



Incidence of Middle Ear Barotrauma following Ten-Meter Chamber Bounce Dives for Naval Diver Selection

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Introduction

- Middle ear (otitic) barotrauma is the incidence of ear pain or fullness, or injury to the tympanic membrane, due to changes in ambient pressure.
- It is the commonest complication in diving and hyperbaric oxygen therapy (HBOT). HBOT studies quote incidences of symptomatic barotrauma of 17.7% to 37%, and asymptomatic barotrauma of 7.5% to 11%.
- Some militaries and commercial firms use hyperbaric chambers to conduct bounce dives for diver selection.
- As the descent rate in a chamber bounce dive is externally-controlled, otitic barotrauma may occur especially in first-time divers who are not accustomed to middle-ear pressure equalization.

Objectives

- To determine the incidence of symptomatic and asymptomatic middle ear barotrauma following 10-meter chamber bounce dives for naval diver selection
- To identify any predictive factors for middle ear barotrauma, such as age and medical history.

Methods

- 183 male subjects, with a mean age of 20.4 yrs (min 18 yrs, max 45 yrs), each underwent a 10-meter bounce dive in a multiplace chamber at the Naval Underwater Medicine Centre, Singapore from August to November 2006.
- The pre-dive medical examination included otoscopy, tympanometry, audiometry and otoscopic visualization of tympanic membrane mobility.
- A questionnaire to identify medical history related to Eustachian tube dysfunction was administered.
- The descent rate of the chamber was as fast as could be tolerated. Descent was slowed or stopped when an individual complained of ear symptoms, then resumed where possible. The bounce dive was aborted if the total elapsed descent time was greater than 15 min.
- A symptom questionnaire was administered post-dive.
- Otoscopy was performed for all subjects and the images recorded using a video otoscope.
- Barotrauma was diagnosed from symptoms and otoscopic signs and graded according to a modified Teed's Classification.

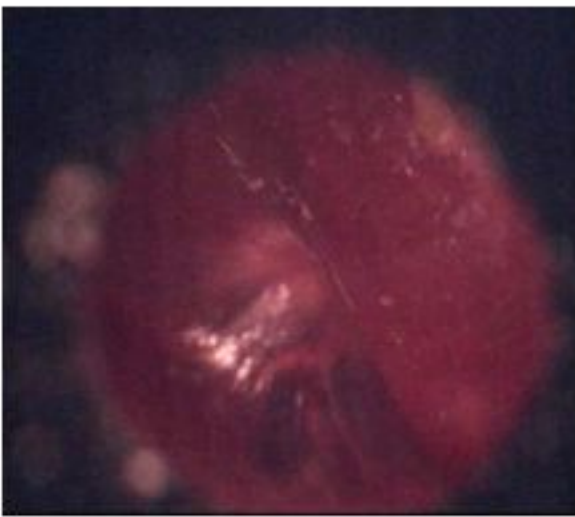
Results

Table 1: Incidence of Symptomatic and Asymptomatic Barotrauma (n=183)

		Incidence (%)
Symptomatic barotrauma	Without otoscopic signs	2.7%
	With otoscopic signs	4.9%
Asymptomatic barotrauma		3.8%
Total (symptomatic + asymptomatic)		11.4%

Table 2: Distribution of Severity of Barotrauma

Teeds' Score	Number of ears (n=366)	% of ears	% of ears with abnormal otoscopy
0	5	1.4	-
1	14	7.5	73.7
2	3	0.82	15.8
3	2	0.54	10.5
Normal	342	93.4	



Tympanic membrane of subject with Teeds' 3 barotrauma

- Most (73.7%) of the barotrauma was Teeds' 1 (mild), including all the asymptomatic cases. 3 subjects had bilateral barotrauma.
- The only medical conditions which were associated with a statistically significant risk of middle ear barotrauma were:
 - history of ear injury
 - previous nose surgery (for deviated septum)
 - symptoms of sinusitis within the same week of the dive (see Table 3)

Table 3: Correlation of Risk Factors with Middle Ear Barotrauma (* indicates 95% level of significance using Pearson's Chi-squared test)

	P Value
Age (21 and under, or above 21 years)	0.929
History of Sinusitis	0.148
History of Middle Ear Infection	0.718
History of Nose Injury	0.231
History of Nose Surgery	0.005*
History of Ear Injury	0.005*
History of ear pain during commercial flights	0.600
Recent sinusitis within the last week	0.015*
Recent "cold" during the last week	0.891
Recent sore throat within the last week	0.814

- The mean compression rate in this study was 2.08 m/min (median 1.67 m/min). There was no difference in barotrauma incidence between slow (up to 1.1 m/min), intermediate (1.1 to 2.8 m/min) and fast (> 2.8 m/min) rates of descent.

Discussion

- The incidence of barotrauma of 11.5%, one third of which were asymptomatic, was lower than that in HBOT studies. This is likely to be because of the military fitness selection process as well as the stringent pre-dive medical screening.
- Visualization of tympanic membrane movement (while performing the Valsalva maneuver) has been suggested to be a predictive factor for Eustachian tube function in previous studies.
- The institution's current practice of performing otoscopy only on divers with ear symptoms after the dive may be continued, as the cases of asymptomatic barotrauma were all Teeds' 1 (mild) and managed conservatively.
- The compression rates of the dives performed in this study varied considerably. The mean compression rate in this study was also slow compared to the standard HBOT compression rate of 2.8 m/min. Although there is no international standard for the speed of selection bounce dives, the acceptable rate of descent should be set within narrower limits, and cross-referenced with other institutions.
- This study showed that otitic barotrauma occurs in a small but significant percentage of novice bounce divers despite stringent medical selection criteria, without an apparent relationship to most pre-existing middle-ear and sinus conditions, or the speed of the bounce dive.
- A possible cause for middle ear barotrauma in these subjects may be poor auto-insufflation technique (not performing Valsalva forcibly or frequently enough). Diving may not be contra-indicated in these subjects, after adequate training and experience – thus passing a single bounce dive may not be an essential criterion in the diver selection process.
- However divers who have symptoms or injury during the bounce dive may have marginally patent or narrowed Eustachian tubes, and may have difficulty diving in certain positions (such as during head-down descent where soft tissue further obstructs the tube) or have a higher incidence of training injury.
- The chamber bounce dive also provides a controlled environment to identify divers with other contra-indications to diving, such as anxiety or claustrophobia, or pre-disposition to pulmonary or sinus barotrauma, although these complications are very rare.

Conclusion

- A small incidence of barotrauma, which is usually self-limiting or requires minimal medical treatment, may be an acceptable risk for chamber bounce dives to be used as part of the diver selection process. However proper instruction on auto inflation is required to avoid unnecessary attrition from poor technique. The value of chamber bounce dives in identifying divers with predisposition to training injury could be studied prospectively in militaries which screen and train large numbers of divers annually.