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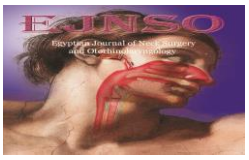

Effects of hyperbaric oxygen therapy on middle and inner functions

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Abstract:

Objectives: The present study aimed to detect the prevalence of middle ear barotrauma (MEB) and eustachian tube dysfunction (ETD) complicating HBOT, identify values of eustachian tube function tests (ETFT) as predictor factor for MEB and estimate the hearing sensitivity of the patients before and after exposure to HBOT.

Patients and methods: A total of 54 patients were recruited from HBOT center regardless their medical condition that required HBOT. ETF tests were performed to all patients before and just after the first session of HBOT and also after the 10th session.

Result: Middle ear barotrauma representing the most common side effects of HBOT by percentage of 38.9% followed by sinus and inner ear barotraumas. There was decreasing in the category of good ears in contrast to increasing in categories of median and bad ears by the effect of exposure to HBOT There was statistically significant association between old age and female sex and occurrence of MEB.

Conclusion; In this study MEB constituted the major percentage of E.N.T (Ear, Nose, Throat) complications after HBOT. There were worsening in the grades of the tympanic membrane (TM) appearance (according to modified Edmond`s criteria) for MEB with successive sessions of HBOT. Eustachian tube function tests were valuable tool in prediction of MEB.

Key words: Hyperbaric oxygen therapy, Middle ear barotrauma, Eustachian tube function tests.

Introduction

Hyperbaric oxygen therapy (HBOT) includes intermittent inhalation of 100% oxygen inside a hyperbaric chamber which is pressurized to greater than sea level pressure. [1]

By use of HBOT, oxygen transported by plasma is significantly increased because of the higher solubility of oxygen when pressure increased so, it could be used to correct tissue hypoxia and aid in the clinical management of different pathological processes. [2]

It is used as a primary treatment in some medical emergent conditions as: decompression illness, air embolism, carbon monoxide poisoning, central retinal artery occlusion. [3]

It also used as an adjuvant treatment in combination with other medical treatments in idiopathic sudden sensorineural hearing loss (ISSNHL, acute acoustic trauma, improvement of tinnitus, malignant otitis externa, mastoiditis and osteomyelitis of the temporal bone, invasive fungal

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infections, enhancement of wound healing, diabetic foot ulcers. [4]

Increasing oxygen pressure in the tissues by increasing atmospheric pressure during therapy may result in complications and MEB which is defined as a pressure-related injury caused by un equalization of pressure between middle ear cavity and environmental pressure. [5]

It is considered the most common complication [6] followed by sinus barotrauma which is the second most common complication of HBOT as the pressure inside the sinus increases, affecting the walls of the sinus and producing pain or epistaxis. [7]

Inner ear barotrauma which is a pressure related pathology in the inner ear with risk of rupture of the round or oval window membranes and damage to sensitive inner ear structures which considered a complication of HBOT. [8]

The primary function of the Eustachian tube (E.T) is to equalize the pressure between the middle ear (ME) and the external environment when barometric changes occurred to maintain middle ear mucosa and TM healthy. [9] So, ETD is the most important cause of MEB.

The symptoms of MEB range from ear discomfort, ear ache, ear fullness and even otorrhagia [10] and its signs consist of TM retraction, mucosal edema, rupture of small blood vessels, and serous effusion or bleeding in ME culminating in a perforated eardrum. [11]

Hyperbaric oxygen therapy complications due to high O2 concentration include: CNS toxicity, Ocular toxicity and Pulmonary toxicity. [12]

Other complications include: Claustrophobia, hypoglycemia and the risk of fire in the chamber.

Patients and methods:

It is an observational cross-sectional study included 54 patients (108 ears), their age ranged from 19 to 65 years (39 males and 15 females). All patients were recruited from center of HBOT for treatment of various diseases from August 2021 to December 2022 and they were clinically evaluated in audiology unit of Assiut general hospital before and after HBOT sessions, informed consents were obtained from all participants after explaining the tests and its purpose to them.

Inclusion criteria of participants:

All patients referred for the HBOT center seeking treatment regardless their medical condition that required HBOT aged from 18 to 65 years old.

Exclusion criteria:

Patients with middle ear effusion, cleft lip, cleft palate and maxillofacial anomalies.

Patients with history of previous otologic operations such as tympanoplasty or mastoidectomy.

Nasal allergy & nasal polyps.

Unconscious patients or those with artificial airways.

The participants were undergoing the following:

(1) **Detailed history** was obtained from all participants before the session.

(2) **Otoscopic examination** was performed to all participants just before the 1st session and within one hour after 1st session and after the 10th session to assess any sign of MEB that was accepted by a higher grade of changes on TM appearance after HBOT sessions and compared with its state before HBOT and graduated in to five grades according to Modified Edmonds scale. [13]

Grade (0) Normal T.M

Grade (1) Redness of T.M

Grade (2) Redness + slight

hemorrhage within T.M
Grade (3) Gross hemorrhage or ME effusion.
Grade (4) Hemotympanum.
Grade (5) T.M perforation.

(3) **Hyperbaric oxygen treatment:**

We used a multiplace hyperbaric chamber (Baromed, Red Sea, Egypt) with capacity of seven persons, model (PC/UL/1600/HBO) at 2.4 ATA (Absolute Atmospheres) and each patient received once daily session (for 90 minutes) of HBOT for ten successive days.

(4) **Eustachian tube function tests:** were performed to all patients in pre 1st, post 1st session and post 10th session:

A. **Toynbee and valsalva maneuvers** (for patients with intact TM); Tymapanometry is programmed to measure the middle ear pressure (MEP) in 3 conditions: -

1. **Resting middle ear pressure:** It is the MEP which measured in the ear at the start of the test (resting pressure) before doing any pressure equalization by the patient and this could be classified according to the Jerger (1970) [14] (classification into three types according to shape: A, B and C tympanograms.
2. **After recording the resting MEP;** Toynbee maneuver was done; the patients were asked to swallow a sip of water while pinching the nostrils [15] and the MEP after swallowing was recorded and it considered positive test when an alteration in MEP (values above 20 daPa) towards negative pressure side on tympanogram indicating that the ET is most likely to be normally function functions. [16]
3. Five minutes intervals were allowed and the patient was instructed to drink water in an attempt to return the MEP to baseline values.
4. The resting MEP was measured again.
5. Valsalva maneuver was done as patients instructed to pinch the nostrils and inflate the cheeks through forced expiration with the mouth closed during which the MEP was recorded and it considered positive test when an alteration in MEP (values above 20 daPa) towards positive pressure side of the tympanogram indicating most likely normal ET functions. [16]
6. Five minutes intervals were allowed with instruction for the patient to drink water before doing the E.T.F tests for the other ear (resting MEP, Toynbee test, valsava test) by the same manner.

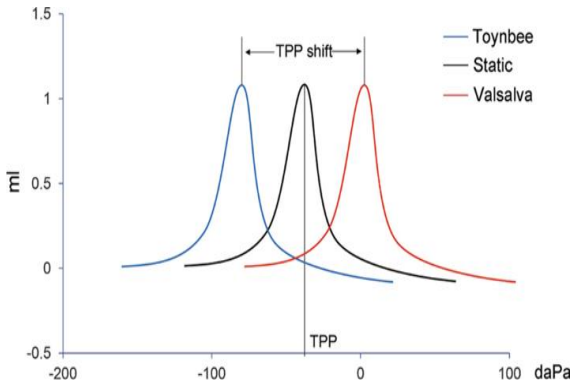

Figure (1) showed the changes in the resting MEP after valsalva and Toynbee maneuver quoted from lingwein et al; [17]. (TPP) : Tympanometric peak pressure.

According to the outcomes of these tests either positive or negative tests, the following groups of ears were obtained:

- Good ear: with positive Valsalva and Toynbee maneuvers.
- Median ear: with only one positive maneuver (Valsalva or Toynbee).
- Bad ear: with negative Valsalva and Toynbee maneuvers.

B. **Modified** inflation-deflation test (For patients with non-intact TM) after confirmation of dryness by the following steps **:**

1. The probe of tympanometry was fitted into the external auditory canal (EAC) with positive pressure (typically 100 –300 mm H2O) [18] or until the ET passively opens.
2. The patient is then asked to swallow repeatedly three times at intervals of 3-5.
3. seconds with nose and mouth closed until no further MEP changes were detected and the residual pressure (RP) plateau is reached.
4. The procedure is then repeated by applying a negative pressure of similar magnitude.
5. The residual pressure and number of swallows required to reach it were recorded.
6. Tympanometry is programmed to artificially increase or decrease the air pressure in the middle ear and then record graphically the change of air pressure in the middle ear each time when the patient swallows.
7. Changes of pressure during swallowing were recorded as step ladder type of graph that is normal.

ET function was evaluated and graded with reference to RP in the middle ear after each application of positive or negative pressure [19] as**;**

- Grade I: completely equilibrated to both positive and negative pressures**.**
- Grade II: partially equilibrated to both positive and negative pressures (Pr>10 daPa and <-10 daPa, respectively)**.**
- Grade III: completely or partially equilibrated to positive pressure but, could not equilibrate to negative pressure **.**
- Grade IV: could not equilibrate to either positive or negative pressure.

(5) **Basic audiological evaluation**:

(a) Pure tone audiograms (PTA) and Speech audiometry were obtained from all patients at the initial visit and at the end of the 10th session.

(b) Tinnitus handicap inventory questionnaire (THI): (only from patients who suffering from tinnitus): It must be fulfilled before and after HBOT sessions**.**

(6) **Vestibular tests**: only for patients who complaining of vestibular abnormalities during or after the sessions through**:**

(a)Detailed history was obtained about the vertiginous attacks regarding; character, frequency, duration and severity of attacks**.**

(b) Videonystagmography (VNG) testing**:**

It could detect nystagmus in response to various stimuli to allow distinguishing between central and peripheral vertigo**.** [20]

VNG testing consisted of:

1. Spontanous nystagmus test**.**
2. Oculomotor functions: gaze, fixation, saccade, pursuit and optokinetics tests**.**
3. Positioning and positional tests**.**
4. Caloric tests.

Statistical analysis:

The collected data were revised, organized, tabulated and statistically analyzed using statistical package for social sciences (SPSS) version 22.0 for windows. Data are presented as the Mean ± standard deviation (SD), frequency, and percentage. Categorical variables were compared using the chi-square ($\chi 2$) test. Continuous normally distributed data were compared by the student t test (two-tailed)

Pearson correlation was used to study the correlation between the continuous

variables. The level of significance was accepted if the P value < 0.05.

Results

Demographic data:

The study group consisted of 54 patients (108 ears) of both sexes 39 males (72%) and 15 females (27.8%), their age ranging from 19 to 68 years with mean 41.93 ± 14.83 years.

One hundred and one ears with intact T.M and seven ears with perforated TM.

Three patients (6 ears) did not complete treatment to the tenth session. So, our sample in the post 10th session was (102 ears); (95 ears) with intact TM and (7 ears) with perforated TM.

In this study most of patients who required HBOT are those with ear disease conditions representing 14/ 54 (26%) of cases; 7 cases with SSNHL (13%) and 7 cases with tinnitus (13%) followed by 10 cases (18.5%) with diabetic foot lesions and 8 cases (14.8%) with mandibular osteomyelitis.

Hyperbaric oxygen therapy complications.

In this study which included 54 patients, E.N.T complications represented the highest percentage among other complications of HBOT which were recorded in 24 patients (44.4%), MEB represented the main of these E.N.T complications (87.6%) which occurred in 21 of 24 patients and only one patient complicated by IEB that manifested by true vertigo (spinning attack, vomiting with nystagmus) but, she refused to do the laboratory vestibular assessment. On the other hand, there were 28 patients (51.9 %) representing no complications of HBOT.

Grades of modified Edmonds criteria in pre & post HBOT sessions.

There was statistically significant worsening in grades of modified Edmonds in post 10th session in comparison to pre 1st and post 1st session in both right and left ears.

Eustachian tube function tests:

There was statistically significant increasing in numbers of ears with bad category and decreasing in No. of ears with good category in post 10th session compared to No. of ears both in pre and post 1st session for both ears.

In our study there was no improvement in E.T functions in ears with perforated drums by using modified inflation – deflation test due to presence of edema in ME mucosa in spite of cessation of discharge after HBOT sessions (four ear with wet perforations were changed to dry perforation).

Regarding the risk factors for MEB, there were increasing in percentage of occurrence of MEB with increasing the age of the patients and also with female patients who showed high percentage of occurrence of MEB (48%) in comparison to MEB in male patients (25.7%) with statistically significant differences in post 10th session of HBOT.

Results of pure tone audiometry

There were no statistically significant differences in air conduction threshold at all frequencies (250-8000 HZ) in both ears between pre 1st & post 10th HBOT sessions. There were neither statistically significant differences SRT, nor WRS in both ears between pre 1st & post 10th sessions.

Also, there were no statistically significant differences in air conduction threshold at all frequencies (250-8000 HZ) in both ears between pre 1st & post 10th HBOT sessions in the 24 ears that were complaining of sensorineural hearing loss.

Although cases with CSOM in post 10th session recorded better air conduction threshold at nearly all frequencies (250- 8000 HZ) in both ears compared to pre 1st session threshold.

but these differences did not reach the statistically significant difference. There were no statistical differences in SRT nor WRS in both ears between pre & Post sessions.

There were no statistically significant differences in bone conduction thresholds at frequencies (500- 4000 HZ) in all patients exposed to HBOT between both ears in pre & post sessions.

There was improvement in the air conduction thresholds in only one case of the seven cases of ISSNHL who came early within three days of the disease onset and with moderate degree of hearing loss after completion of successive ten sessions of HBOT in combination with corticosteroids, the hearing threshold of the patient returned to normal level except dipping at 4 KHz down to mild hearing loss due to occupational noise exposure.

There was decreasing in THI score in patients in post 10th HBOT session in comparison to pre 1st session of HBOT. But, with no statistically significant differences.

Table (1): Complications that were reported among all participants during the sessions of HBOT.

Complications Of HBOT	**No. of patients (n=54)**	**Percentage**
E.N.T complications:	**(24)**	**(44.4) %**
1-Middle ear barotrauma (According to modified Edmonds scale)	21	38.9%
2- Sinus barotrauma (Epistaxis)	2	3.7%
3- Inner ear barotrauma (Vertigo)	1	1.8%
Other complications:	**(2)**	**(3.7) %**
1-Hypoglycemia	1	1.85%
2-Claustrophobia	1	1.85%
No complications:	**(28)**	**51.9 %**

Table (2): Comparison of grades of MEB among ears with intact T.M in pre 1st, post 1st and post 10th session of HBOT according to modified Edmonds criteria by using parried T test.

Session time	Grades of modified Edmond	Right ears		Left ears		P-value[1] (Rt – Lt ear) Student T test
		No.	%	No.	%	
Pre 1st session (n= 101 ears) Rt. ears= 50 Lt. ears= 51	**Grade 0**	47	94%	45	88.2%	0.573
	Grade 1	3	6%	6	11.7%	
	Grade 2	0	0.0%	0	0.0%	
	Grade 3	0	0.0%	0	0.0%	
	Grade 4	0	0.0%	0	0.0%	
	Grade 5	0	0.0%	0	0.0%	
Post 1st session (n= 101 ears) Rt. ears= 50 Lt. ears= 51	**Grade 0**	43	86%	43	84.3 %	0.368
	Grade 1	4	8%	2	4%	
	Grade 2	3	6%	6	11.7%	
	Grade 3	0	0.0%	0	0.0%	
	Grade 4	0	0.0%	0	0.0%	
	Grade 5	0	0.0%	0	0.0%	
P- value [2] (Pre & Post 1st session) Paired T test.		0.739		0.791		
post 10th session (n= 95 ears) Rt. ears= 47 Lt. ears= 48	**Grade 0**	30	63.8%	33	68.7%	0.190
	Grade 1	8	17 %	6	12.5%	
	Grade 2	6	12.8%	6	10.4%	
	Grade 3	2	4.2%	2	4.1%	
	Grade 4	1	2.1%	1	2 %	
	Grade 5	0	0.0%	0	0.0%	
P- value [3] (Post 1st & post 10th session) Paired T test.		**0.017***		**0.038***		
P-value[4] (pre 1st & post 10th session) Paired T test		**0.002***		**0.044***		

Grade (0) Normal T.M. **Grade (1)** Redness of T.M.
Grade (2) Redness slight hemorrhage within T.M. **Grade (3)** Gross hemorrhage or ME effusion.
Grade (4) Hemotympanum. **Grade (5)** T.M perforation.

Table (3): Results of Valsalva and Toynbee maneuvers in patients with intact T.M in pre & post HBOT sessions.

Category of ear	Right ears		Left ears		P-value[1] (Rt &Lt ear) Student T test
	No.	**%**	**No.**	**%**	
Pre 1st session (n=101) ears (Rt. ears= 50 & Lt. ears= 51)					
Good	40	80%	37	72.5%	
Median	9	18%	12	23.5%	0.757
Bad	1	2%	2	4%	
Post 1st session (n=101) ears (Rt. ears= 50 & Lt. ears= 51)					
Good	38	76%	36	70.5%	
Median	11	22%	13	25.5%	0.451
Bad	1	2%	2	4%	
P-value[2] (Pre & Post 1st session) Paired T test	0.968		0.767		
Post 10th session (n= 95) ears (Rt. ears= 47 & Lt. ears= 48)					
Good	20	42.6%	20	41.7%	
Median	18	38.3%	20	41.7%	0.926
Bad	9	19.1%	8	16.6%	
P-value[3] (Post 1st & Post 10 th session) Paired T test	**0.000***		**0.005***		
P -value 4 (Pre 1st & post 10th session) Paired T test	**<0.001****		**0.005****		

Good: ears with positive both tests. **Median**: ears with one positive and one negative test.
Bad: ears with negative both tests.

Table (4): Comparison of (PTA) of air conduction threshold (mean ±SD) in (65) ears with normal peripheral hearing threshold at frequency range (250- 8000) HZ in dB HL in pre 1st & post 10th HBOT sessions using paired 'T' test.

Frequency	Session time	Right ears	Left ears	P-value[1] Student T test
250 Hz	**Pre 1st sessions:**			
	Mean ± SD	10.17 ± 4.04	10.15 ± 6.09	0.453
	Median (Range)	10.0 (5.0-20.0)	10.0 (5.0-25.0)	
	Post 10th sessions:			
	Mean ± SD	12.78 ± 8.13	12.26 ± 9.02	0.402
	Median (Range)	10.0 (5.0-40.0)	10.0 (5.0-40.0)	
	P-value[2] (Paired T test)	0.102	0.101	
500 Hz	**Pre 1st sessions:**			
	Mean ± SD	10.00 ± 4.73	10.00 ± 5.64	0.743
	Median (Range)	10.0 (5.0-25.0)	10.0 (5.0-25.0)	
	Post 10th sessions:			
	Mean ± SD	12.22 ± 8.47	12.10 ± 8.54	0.839
	Median (Range)	10.0 (5.0-40.0)	10.0 (5.0-40.0)	
	P-value[3] (Paired T test)	0.102	0.072	

1000 Hz	**Pre 1st sessions:**			
	Mean ± SD	13.83 ± 6.11	12.06 ± 5.92	0.220
	Median (Range)	15.0 (5.0-25.0)	10.0 (5.0-25.0)	
	Post 10th sessions:			
	Mean ± SD	15.56 ± 8.01	13.71 ± 7.30	
	Median (Range)	15.0 (5.0-35.0)	15.0 (5.0-30.0)	0.335
	P-value[4] (Paired T test)	0.223	0.266	
2000 Hz	**Pre 1st sessions:**			
	Mean ± SD	14.83 ± 5.49	14.41 ± 5.74	0.722
	Median (Range)	15.0 (5.0-25.0)	15.0 (5.0-25.0)	
	Post 10th sessions:			
	Mean ± SD	15.93 ± 7.21	15.48 ± 6.50	0.891
	Median (Range)	15.0 (5.0-30.0)	15.0 (5.0-30.0)	
	P-value[5] (Paired T test)	0.167	0.102	
4000 Hz	**Pre 1st sessions:**			
	Mean ± SD	16.17 ± 5.97	15.59 ± 5.74	0.657
	Median (Range)	15.0 (5.0-25.0)	15.0 (5.0-25.0)	
	Post 10th sessions:			
	Mean ± SD	17.41 ± 6.26	15.81 ± 5.79	0.280
	Median (Range)	20.0 (5.0-25.0)	15.0 (5.0-25.0)	
	P-value[6] (Paired T test)	0.591	0.564	
8000 Hz	**Pre 1st sessions:**			
	Mean ± SD	15.33 ± 6.81	17.35 ± 4.48	0.328
	Median (Range)	17.5 (5.0-25.0)	15.0 (5.0-25.0)	
	Post 10th sessions:			
	Mean ± SD	15.93 ± 6.51	16.77 ± 3.77	0.993
	Median (Range)	20.0 (5.0-25.0)	15.0 (5.0-25.0)	
	P-value[7] (Paired T test)	0.180	0.102	

Discussion:

Middle ear barotrauma constituted the major percentage of ENT complications in this study by (38.9%) Table (1) and this in agreement with study by **Plafki, et al. 2000** [21] who reported that the MEB is the most common side effects of HBOT and with **Karahatay et al. 2008** [22] who reported that the incidence of MEB ranged from 8- 68.7%. But It Is in disagreement with a study by **Ferrnau et al. 1992** [23] who reported the highest incidence of MEB (82%) among all previous studies and this is attributed to the selection of their study group regardless of history of ETD and without performing E.T.F tests before the exposure to HBOT.

Sinus barotrauma considered the second complication of HBOT after MEB by an incidence of (3.7%) Table (1).

Inner ear barotrauma, hypoglycemia and clastrophobia complications after HBOT occurred in low incidence of 1.8% Table (1) and this was in agreement with studies conducted by **Drubbel et al. 2019**. [24]

In this study there were worsening in the grades of the T.M (according to

modified Edmond`s criteria) for MEB with successive sessions of HBOT Table (2).

The ears which not complicated with MEB after the 1st session of HBOT were significantly less likely to be complicated during the subsequent sessions Table (2) and this in a line with the study by **Karahatay et al. 2008** [22] who observed that ears that were not traumatized after the first session were significantly less likely to be traumatized during the subsequent six days of therapy.

In our study, there was no grade 5 barotrauma (T.M perforation) in post 1st session Table (2) and this agrees with **Lima et al. 2012** [13] who found no grade 5 barotrauma in post 1st HBOT session.

None of the ears with grade 1 MEB in pre 1st session were improved in post 1st nor in post 10th session of HBOT; they became either at the same grade 1 or become worse Table (2) and this in agreement with the study presented by **Karahatay et al. 2008** [22] who reported that none of the ears with grade 1 barotrauma following the initial HBOT session were better any more by the end of the therapy.

The ears that were not complicated by MEB in post 1st session of HBOT were significantly less likely to be traumatized during the subsequent sessions of HBOT; 63 ears of 95 ears in post 10th session (66.3%) not develop MEB.

This is in agreement with the study by **Karahatay et al. 2008** [22] who reported the importance of the otoscopic examination findings immediately after the first HBOT session and the incidence of MEB with subsequent sessions.

This study reported that there was worsening in E.T functions that showed decreasing in the category of good ears in contrast to increasing in categories of median and bad ears by the effect of exposure to HBOT Table (3) and this in agreement with James et al., 1992 [25] who theorized that HBOT made an atmospheric compression factors placed on the TM , E.T and mesotympanm rendering the patients to be not able to equilibrate the MEP.

Both median and bad ears showed worsening in grading in post 10th session of HBOT in comparison to their grades in pre 1st session Table (3) and this considered predictive factor for MEB and this in agreement with the study conducted by **Lima, et al., 2012.** [23]

This study found that HBOT was neither worse nor affect the air conduction thresholds of hearing in patients with normal peripheral hearing (table 4) and this in agreement with the studies by Lam **k et al. 1998** [26] who reported that HBOT has a beneficial effect by increasing the partial oxygen pressure in inner ear fluids that nourish the sensory and neural elements of the cochlea so it has not worsen the normal hearing of the patients any more.

Conclusion

This study adds more proved evidence to the fact that difficulty in equalizing pressure between the environmental and the middle ear pressure due to E.T.D is the most predicting factor for MEB secondary to HBOT.

Pathological changing in the otoscopic finding of the TM after the HBOT session even if these finding are minor or temporarily changes, it could predict MEB.

The reported risk factors for MEB in this study are:

1. Repeated exposure to HBOT was a risk factor to MEB.
2. Eutachian tube functions tests by Valsalva and Toynbee tests for intact TM and by modified inflation deflation tests for perforated TM are a valid indicator of ET function that

can be used to identify groups at risk for developing MEB following exposure to HBOT.

Old age and female sex patients were more subjected to MEB.

Exposure to HBOT could not worsen the hearing of the patients.

Only one patient complained of vertigo after HBOT session, V.N.G test battery should be done to assess the vestibular function but, the patient refuses to do the test.

Funding support: None.

Conflicts of interest: None.

List of abbreviations:

HBOT	Hyperbaric oxygen therapy
MEB	Middle ear barotrauma
E.T. D	Eustachian tube dysfunction
E.T.F. T	Eustachian tube function tests
E.N. T	Ear, Nose, Throeat
TM	Tympanic membrane
ISSNHL	Idiopathic sudden sensorineural hearing loss
E. T	Eustachian tube
ME	Middle ear
TPP	Tympanometric peak pressure
EAC	External auditory canal
RP	Residual pressure
PTA	Pure tone audiometry
THI	Tinnitus handicap inventory
VNG	Video nystagmography
SPSS	Statistical package for social sciences
SD	Standard deviation
SRT	Speech reception threshold
WRS	Word recognition score

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