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### EAR DRUM RUPTURE IN SCUBA DIVERS.

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#### Key words

Barotrauma, ears, recreational diving.

#### Abstract

Barotrauma of the ear is an inevitable part of diving with self-contained breathing apparatus (scuba). The middle ear is an enclosed air space and accordingly is at risk to barotrauma. One of the more severe forms of damage is when the ear drum ruptures. This paper discusses the diagnosis and prognosis of 80 ear drums ruptured as a result of scuba diving. The commonest diagnostic symptom complex is the development of pain in the ear which is suddenly relieved with a sensation or sound of a pop or bang on descent. In 46% of cases a disturbance of the balance apparatus develops at the time of rupture, with a true rotary vertigo only in 25% of cases. There was a spontaneous cure in 85% of cases with only 12 cases requiring operative repair. Predisposing factors were difficulty in clearing the ear in 59% of cases and some atrophy of the ear drum in 55% of cases.

#### Introduction

Barotrauma of the ear is an inevitable part of diving with self-contained breathing apparatus (scuba). The middle ear is an enclosed air space with a flexible outer wall, the eardrum. If the pressure builds up, either on the outside of the eardrum, as in descent, or on the inside as on ascent, the eardrum will be stretched and, if the pressure is great enough, the eardrum will split or burst open. Stretching of the eardrum on descent is accompanied by a feeling of pressure. This is a signal for the diver to blow air up the Eustachian tube to equalize the pressure inside the middle ear with the outside or ambient pressure. The greater the pressure differential the greater the symptoms. As the pressure on the eardrum increases pain is felt and there may be rupture of blood vessels into the cavity of the middle ear (haemotympanum) or into the substance of the eardrum (bruising). Finally the eardrum can split or burst. This is a different type of perforation from that caused by infection or purulent otitis media. In the latter case, as the pressure of the pus builds up, it pushes the eardrum outwards. The infection plus the pressure results in an area of avascularity, then necrosis with a rupture forming a circular hole. With barotrauma in a normal eardrum the tissue tears in a linear fashion and not infrequently along and just behind the handle of the malleus.

Smith<sup>1</sup> in his article on barotrauma of the ear says that all cases suffer pain before the eardrum bursts and that the inrush of water may cause caloric-induced vertigo. Roydhouse<sup>2</sup> on the other hand in his letter denied the statement that "all cases suffer from vertigo as a result of the inrush of the cold water." Morrison<sup>3</sup> is another one who says that "if cold water enters the middle ear cavity the diver becomes vertiginous, loses his sense of direction and may vomit into his mouthpiece." Since 1970 a record of all scuba divers (1,200) attending St Michael's Clinic has been kept. There were 80 cases of ruptured eardrum. These provide much clinical information which appears to be at variance with the two authors quoted who, in their articles, do not describe the basis of their information.

#### Results

It is necessary to define terminology so that, in the future, valid comparisons can be made. Difficulty in equalizing middle ear pressure with ambient pressure has already been defined and it was present in 59% of the 80 cases. In the previously published<sup>4</sup> group of 656 divers, all with problems of the ear nose and sinuses, only 40% had difficulty in equalizing.

"Vertigo" is used otologically to mean a rotary or spinning sensation. It can be caused peripherally in the vestibular apparatus or centrally. In scuba divers it is always considered to be a peripheral disorder, unless there are signs of decompression illness. However it also covers other conditions which are kept in a separate category because of their lack of specificity. This includes terms like dizzy, giddy, loss of balance, loss of direction or a feeling of disorientation. These terms are not often associated with the vestibular apparatus but, in the context of scuba divers and ruptured eardrums, they have been included as minor vestibular symptoms. When the diver denies any sensation of spinning or rotation but describes a definite feeling to which they append these other names, it is taken that these are vestibular symptoms.

For example, Case 1138 said "You know what it is like when you are underwater. You are in an unusual situation and environment. I was holding onto the anchor chain and you know how you swing around anyway. Yes, I felt disoriented, as if I didn't know which way was up. I was slightly dizzy. Now you ask me if there was any movement. There was a little. What do you mean by spinning? Well yes I would say that there was a very slight feeling of going in circles."

An "atrophic eardrum" is an otological term indicating that the eardrum is pathologically thinner than normal, usually due to a decrease or complete loss of the

central fibrous layer of the eardrum. With a pneumatic speculum the eardrum can be seen to move much more freely, it can be seen to be thin, and it is often medially positioned. As such it may be adherent to the long process of the incus or there may be attic retraction pockets. The cause of the atrophy is either previous multiple middle ear infections or long term otitis media with effusion ("glue ear") in childhood. Atrophic eardrums were present in 55% of the cases. In the ascent cases 41% and in the descent cases 61% were atrophic.

Table 1 gives the distribution of some details of the 80 cases in which 35 perforations (44%) were seen and 45 cases (56%) deduced from the history and symptoms. Tables 2 (major symptoms) and 3 (minor signs and symptoms) divide these into two symptom groups showing the same symptoms to confirm accuracy of the diagnosis of the deduced cases. Of interest is that 6 cases, whose perforations were seen, did not recall any signs or symptoms during the dive.

Table 4 gives both the age distribution and the length of the experience of the diver. Thirty four of the cases (42%) were in the age group 20-29 years. The youngest was 14 years and the oldest 53 years. The latter had been diving for 7 years, was ascending fast from 13 m and noted blood from his ear on surfacing. Examination 14 days later showed a raw linear area just posterior to the handle of the malleus. The modal figure for diving experience was 2-10 years (37%). However 15 cases (23%) had ruptured their eardrums during their basic diving course.

Seventeen (22%) of the ear drums ruptured on ascent. They all healed spontaneously even though 6 cases had atrophic changes. The ascent ruptures occurred at depths of 2-30 m after ascents of 2-25 m. The atrophic drums seemed to rupture with lesser pressure changes. The case of the ascent from 2 m was seen to have a perforation and the drum was described as "macerated." He was not seen for follow up so atrophy was not determined. Ascent cases had vertigo or lesser vestibular symptoms in 35% (6 cases) compared with 53% (30 cases) of those who ruptured during descent.

Of the 57 ear drums ruptured on descent 45 (79%) healed spontaneously leaving 12 (21%) requiring operation. All these had atrophic eardrums as did 24 (53%) of those that healed spontaneously.

In this series 7 cases had a single re-rupture, all of which healed spontaneously. Three cases ruptured the same ear 3 times (Table 5). One of whom healed spontaneously each time. He was case 730 and appears in Table 3 as a case with no symptoms but the perforation was deduced. Case 712 healed spontaneously the first time and then needed 2 operations, firstly a minor fat patch and then a full myringoplasty. Case 1090 healed spontaneously twice and then had a myringoplasty.

TABLE 1

## DISTRIBUTION OF 80 PERFORATIONS

Male	64	Female	16
Left	46	Right	34
On descent	57	On ascent	17
		Unknown	6

TABLE 2

## MAIN SYMPTOMS OF THE RUPTURE IN EACH GROUP

	Perforations		Total
	Seen	Deduced	
<b>All perforations</b>	35	45	80
<b>Symptoms</b>			
A. Pain suddenly relieved	9	13	22
B. A + vertigo	7	13	20
C. A + dizziness	5	6	11
D. Vertigo alone	2	4	6
<b>Totals with symptoms</b>	<b>23</b>	<b>36</b>	<b>59</b>
	<b>29%</b>	<b>45%</b>	<b>74%</b>

TABLE 3

## MINOR SYMPTOMS AND SIGNS OF RUPTURE

Symptoms and Signs	Perforations		Total
	Seen	Deduced	
Pain on ascent	3	1	4
Pain on descent	6	2	8
Deafness	13	7	20
Blood from ear	6	8	14
Bubbles from ear	2	7	9
Hiss from ear	2	5	7
Otorrhoea after dive	6	3	9
<b>No symptoms (Only signs)</b>	<b>6</b>	<b>1</b>	<b>7</b>

TABLE 4

## AGE AND DURATION OF DIVING EXPERIENCE IN YEARS

Age group	Number	Years diving	Number
14-20	6	Course only	15
20-29	32	0-1	15
30-39	26	2-10	25
40-49	14	10-20	9
53 years	1	over 20	1
<b>Total</b>	<b>79</b>		<b>65</b>

Inner ear peripheral vestibular stimulation occurred in 37 (46% of total) cases, being the single major symptom in 6 (10%) of the 57 cases of the ruptures on descending. Four of these had a vertigo and the other 2 had minor vestibular symptoms. Of those descending 21 (37%) suffered vertigo and 10 had minor vestibular symptoms. One case (730) was bottom diving at 13 m and had difficulty clearing his left ear. At 13 m it went bang and he heard a hiss and felt dizzy so he sat on the bottom. When the dizziness went he collected his scallops, ascended and boated them. He then went back underwater. He felt water enter his ear and he vomited. So he finished diving and was seen 2 days later. There was a red line just posterior to the handle of the malleus. This case was the only one of the 80 that vomited. There was another case (936) who had nausea with his vertigo.

**Discussion.**

Ruptured eardrums occur in scuba divers but most (65 cases or 85%) heal spontaneously. Those that do not, all have atrophic changes in the eardrum. One reason for the spontaneous healing is that the perforation seems to be linear in nature. Thus when the pressures equalize on either side of the eardrum, the edges of the perforation come together and healing occurs.

In this series of 80 perforations only 1 case vomited and that was on re-entry to the water after having surfaced from the causative dive. It was said<sup>2</sup> that one of the reasons for this was that New Zealand waters were warmer than English waters. This may be true for surface temperatures but not for temperatures at the depths where ruptures occurred. This lack of vomiting is at variance with other reports.

Of concern is the number of divers rupturing their eardrums during their initial course in scuba diving. However these cases were seen before the introduction of the PADI diving education. Nevertheless instructors should be aware of this and ensure their pupils understand that they must not ignore the sensations of pressure, ache or pain in their ears. Of the 15 divers whose ear drums ruptured doing a course, 10 had atrophic eardrums. Atrophic eardrums could be some bar to such people diving but it would be impractical to police. Anyway there must be many divers with atrophic eardrums who have no problems and such cases do heal spontaneously. Very few re-rupture with normal diving.

There may be some concern about the diagnostic criteria for ruptured eardrums. However the cause and the symptoms are the same in both groups surveyed; that is those cases seen with perforations and the others. Of those seen with perforations, 6 had no symptoms but only signs such as bleeding or discharge from the ear.

**TABLE 5**

**13 RE-PERFORATIONS IN 10 CASES**

<b>7 single re-perforation</b>	<b>Operation</b>
1 twice	spontaneous cure
1 twice	first spontaneous cure
	second operation
1 twice	twice operation

**Conclusion**

Ruptured eardrums in scuba divers, when properly handled, do not cause any long term effect. Although possible serious sequelae have been described in the literature, in this series there was no indication that these divers were seriously at risk. Of the cases who required treatment, most went back diving. Of those who had the full myringoplasty operation none ever came back with a re-rupture. It is probable that after operation their eardrums were no longer atrophic.

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