PEARLS FROM THE DEEP

A STUDY OF AUSTRALIAN PEARL DIVING 1988-1991

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Abstract

Pearl divers are a unique diving group. It remains a fairly hazardous occupation, but much less so than in the past. A survey covering four seasons (1988-91) of pearl diving has been conducted. In 1991 decompression sickness (DCS) was the dominant medical disorder (45%), followed by ear problems in 15%, salt water aspiration in 10% and others less than 10% each. The decompression profiles are discussed in relation to the DCS incidence. Decompression and treatment experience with oxygen is described, and the relevance of this to diving physiology is noted.

Background

The excitement of pearl diving lies not only in its product, but also in its mystique.

Since the papers of Bassett-Smith and Blick,[1,2] the superb documentation of historians such as Idriess,[3] Edwards,[4,5] and Bain[6] have excited the adventurers, entrepreneurs, divers and pirates.

The exceptional dives that these men appear to have performed have led to various research approaches, including those of Le Messurier and Hills,[7-9] who derived interesting and innovative concepts and questioned the conventional knowledge of decompression.

Factual information regarding the actual diving performed by the pearl diver, and its sequelae, is not readily obtained. Secrecy and paranoia have bedevilled researchers looking for facts. There is no paucity of fantasy, and each investigator group has its own perspective, depending on whose story is heard. The parable of various blind men independently trying to describe an elephant after only touching one part, is germane.

Recently Wong[10] and his co-workers have rekindled the fascination with this occupational diving group. Their interest involves both the practical diving capabilities and research projects attempting to elucidate an explanation for the relative low incidence of DCS, despite the diving exposures extending far beyond the limits acceptable by the conventional diving manuals.

The history of the Western Australian pearl divers is discussed elsewhere.[11] Analysis of the actual diving exposures, computation of the various tissue saturation levels and Doppler studies on the industry recommended decompression protocols have been published.[12-14]

It has been stated that there have been probably about 1,000 diving deaths since 1883[4,5] when pearl diving commenced. Between 1909 and 1917 there were 145. In 1914, 33 died from diver's paralysis and in 1915, only 21. This improvement was attributed to safer diving practice, but paralleled the reduced diver numbers which accompanied World War 1. A salutary reminder to question all statistics from the industry.

The "official figures for 1993" from Broome[4] claim that there were no deaths reported and only three cases of DCS, all successfully treated with underwater oxygen, amongst the 74 divers. During that time the Broome divers were said to have performed 21,452 dives, with approximately 15,000 hours underwater and averaging 290 dives per diver, per year.

There were approximately 100 divers in the Broome/ Darwin area, during 1988-91, with approximately a 3:1 ratio. It varies somewhat each year, depending on commercial decisions.

Methodology

This present report is a documentation of a sample of pearl diving activities carried out during the years 1988-1991 in two areas.[15] It includes a report on the DCS incidence and the use of oxygen in decompression and underwater recompression therapy. The first three years involved pearling from Broome, and the last year from Darwin.

The information was obtained from diver log books and not from the official "boat logs". The reasons for this were three fold. Firstly the boat logs are not fully documented, either as regards diving profiles or accidents. Secondly, it is much more difficult to obtain the boat logs from the pearling industry, than it is to obtain divers' logs. Thirdly, the diving logs documented the exact durations on oxygen.

Also, the diving logs had a great deal of interesting information, such as clinical details of accidents, marine animal behaviour, etc. Boat logs were used to clarify and verify some data when it appeared to be conflicting.

The presence of DCS was noted by the statements in the log books indicating this, and verified by checking the extended oxygen decompression times employed for treatment.

TABLE 1

PEARL DIVER DCS STATISTICS 1988-1991 (10% SAMPLE)

Depth m	Diver days	Average dives per day	Total underwater time (average)	O_2 time (average)	DCS numbers	DCS % diver days
45-54	140	4.4	152	96	19	13.6%
35-44	406	4.4	210	80	27	6.7%
25-34	322	4.7	285	73	7	2.2%
15-24	511	8.0	406	9	2	0.4%
10-14	455	8.3	444	-	?1	0.2%

Totals = 1,834 diver days, 11,776 dives, 56 DCS, 1 medevac. This sample represents approximately 10% of the pearl divers 1988-91.

Results

During the 4 years 1988-1991, extending over 4 pearl diving seasons, there were a total of 1,834 days dived by these open ocean shell divers. It comprised 11,776 dives, averaging 6.4 dives per day. The divers were exposed to depths between 10 and 54 m (Table 1).

The boats would "drift", usually carrying 8 divers at a time, collecting shell. At the end of the drift the boat would return and then carry out another drift. For the shallower depths there would be more dives per day, and a much longer bottom time. For depths over 23 m there would be a limit of 5 dives per day. The divers tended to use oxygen decompression towards the end of the day and/or following deep dives. The Broome profiles and their analyses are described elsewhere.[12-14]

The oxygen was always used at a fixed depth of 9 m (Table 2). The average duration on oxygen was 70 minutes per day, with a range of 10-150 minutes. Oxygen was used on 1,064 diver days (with an average of 5.6 dives per day). In accordance with the pearl diving recommendations at the time, it was much more likely to be used on the last dive of the day than the previous ones, and if it was used on the previous dives then the oxygen amount would be increased with subsequent ones.

An extrapolation from the survey would suggest that there had been over 10,000 diving days with oxygen, for either decompression or DCS treatment. There were no oxygen hits during this time, and none since.[14]

If a diver developed DCS, then he would often be treated for this either immediately, on oxygen, underwater, or following the next dive (he would have had another shell-collecting dive and that would be followed by an extended oxygen decompression regime).

TABLE 2

OXYGEN DECOMPRESSION AT 9 m

Duration O_2 mins/day(average)	Diver days	Maximum depth (m)	Underwater hours	Dives number
120-150(138)	147	43.3	3.24	4.95
90-149 (95)	147	37.3	4.26	4.81
60-89 (75)	420	34.2	4.65	4.83
30-59 (37)	147	29.5	5.05	5.67
10-29 (16)	203	22.2	6.48	8.0

This represents approximately 10% of the pearl divers 1988-91.

Like the abalone divers before them,[10] the pearl divers have modified the oxygen underwater treatment regime, but not in the same direction. Their consistent routine is to employ oxygen for 30 minutes at 9 m, extended if symptoms persist, and then ascend at a relatively fast rate, 3 m per minute.

The cases of DCS were of interest. Of the 56 cases recorded, only one required medevac to a chamber. All the others were treated effectively and successfully with an abbreviated underwater oxygen regime.

All DCS cases occurred at sea and treatments were usually given within 30 minutes, either:

a receiving oxygen at 9 m for 30 minutes; or

b recompressing on air for the next routine dive, to a depth approximating the original dive, and then being given supplementary oxygen at 9 m after the dive.

One interesting observation was made. No matter how serious the decompression case was, no matter how painful or disabling the symptoms, it was always recorded as "niggles". The reason for this is given by the divers themselves. Had the designation "DCS" been made, then the diver would have been required to miss all further diving on that, and possibly the following, day. Thus there was a strong financial inducement to ensure this did not happen, and in doing so a whole new concept of "niggles" evolved.

The incidence of injury, accident or illness was recorded, but there can be no assurance of these records being comprehensive. They demonstrated a preponderance of DCS, in 45%, followed by ear disorders, (barotrauma, infections, vertigo) in 15%, salt water a spiration was well recognised by this group and comprised 10% of the accidents noted. All other causes comprise less than 10% each (See Table 3).

Only 7% of the illnesses were probably not related to diving, and were often a recurrence of previous medical conditions. The marine animal injuries were mainly fish and irukandji stings, although they did include a sea snake bite, whale entanglement, and a stone fish sting.

Deviations from customary diving practice

Also of interest are the deviations from customary diving practice, which may have important implications.

1 The slow ascent time, being 5 m per minute to 21 m, then 3 m per minute to the surface(See Table 4).

2 Not all dives were carried out reducing the depth with each repetitive dive. On the contrary, 41% of the dives increased in depth during the day, 39% decreased depth and 20% were relatively flat. In making these calculations the dives were grouped in 2 metre increments of depth to determine whether the profile was either increasing in depth, decreasing in depth or remaining flat.

3 The rapid return to diving after DCS. Except for the diver who required medevac, most divers continued to dive on that or the next day. Most (49/55) without any more problems.

4 The underwater oxygen treatment was different from that previously recorded.[15] As all the cases were treated rapidly, either immediately or following the next drift dive, it is possible that less oxygen was required.

By extrapolation of this sample to the remainder of the Broome and Darwin fleets, we can presume a DCS case load of over 500 cases treated underwater on oxygen over the 4 seasons studied. During that time there was not one incident of an oxygen "hit" (convulsion) on the treated divers, and nor on those who were using oxygen for decompression.

TABLE 3

DISTRIBUTION OF 125 PEARL DIVER ACCIDENTS

DCS	56	45%
"Ear" barotrauma, infections vertigo	18	15%
Salt water aspiration syndrome	12	10%
Marine animal injury	8	7%
Respiratory infections	7	6%
"Sinus" barotrauma, infections	6	5%
Previous disorders	6	5%
Pulmonary barotrauma	2	-
Near-drowning	1	-
Others 9	7%	

This represents approximately 10% of the pearl divers 1988-91.

TABLE 4

PEARL DIVING ASCENT RATES

Ascent rates after an air dive
3 m/minute shallower than 21 m
5 m/minute deeper than 21m

Oxygen decompression ascent times
3 m/minute between 9 m and the surface

Oxygen decompression stops at
9 m for variable times

Discussion

These divers well exceed the limits normally imposed on most other commercial divers, both as regards the repetitive dive exposures and the amount of oxygen used.

They do not comply with the requirements to have shallower depths with each repetitive dive. However each dive is not much different in depth from the previous one.

They also do not comply with the usual multi-day dive rules of having one day rest for every three days diving. On the contrary, they dive throughout the neap tide, and this determines not only their initial depth but the consecutive depths of each dive. They dive on consecutive days during those tides.

They could not be said to "acclimatise", as in fact they do the opposite. They spend some weeks absent from diving and then return immediately to a full diving program without work up.

The rapid exposure to underwater oxygen treatment may be the reason why the treatment appears to be more effective in the pearl divers than it is in most other diving situations. Certainly with the delayed cases that we treated in the RAN School of Underwater Medicine, the ascent rate had to be much slower, 12 minutes per metre for some of the cases.[15]

The reasons why these divers can reduce the expected consequences of DCS, could be explained in a number of ways.

1 The very slow ascents could well have an influence in reducing the likelihood of lung over pressure accidents causing air emboli. It would also be expected to reduce the likelihood of bubbles developing[16] at least in the fast tissues. Multi-level diving is not performed and there is only one ascent per dive.

2 The use of oxygen at 9 m after most dives of 20 m and greater, and at the end of the day with shallower dives (13-19 m), will reduce bubble formation and DCS.[17] With increasing depths, certainly in excess of 20 m, there was a considerable reduction in the hours of exposure and an escalation in oxygen consumption.

3 Even though there are between 5 and 10 dives per day, the surface interval is so short that insufficient time may be available for maximal bubble development after the earlier dives, before being recompressed by the subsequent dives. This is especially so with the shallower non-oxygen dives with 8-10 drifts/day. Whether this would be an effective way of reducing gas nuclei is not known, but could be one factor.

4 The majority of these dives would not be considered deep by recreational diving standards (less than 30 m in experienced divers). Although bubble production may be more rapid in deeper dives, thereby reducing the latent period or tolerable surface interval, these are the very dives in which oxygen decompression is used, thus reducing the likelihood of fast tissue bubble formation.[18]

5 The divers age, physical fitness and warm water diving might well be factors in reducing the DCS incidence. Most of the divers are young, very fit males, who do not usually stay in the industry very long. This is in contra-distinction to the old pearl divers who, because of their experience in the use of hard hat equipment and shell gathering, stayed in it for many years or most of their life, whichever came first.

Because of the above, there should be no automatic extrapolation of the pearl divers decompression regimes and their use of oxygen decompression, to other diving groups.

As regards their underwater oxygen treatments, we have no idea how this treatment influences the development of dysbaric osteonecrosis, either positively or negatively.

There is every reason to believe that the nitrogen build up in the slower tissues is excessive, and this could lead, on theoretical grounds, to an increased incidence of dysbaric osteonecrosis. The disorder is frequently seen amongst this occupational group, but no medical survey to determine its actual incidence has yet been reported.

Oxygen toxicity may be a problem. There is a large amount of oxygen exposure over 1-5 dives per day, but we have no concept as to the short-term cumulative effect of this. Thus a diver may use oxygen on his second last dive, but whether this contributes to any oxygen toxicity for the last dive of the day, after breathing air for 1-2 hours, is not known. The degree of long-term oxygen toxicity, if any, still needs to be assessed.

The value of the oxygen is evident in the capability to undertake such dive profiles and not cause more deaths.

The dive protocols used by the pearl diving industry have always been in a state of flux, and have also varied somewhat over the last few years. It is therefore not now (1992-95) exactly the same as it was during the 1988-91 survey period.[13] This fact is used to allay criticism of the current decompression regimes, as it always has been.

In conclusion it does appear that pearl diving remains a somewhat hazardous occupation, but much less so than in the past. Pearl divers' profiles and treatment regimes are potential gems for the diving medical community.

Key Words

Decompression illness, occupational diving, oxygen, tables.

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WESTERN AUSTRALIAN PEARL DIVERS' DRIFT DIVING

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Abstract

This is a report on pearl diving out of Broome, in Western Australia, from 1991 to 1994. The mode of diving in earlier days has been reported elsewhere.[1]

Despite popular misconception and the "cow-boy" image perceived by conventional commercial divers, the incidence of decompression illness (DCI) amongst the pearl divers has been less than 0.01% and the type of DCI has been confined to the musculo-skeletal system.

The reasons for this low incidence of DCI are discussed and has been reported elsewhere.[2] It is believed that the contributing factors are:-

a slow rate of ascent;
b appropriate depth of decompression;
c use of oxygen in decompression;
d suitable between dive (surface) intervals.

Pearling in Western Australia

The pearling industry of Western Australia now employs some 600 people. Of these, 142 are divers (based on the records of medical examinations conducted in 1994) and only 90 or so of these are pearl divers engaged in drift diving. The others are pearl farm divers.

The drift divers harvest wild oysters (*Pinctada maxima*) which are then seeded by highly skilled technicians and placed on panels and immersed in water in pearl farms. The farm divers attend to these oysters, since 1985 they have dived according to the USN Dive Tables.

Pearl divers

Unlike the past, when most of the divers were Japanese, Malays and Koepangers, nowadays virtually all are Caucasian Australians and New Zealanders.

Divers usually enter the industry as a qualified recreational diver holding the Open water certificate or higher. The industry has an induction course conducted by its Safety Officer and Chamber Operator who is an ex-pearl diver. All potential pearl divers have to pass the course before they are accepted into the Industry. Most work initially in the farm sector, while a smaller number are employed as drift divers.