Technical Communications

AN INVESTIGATION OF EAR TRAUMA IN DIVERS INCLUDING EAR BAROTRAUMA AND EAR INFECTION

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Mawle SE & Jackson CA: An investigation of ear trauma in divers including ear barotraumas and ear infection. European J Underwater Hyperbaric Med 2002; 3(1): 47-50 - A sample of 142 divers including technical, recreational and instructors were examined via postal questionnaire to determine prevalence of ear barotrauma, related barotrauma symptoms and middle ear infection. Sixty-four percent of divers reported symptoms of barotrauma, which included pain (47.9%), temporary deafness with tinnitus (27.5%) and vertigo (9.9%). The prevalence of middle ear infection was present in over a third of the total sample (37.3%), and were significantly more prevalent in the left ear than the right ear (P=.016). Consistently wearing a hood when diving was associated with greater barotrauma symptoms than wearing a hood only in cold conditions (P<0.00). A significant relationship was found between barotrauma symptoms and diver separation (P<0.00), and the implications are discussed with relevance to the finding that nearly 27% of divers reported incidents involving separation from buddies when diving.

Ear barotrauma, ear infection, diving

Introduction

Barotrauma, in general terms, is documented as the most common medical problem in divers (1). Like most other sports there are health risks associated with diving that can be significantly reduced by 'safe' practice (2). Barotrauma is an injury that occurs due to the result of rapid or extreme changes in pressure, and is defined as tissue damage resulting from expansion or contraction of enclosed air spaces as a result of such pressure changes, the greatest occurring near to the water surface (3). The sensation of increased pressure in the ear is commonly called 'ear squeeze' amongst divers, where the diver needs to 'equalize' by driving air from the throat through the eustachian tube to the middle ear. Failure to increase gas in the middle ear to be equal with the ambient water pressure can lead to barotrauma of descent and possible rupture of the tympanic membrane. Any condition that blocks the eustachian tube predisposes individuals to middle ear barotrauma (4). It is not clear if ear infections are related to ear barotrauma either as a causal agent or as a result of barotrauma itself (1).

Methods

This cross-sectional study used anonymous postal questionnaires containing a range of self reported outcome measures related to symptoms associated with barotrauma. A pilot study for the questionnaire was conducted at the Excel dive exhibition in London in March 2001, where comments made by divers completing the questionnaire were incorporated into the final questionnaire design. The refined questionnaire collected data concerning demographic information, diving activities, incidences of diving problems, illnesses and treatments sought for any conditions. The questionnaire defined the symptoms and conditions of: Barotitis media, Chronic media otitis, and Barotrauma. Exclusion criteria rejected divers who had completed less than one year as divers, and divers without a recognised qualification (e.g. British Sub-Aqua Society (BSAC), Professional Association of Diving Instructors (PADI), or the National Association of Underwater Instructors (NAUI)). The population was comprised of divers registered at eight dive schools in the UK, and 300 questionnaires were distributed equally amongst the schools by the postal system. Respondents were able to return their completed questionnaires using pre-paid self-addressed envelopes.

Table 1: Methods used by divers to equalise ear pressure

Action	N	%
N/A	89	62.7
Ascend	19	13.4
Valsalva	13	9.2
Decongestants	5	3.5
Don't dive	4	2.8
Persist	3	2.1
Abort	2	1.4
Slow down	1	0.7

Results

A total of 142 divers (47.3%) completed the questionnaire; the majority of which were recreational divers (n=80, 56.3%) followed by dive instructors (n=44, 31%) and technical divers (n=18, 12.7%). Mean age of divers was 37.8 years ± 10.2, ranging from 17 to 70. Of the sample, 101 (71.1%) divers had experienced a problem equalizing their ears while diving. Because some divers had a total dive exposure of less than 100 dives, a time weighted exposure percentage was calculated in relation to divers with a problem equalizing, and the total dive exposure time with difficulty of ear clearing was calculated. The number of diving years and frequency of dives over diving years were used to calculate the percentage of time divers experienced equalizing difficulties, and was expressed thus:

$$\textit{Equalizing difficulties (\%)} = = \frac{100}{\textit{Dive frequency} \times \textit{Equalizing problems}}$$

The results of this indicated how often divers presented with clearing difficulties whilst diving. Fifty percent (n=71) suffered clearing problems between 1-10% of the

time, nine percent (n=13) suffered between 11-20%, five percent (n=7) suffered between 21 - 90%, and seven percent (n=10) suffered between 91-100% of the time.

Equalizing

Divers were asked what actions they took if they had trouble equalizing their ears. The majority of divers claimed this was not applicable to them, and the various methods of equalizing are shown in table 1. The following barotrauma symptoms were measured, and divers were requested to confirm which they had experienced at any time: blood, pus, temporary deafness, tinnitus, vertigo, nausea, vomiting, disorientation and pain. Fifty-one divers (35.9%) experienced no symptoms, 47 (33.1%) experienced one symptom, 15 (10.6%) experienced 2 symptoms, 20 (14.1%) experienced 3 symptoms, 4 (2.8%) experienced 4 symptoms, 4 (2.8%) experienced 5 symptoms, and 1 person (0.7%) experienced all 6 symptoms.

Barotrauma and symptoms

Sixteen divers (11%) confirmed that they had been diagnosed with barotrauma previously, and the number of known barotrauma symptoms reported by this group were compared with the symptoms reported by divers never diagnosed with barotrauma (n=126). There was a highly significant difference (P=.002) in the mean number of symptoms reported by barotrauma cases (2.2 ± 1.5) compared with non-cases (1.1 ± 1.2).

It was found that 54 (38%) of the divers had suffered with middle ear infections, and 88 (62%) had not. Twenty-nine divers (20.4%) only experienced one infection, although up to 10 separate infections were reported by one respondent. In comparing those with and without ear infections, significantly more barotrauma symptoms were reported by those with ear infections (1.9 ± 1.5) than those without (0.85 ± 1, P<0.00). Even though symptoms overlap in all cases of barotrauma, the specific symptoms of different barotrauma types were categorized as indicated by dive literature (1): descent barotrauma consisted of pain; ascent barotrauma consisted of tinnitus and hearing loss; and inner ear barotrauma consisted of tinnitus and vertigo. The relationships between the symptoms reported for each type of barotrauma and ear infection status were investigated and shown in table 2. A significant difference was found (P=0.01) between those with and without middle ear infections and reporting of symptoms consistent with ascent barotrauma, to the detriment of those with middle ear infection.

Ear infection treatment

Of the 54 divers reporting previous ear infections, 15 (28% of ear infections) were bilateral infections, 12 (22%) concerned the right ear, and 27 (50%) concerned the left ear. Irrespective of bilateral infections, there was a greater number of infections occurring in the left ear (P=0.01). Divers were asked about possible treatments of their ear infections: 39 divers (72% of those with ear infections) sought professional treatment (GP, health centres, A&E services) and 15 (28%) sought other, non-professional treatments (self-medication, colleagues, or none). Reoccurrence of ear infections were measured to compare any benefit between the two treatment groups, and no significant difference was found (P=0.29).

Hood wearing

To identify possible risk associations with ear problems when diving, hood wearing was measured in terms of when divers wore a hood to dive (worn all the time, only in cold water, or never). Eleven (7.7%) never wore a hood, 66 (46.5%) wore a hood all the time when diving, and 65 (45.8%) only wore a hood in cold water. Divers who wore a hood in all dives had significantly more barotrauma symptoms (1.6 ± 1.5) than those divers who only wore a hood in cold conditions (0.8 ± 1, P<0.00). Further, it was found that divers who wore a hood all the time were more likely to suffer symptoms of barotrauma than those who wore a hood only in cold water (P<0.01). Symptoms of barotrauma were divided into those which represented ascent, descent and inner ear barotrauma, and the relationship with hood-wearing behaviour was investigated, with a significant difference found between hood-wearers on symptoms of ascent barotrauma only (P<0.00), as shown in table 3, to the detriment of those who permanently wore hoods.

Buddy separation

Divers were asked if they had ever separated from their buddy on a dive due to an ear problem, and 38 divers (26.8%) confirmed this. Those divers who had been separated from their buddy on a dive had greater symptom scores (1.9 ± 1.5) than those who had not separated (1 ± 1.1, P<0.00). There was no difference in the number of divers with/without symptoms consistent with descent barotrauma between the separated and not separated divers (20/18 and 46/58 respectively, P=0.37) but there was in the number of ascent barotrauma symptoms (27/11 and 93/11 respectively, P<0.00).

Table 2: Cases of ear infection and symptoms consistent with three barotrauma types

Symptoms of barotrauma type		Past ear infection	No ear infection	X^2	P
Inner ear barotrauma	Yes	3	2	0.36*	0.55
	No	50	87		
Descent barotrauma	Yes	26	40	0.23	0.63
	No	49	27		
Ascent barotrauma	Yes	14	8	6.43*	0.01
	No	39	81		

* signifies use of Yates' correction for continuity when cell values were <10

Table 3: Hood-wearing behaviour and symptoms consistent with three barotrauma types

Symptoms of barotrauma type		Hood always	Hood in cold	X^2	P
Inner ear barotrauma	Yes	4	1	0.8*	0.37
	No	62	64		
Descent barotrauma	Yes	31	30	0.01*	0.93
	No	35	35		
Ascent barotrauma	Yes	17	4	7.95*	.004
	No	49	61		

* signifies use of Yates' correction for continuity when cell values were <10

Discussion

The incorrect use of methods to equalize ear pressure is a common cause of ear barotrauma (1). In this study, 71% of divers encountered a problem clearing their ears, and the largest single group of those (n=71) reported clearing difficulties between 1-10% of the time.

Some divers explained they had clearing difficulties due to reasons ranging from deviated septum to eustachian tube problems, previous studies have found some divers more susceptible to ear barotrauma than others (6,7). Divers in this study used various methods when they experienced clearing difficulties. Although it is suggested there are a few ways to equalize, a lack of education is highlighted amongst divers in this area as the preferred taught method is for a diver to stop and ascend (approximately 1-2 meters) until able to equalize before continuing the dive.

The incidence of ear infections among recreational divers and instructors was 35% for both groups, yet was slightly higher for technical divers at 50%, suggesting a greater risk among this group, however, no significant differences were found when investigating equalizing difficulties between the qualification groups.

The symptoms of different barotrauma types were quantified, and although some overlap among symptoms was present, it was possible to distinguish between symptoms of inner-ear, descent and ascent barotrauma. A significant association was found between symptoms of ascent barotrauma and the incidence ear infection. It is not obvious why this is so, although it is possible that after a vigorously performed valsalva, causing serious injury of the ear drum, cultures from dirty water environments could penetrate the middle ear during descent. Another reason is after inversed barotrauma of ascent. In this study ear barotrauma symptoms preceded middle ear infection.

It was also interesting that a significantly greater number of divers suffered an ear infection in their left ear than right ear. There is no reason why this is the case. Previous studies (8,9) have found that the left ear has been more prominent in hearing loss due to diving, although underwater noise was considered the main contributor to this. It is unlikely that any anatomical differences could influence laterality of ear infection as there is no clear evidence recorded for asymmetry between left and right ears, although other authors showed problems with the right TMJ joint possibly leading to external otitis like problems more often on the right side (10). It is possible that the ergonomic design of dive equipment may be associated with the frequency of ear infections: the demand valve which feeds air into the mouth from the SCUBA usually sits to the right of the mouth and may influence methods of equalizing. Another possibility is that of laterality, with most individuals being right-handed, and possibly having greater awareness of their right side than left side, which could bias divers to differences in equalizing behaviours.

In relation to the treatment of ear infection, it was interesting to note that overall, no greater reoccurrence of ear infection was reported by divers who chose to seek alternative treatment rather than professional help. These results may tenuously suggest equal efficacy of both professional and alternative treatments with respect to reoccurrence of ear infections after treatment, although the literature promotes professional treatment (7). This result may also suggest that specialised treatment of divers' ears should be promoted, in order to detect any possible signs of barotrauma that divers may be unaware of.

Hood wearing is often seen as essential for warmth in cold water, although some divers choose to wear a hood all the time even in warmer waters to provide some protection for their heads. This study demonstrates that permanent hood wearing when diving is associated with more incidences of barotrauma symptoms than when wearing a hood only in cold waters. This suggests hood wearing has some association with the onset of ear barotrauma, possibly by preventing air escaping from the external ear. Tight fitting hoods have been acknowledged in the literature as having an association with external ear barotrauma (1). External ear barotrauma is very much related to middle ear barotrauma in relation to symptoms. On ascent, air can be prevented from escaping from the ear by a tight fitting hood, possibly leading to ascent barotrauma of the middle ear. Almost a third of the sample in this study had separated from their buddy due to an ear problem when diving, which is a significant cause for concern as diver- diver separation is acknowledged as one of the greatest risks of fatality in diving in novice

divers (2). This study has revealed a number of findings of importance to divers, including symptomology, ear infection rates and laterality, and implications of hood wearing and diver separation. This collection of findings indicate the need for further work into the area of ear trauma in divers.

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BOOK REVIEW

C. Edmonds; C. Lowry; J. Pennefather & R. Walker: Diving and Subaquatic Medicine, 4th edition

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Since its first edition in 1976, 'Diving and Subaquatic Medicine' has applied current understanding in medicine, physiology and the behavioural sciences to the stresses which are faced both by commercial and recreational divers. Some of the world's most experienced diving physicians have been employed over the many years, and 'Diving and Subaquatic Medicine', now in it's fourth edition, has always been amongst the leading texts in the field.

This edition has been completely revised and covers the latest research in diving medicine, the current diving patterns and the necessary diving equipment, as well as free and indigenous diving. It is also updating the previous edition's coverage of established diving disorders, discussed from an historical, aetiological, clinical, pathological, preventative and therapeutic perspective in the accessible but informative style that has made the previous editions so popular.

Compared to other textbooks 'Diving and Subaquatic Medicine' has always put much emphasis on clinical diving medicine, without lacking the scientific evidence background. The book encompasses the complete range of diving disorders and therefore remains the most valuable text for doctors and paramedics who are called upon to minister to the medical needs of those divers who venture on or under the sea, especially in remote locations.

There is little to find missing in this book. Even the Appendices have been updated and the diving medical reading list contains some newly acquired texts. It is one of the minor pitfalls in this book that journals and professional societies are listed incompletely, and some of those listed are given with an expired contact address.

Those who know the book will waste no time in acquiring this update, those new to the text will find it a must for the personal bookshelf.

Dr Peter HJ Mueller,
EJUHM Editor