was carried out with the permission of Pamukkale University Noninvasive Clinical Research Ethics Committee (Date: 30.11.2021, Decision No: 21). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Statistical analysis

The data collected in the study were analyzed using a statistical program. The normality test was performed using the Kolmogorov-Smirnov test. The chi-square test was used to analyze the data related to sex, age, body mass index (BMI), smoking status, comorbidities, and septal deviation in MEB after the HBOT session. Pearson's correlation test and Spearman's rho test were used to determine the correlation between the occurrence of MEB and all the other factors (Sex, age, BMI, being a smoker, comorbidity, septal deviation). To determine statistical significance, $p < 0.05$ was considered significant.

RESULTS

We started the study with fifty-eight HCIAs. One HCIA was excluded because of being pregnant, and one HCIA was excluded because of claustrophobia. Fifty-six HCIAs were assessed in the study. Thirty-eight (67.9%) participants were female and eighteen (32.1%) were male. The mean age of the participants was 23.63±3.00 (19-41) years. **Table 1** contains the data related to the demographics and examination findings only four participants had a positive medical history: one with migraine, one with hypothyroidism, one with gout, and one with polycystic ovary syndrome. One was receiving migraine treatment. Septal deviations were detected during pre-compression otolaryngological examinations in eight participants (14.3%).

Table 1. Demographic data and examination results

Demographic data and examination results	Mean ±SD	Min-max
Age (years)	23.63±3.00	19 - 41
Height (cm)	167.57±7.51	150 - 188
Weight (kg)	63.43±12.45	42 - 112
BMI (kg/m2)	22.61±3.58	16.10 – 31.70
	n	%
Gender		
Male	18	32.1
Female	38	67.9
Septum deviation		
Yes	8	14.3
No	48	85.7
Smoking habit		
Smoker	33	58.9
Non-smoker	23	41.1
Barotrauma		
Yes	12	21.5
No	44	83.5
Affected ear		
Right	9	64.3
Left	5	35.7
Bilateral	2	14.3
Barotrauma grade		
Grade 1	6	42.9
Grade 2	4	28.6
Grade 3	2	14.3
Grade 4	2	14.3

BMI: Body Mass Index

A total of 12 participants (21.5%) exhibited evidence of MEB at the post-session examination, with two cases presenting bilaterally. Six (42.9%) of the fourteen ears with MEB were graded by the otolaryngologist as grade 1, four (28.6%) as grade 2, two (14.3%) as grade 3, and two (14.3%) as grade 4 (**Figure 1**). During the study, eight participants with MEB experienced pain. Five participants reported ear fullness, two experienced dizziness, and three had temporary hearing loss. None of these complaints were permanent. On the following day, no further complaints were received.

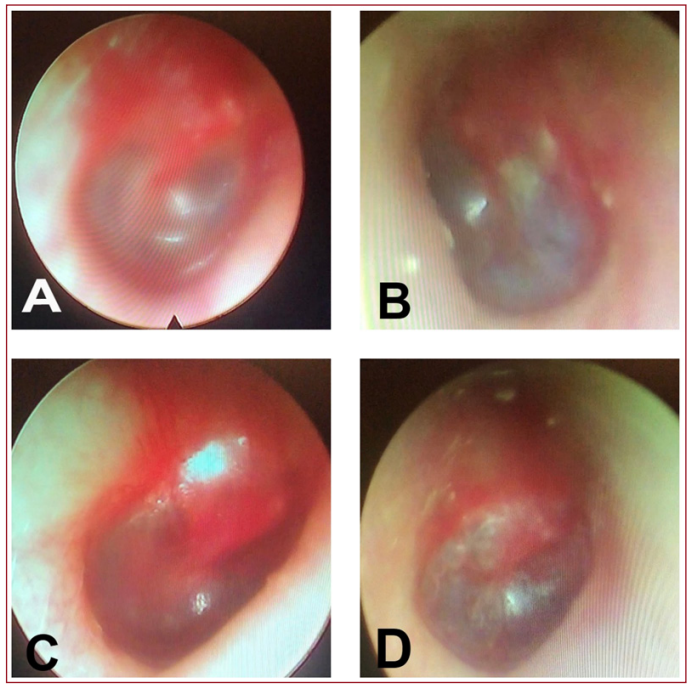

Figure 1: Middle ear barotraumas graded by an otolaryngologist. A: Grade 1, B: Grade 2, C: Grade 3, B: Grade 4.

In the statistical analyses, no association was found between height, weight, BMI, gender, or smoking and the occurrence of MEB ($p > 0.05$). Septal deviation did not statistically increase the risk of MEB (p: 0.514). The rate of MEB was 27.4% in men and 18.4% in women. There was no correlation between grade and height, weight, BMI, gender, smoking, or septal deviation ($p > 0.05$).

DISCUSSION

Implementing proper safety protocols, providing training, and raising awareness about barotrauma can significantly reduce the risks of MEB for individuals working in environments with pressure changes, such as HBOT. Individuals must know the importance of frequent and early ear equalization to prevent MEB. In case of symptoms and visual changes in the TM with an otoscope, it is essential to seek appropriate medical evaluation and management promptly. This will help address potential MEB and prevent complications. Surprisingly, 21.5% of our study participants had MEB.

There are no prospective studies in the literature to support the risk of MEB in HCIAs. Conducting studies on patients may provide valuable insights. In patients treated with HBOT, significant differences in the incidence and prevalence of MEB, ranging from 8 to 94%, have been reported.[10] The reason for the high prevalence in some publications is that the study population was selected from particular groups, such as patients with cerebral palsy or unconscious patients.[11,12] Studies generally defined female sex, older age, and intubation as risk factors.[10,13] Factors such as allergy, septal deviation, smoking, and a history of otitis media are also thought to increase the risk of MEB.[9] In our study,

no statistically significant correlation was found between these variables. The finding of 37.5% MEB in HCIAs with septal deviation appears to increase the risk, although not statistically significant.

In a retrospective study in France reviewing occupational accidents occurring during HCIA, the risk of developing MEB during a session was reported to be 173 per 100,000 compression.[6] Another study reported 1 MEB per 400 compressions in HCIAs.[14] The risk of MEB in HCIAs was found to be relatively low in these retrospective studies. A short delay in ear equalization during compression in HCIAs may result in missed MEB with painless or mild ear pain, which may be overlooked in retrospective studies. Some studies have included grade 2 Teed in grade 1 when grading modified Teed.[15] Taking this into account in our study, we can conclude that 71.5% of participants in our study experienced low-grade MEB that caused little or no pain. It is worth noting that 25% of HCIAs with MEB did not report any pain, which suggests that a considerable number of MEB cases may go unnoticed if not properly investigated and examined.

The fact that these missed MEB were also detected in HCIAs in our prospective study may explain the high unexpected average. In other words, this study revealed the risk of MEB in HCIAs that we would not have been able to detect without testing, which is indeed high. In patients' studies, a retrospective study found the risk of MEB to be 2,8%,[16] while a prospective study found it to be 66.7%.[15] Hyperbaric centers should consider the 21.4% MEB rate.

No permanent ear damage has been reported in divers exposed to pressure changes similar to those experienced by HCIAs.[17,18] While this suggests that pressure changes may not cause permanent damage in HCIAs, this study aims to highlight this issue with a high MEB rate and establish a starting point for further research.

Limitations

The main limitation of the study is its design. A proper incidence analysis typically involves looking at the number of cases per total number of sessions. In this case, calculating an incidence based on only one session could be misleading. The sample size in the clinical study is relatively small, which makes it challenging to capture statistical significance. Additionally, the study did not consider the repeatability of MEB, only whether it occurred in a single session. As a result, the study's findings may not be generalizable since the data were only collected from one HBOT session at a single center.

CONCLUSION

This study indicates that many MEB cases may go unnoticed without proper screening and assessment. Despite the occurrence of MEB, there is no evidence to suggest permanent damage to HCIAs. The study emphasizes the need for comprehensive inspection and monitoring to understand the occupational risk of MEB for HCIAs. The findings imply that the risk of MEBs in HCIAs may be greater than previously thought, highlighting the necessity for further research to comprehend and prevent this occupational injury.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Pamukkale University Noninvasive Clinical Research Ethics Committee (Date: 30.11.2021, Decision No: 21).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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