ear problems or other major scuba diving injuries. But from experience, there must have been many times more with decompression therapies being but the tip of the iceberg. Consequently diving medicals, accident prevention and treatment are areas of medical attention by doctors interested in Sports Medicine. So far in 1988 (May)there have been 7 deaths (scuba) and 15 recompression.

At a recent course at the Philomel Naval Hospital conducted by Dr Des Gorman, a Hyperbaric Medicine Specialist from the Royal Adelaide Hospital in South Australia, the physics, physiology and mechanisms of air embolus and decompression sickness were clearly presented, as were other diving medical problems related to lung and ear.

Air embolus is an intravascular collection of air or other respired gas resulting from barotrauma to lungs usually after a rapid ascent from depth. The exact site of this intravascular gas entry in the lungs is only rarely accurately located. The resultant gas can pass to vital areas such as the cerebral circulation if the person is head up and the coronary circulation if prone. Cerebral arterial gas embolsim, CAGE, causes loss of consciousness and other neurological symptoms. The natural history of CAGE is that some cases spontaneously resolve, regaining consciousness if unconscious, as the gas embolus passes through the cerebral circulation.

Decompression sickness (DCS) is now thought to be a tissue disease rather than a vascular disease with nitrogen dissolving more slowly out of some tissues, especially fatty tissue, neural tissue and myelin sheathes at a rate slower than it can be cleared and thus bubbles are formed. It is these bubbles which cause local tissue effects of local compression, evoking chemical effects and rupturing into blood vessels. The single and multi tissue models of nitrogen off-gassing used by decompression tables and decompression meters have little relevance except as an empirical model when one considers the multiplicity of tissues which are off-gassing and at varying rates. Doppler studies show intravascular bubble formation in most divers who have dived below 30 feet. These venous bubbles usually clear in the circulation at the lung unless there is an arterial-venous connection and momentary back flow, e.g. Atrial septal defects are potentially patent in 20% of the population.

Intravascular bubbles, be they air embolus or decompression sickness in origin, not only can cause immediate intravascular effects, but can become lined by surfactant produced in the lungs making these bubbles stable. This may explain why delayed signs and symptoms, especially with DCS, present many days after exposure.

Any patient presenting with unusual signs or symptoms following a scuba dive should have a careful history and examination with the physician considering a scuba diving cause. The first aid management is as follows for acute dive accidents:

1. A, B, C, resuscitation.
2. Head down 30° left lateral.
3. Give fluids, preferably intravenous and carefully record fluid balance.
4. Give oxygen at maximal rate, carefully recorded.
5. Obtain diving medical advice re resuscitation, diagnosis and retrieval to an appropriate treatement site.

THE DIVER EMERGENCY SERVICE

This toll-free, New Zealand-wide, telephone number, paid for by the New Zealand Underwater Association, located at the Philomel Naval Hospital is (09) 458-454. South Island cases being referred to Christchurch (03) 792-900.

This is a summary of a paper presented to the International Sports Medicine Meeting held in New Zealand 12th to 15th May 1988

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HOW DO AMERICAN DIVERS DIE?
A Review of the Scuba Diving Fatalities in the USA in 1985

John Lippmann

This review is a summary of an extensive report titled "U.S. Underwater Diving Fatality Statistics, 1985" issued by the National Underwater Accident Data Centre (NUADC) at the University of Rhode Island.

The full report addresses two distinct types of underwater fatality. The first is the Non-occupational fatality, which includes all fatalities of a sport or recreational nature which occurred while using scuba (or in a few cases, some other type of underwater breathing system). The second type of underwater diving fatality is titled Occupational, and addresses fatalities associated with professional, commercial and military diving.

This review will only consider the Non-occupational fatalities since these are far more relevant to the sport diver.

NUADC defines an active diver as one who dives at least three times per year, and estimates that in 1985 there

were 2.6 to 2.9 million such divers in the U.S.A. This estimate allows for drop-outs, cross-certifications and speciality certifications, but did not count resort courses, which are thought to account for 300,000 to 400,000 dives per year.

In 1985 there were 76 Non-occupational fatalities, 14 Occupational fatalities and 8 skindiving deaths.

The total of 76 Non-occupational deaths gives a fatality rate of 2.6 to 2.9 deaths per 100,000 divers. When this rate is compared to the rates for previous years, it appears that sport diving may be becoming safer.

Location

The locations of the non-occupational fatalities were as follows:

54 occurred in ocean, bay or sea (this represents 71% of the total)
12 occurred in lakes
9 occurred in caves
1 occurred in a river.

Thirty fatalities occurred while the divers operated from the shore or a shore-line facility, whereas 22 deaths occurred from dive charter boats. An additional 17 divers died while diving from private vessels.

Most of the sport diving deaths happened in relatively shallow water, with 75% occurring in water shallower than 27 m. On this basis the NUADC suggests that sport diving is relatively safe to depths of approximately 30 to 39 m, which is in line with the recommended depth limit of most sport diver training agencies.

Conditions

Weather and/or other environmental conditions may have been factors in several of the deaths during 1985. Three cases mentioned strong currents, four fatalities occurred in heavy or dangerous surf, and an additional eight divers died in conditions where the wave height was greater than 0.7 m (although in these latter cases the wave height may not have been a contributory factor to the accident).

Age distribution

Thirteen of the 1985 fatalities were divers aged more than 50 years. This represents 17% of the total deaths, which seems to me to be disproportionately high for the number of divers in this age group. Although the NUADC were hesitant to make any statement about this high percentage, it appears that divers older than 50 years of age may have a greater risk of becoming a diving fatality than a younger diver does.

Diving experience

The latter three levels in Table 1 indicate an exposure level far higher than in the first two levels, and may indicate dozens or even hundreds of dives per victim. The more dives one does the more one exposes oneself to the risk of an accident.

Fatalities while under instruction

In 1985, 8 fatalities occurred during formal diver training and one occurred while the victim was being taught by a "friend" who was not qualified to teach diving. I have summarised specific aspects of these deaths as it may provide some interesting insights, especially for diving instructors.

1. A 60 year old female doing an advanced level diving course developed difficulty after a dive to 15 m for 30 minutes, ascended safely to the surface and complained of a tight wetsuit and difficulty breathing. She began foaming at the mouth and passed out. Despite extensive CPR she died. Her medical history indicated a diabetic condition and possible heart problems. The exact cause of death was not confirmed.

2. A 29 year old male who was 14-18 kg overweight was diving with group of 13 students led by one instructor and one assistant instructor. It was their first openwater dive. About 6 m from shore the victim tried to descend but surfaced immediately, thrashing wildly. He lost consciousness and was rushed to shore where CPR was begun. The cause of death was drowning.

3. A 47 year old male was doing his openwater certification dives. After diving to 15 m he lost consciousness while swimming towards the boat on the surface. His subsequent death was thought to be due to a combination of drowning and poor coronary circulation due to a pre-existing heart condition.

4. A 34 year old female became entangled in lines from a buoy and subsequently ran out of air just under the surface and drowned.

5. A 52 year old male suffered a stroke and died during an ocean dive with three other students.

6. A male dive student was noticed to be missing during a night dive to 18 m. He was found tangled in kelp with his regulator out, his weight belt in place and BC uninflated.

7. A 52 year old male surfaced several times during a 9 m reef dive. He complained of an ill-fitting mask. The last time he surfaced he lost his mask, became unconscious and died despite extensive CPR. The cause of death was arterial gas embolism.

8. A 24 year old diver became unconscious immediately after demonstrating a controlled emergency swimming ascent from 12 m. Despite extensive CPR he died of a massive arterial gas embolism.

9. An 18 year old female died during her first ocean dive. She was taking a lesson from a "friend" who was not a trained instructor. She panicked and refused to take her regulator. She had previously dived once before; in a pool.

It was noted that a disproportionate number of these training fatalities were in divers older than 35 years. It was also noted that some of the training facilities lacked immediate close-by supervision or assistance for a distressed trainee.

Cave diving fatalities

As previously mentioned, 9 divers died in caves. These included two double-fatalities.

The report notes that the pattern of cave diving fatalities has remained the same over the 15 years or more of reportage by the NUADC. The typical cave diving fatality involves young men who have completed openwater training and have had some openwater experience, but no experience whatsoever in cave diving. The NUADC has never reported a cave diving fatality in a properly certified cave diver.

Wreck diving fatalities

Four sport SCUBA divers died while diving on submerged wrecks. The depths of the dives range from 25 m to 62 m. Three of the four divers had become entangled and two were not able to free themselves. The third freed himself but lost his weight belt, had an uncontrolled ascent and died from a massive arterial gas embolism. The fourth was found to have a faulty BC and was thought to be overweighted and unable to ascend.

Thrill seeker ?

One diver was driving an underwater scooter at 22 m at night. He hit a submerged object, was knocked unconscious and died.

Autopsies

The results of the autopsies of 53 of the 76 Non-occupational fatalities were obtained and are shown in Table 2.

Probable starting causes of recreational facilities

After careful analysis of the accident and in some cases the diver's medical history, a list of the likely starting causes of the accidents was constructed. Table 3 is a summary of this list.

TABLE 1

EXPERIENCE OF NON-OCCUPATIONAL DIVING FATALITY VICITIMS, 1985

Experience	Percent of cases
First ever dive with SCUBA	2
Early openwater	19
Some experience	30
Considerable experience	37
Very experienced	12

TABLE 2

RESULTS OF AUTOPSIES, 1985

Cause of death	No. of cases
Asphyxiation or drowning	30
Barotrauma/embolism, etc.	16
Acute decompression sickness	1
Pulmonary embolism	1
Cardiovascular event (e.g. heart attack, stroke)	5
Total	53

I hope that this review provides some interesting insights to its readers. We can all learn from other people's misfortunes and mistakes, and can use this knowledge to increase the safety of our own diving.

Readers who are interested in obtaining a copy of the complete report (Report No. URI-SSR-87-19) can probably obtain a copy by writing to:

NUADC,
University of Rhode Island,
P.O. Box 68,
Kingston, R.I. 02881
U.S.A.

TABLE 3

PROBABLE STARTING CAUSES AND NUMBER OF RECREATIONAL FATALITIES

A.	**Medical and Injury Causes**	39	
1.	Possible exhaustion, embolism or panic		15
2.	Diagnosed embolism		16
3.	Cardiovascular event		5
4.	Aspiration of vomitus, etc.		3
B.	**Environmental Causes**	19	
1.	Lost/out of air in cave		9
2.	High waves/surf		3
3.	Strong current		2
4.	Entangled in kelp/weeds		1
5.	Entangled in external lines		1
6.	Suspected shark attack		1
7.	Lost in wreck		2
C.	**Equipment-Related Causes**	4	
1.	Overweighted at depth		2
2	Weight belt tangled in BC straps		1
3.	Faulty tank pressure gauge		1
D.	**Causes not defined**	14	

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THE DIVERS ALERT NETWORK REPORT 1988 COVERING DIVING ACCIDENTS IN 1987

John Knight

The Divers Alert Network (DAN) is the United States equivalent to the Australian Diving Emergency Service (DES). The DAN 1988 report makes interesting reading with masses of tables and figures. This is an attempt to convey those parts of the report that I found most interesting. The report is strong on tables but there is little text, which makes the interpretation of the tables difficult. All the tables in this paper have been constructed from, or are modified from, the tables in the report. Any errors of interpretation in this paper are mine.

The report states that DAN received 402 case reports from the US and Caribbean in 1987. 74 were not sports divers so were excluded, 63 histories were too incomplete to be used, so 265 cases were left for study. 149 (56.2%) of these decompression accidents came from the South East region, which includes Florida and the Caribbean, presumably reflecting the large numbers who dive in these tourist areas. Somewhere the mathematics are incorrect as most of the analyses were done on 264 cases with the odd one using 265. The mathematics get queerer when the case reports are broken down by region, as the cases tabulated by states in regions as having been reported in 1987 add up to 557, including 92 cases of arterial gas embolism (AGE) or decompression sickness (DCS) and AGE, instead of 402.

Symptoms and signs

DAN uses a Type I and Type II classification for DCS. Only pain, rash and itching are classified as Type I which provided 31 cases (6 female, 25 male) compared with 204 (51 female, 153 male) of Type II. For some of the analyses a disease severity code was used. Type I DCS was Code 1. Codes 2-5 were Type II and Code 6 AGE. Code 2 patients had "pain, numb/tingle, headache, skin sensation" symptoms. Code 3 "Ringing ears, dizziness, pain, fatigue, reflex". Code 4 "weakness, numb/tingle, breathing, nas/vomit, hearing loss, skin sensation, personality, walk/standing", while Code 5 had "visual-dis, speech-dis, weakness, paralysis, bladder, bowel", whether the whole constellation of symptoms and signs had to be present for each code is not spelt out. These cases who were semi-conscious or unconscious, who had convulsions or who had bilateral paralysis were classed as AGE. There were 29 (7 female, 22 male) cases classified as AGE.

Experience

The table headed "Years Diving Experience and Diagnosis Code. Analysis variable; Average number of dives a year", deals with the number of dives a year rather than years of diving. The minimum of 0 dives a year is unlikely to be achieved by a diver developing symptoms, while the maximum of 999 dives a year seems improbable, involving as it does 3 dives a day for 269 days a year and 2 a day for the remaining 96 days, for sports divers diving for fun. But American's on diving holidays in Australia have been known to do 7 dives a day. At this rate only 143 days diving would be needed for 999 dives.

Age

The ages and sex of the sample are shown in Table 1. Nearly half the victims (47%) were aged from 30 to 39. From the data presented one cannot guess why they figure so prominently. Based on the Australian diving community most of these people would have been diving for some years. I would hazard that some had got into trouble from over confidence of the years of trouble free diving; while others