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OBJECTS OF THE SOCIETY

To promote and facilitate the study of all aspects of underwater and hyperbaric medicine.
To provide information on underwater and hyperbaric medicine.
To publish a journal.
To convene members of the Society annually at a scientific conference.

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Membership is open to medical practitioners and those engaged in research in underwater medicine and related subjects. Associate membership is open to all those, who are not medical practitioners, who are interested in the aims of the society.

The subscription for Full Members is $A90.00 and for Associate Members is $A 45.00.

The Society's financial year is January to December, the same as the Journal year.

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SPUMS Membership, C/o
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Abbreviations do not mean the same to all readers. To avoid confusion they should only be used after they have appeared in brackets after the complete expression, e.g. decompression illness (DCI) can thereafter be referred to as DCI.

The preferred length for original articles is 2,500 words or less. Inclusion of more than 5 authors requires justification. Original articles should include a title page, giving the title of the paper and the first names and surnames of the authors, an abstract of no more than 200 words and be subdivided into Introduction, Methods, Results, Discussion and References. After the references the authors should provide their initials and surnames, their qualifications, and the positions held when doing the work being reported. One author should be identified as correspondent for the Editor and for readers of the Journal. The full current postal address of each author, with the telephone and facsimile numbers of the corresponding author, should be supplied with the contribution. No more than 20 references per major article will be accepted. Accuracy of the references is the responsibility of authors. Acknowledgments should be brief.

Abstracts are also required for all case reports and reviews. Letters to the Editor should not exceed 400 words (including references which should be limited to 5 per letter).

References

The Journal reference style is the "Vancouver" style, printed in the Medical Journal of Australia, February 15, 1988; 148: 189-194. In this references appear in the text as superscript numbers.[1-2] The references are numbered in order of quoting. Index Medicus abbreviations for journal names are to be used. Examples of the format for quoting journals and books are given below.

1 Anderson T. RAN medical officers' training in underwater medicine. *SPUMS J* 1985; 15 (2): 19-22
2 Lippmann J and Bugg S. *The diving emergency handbook*. Melbourne: J.L.Publications, 1985

There should be no full stops after the reference numbers. There should be a space after the semi-colon after the year and another after the colon before the page number and no full stop after the page numbers. The Journal uses two spaces after a full stop and before and after the journal name in the reference. The titles of books and of quoted journals should be in italics.

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Any report of experimental investigation on human subjects must contain evidence of informed consent by the subjects and of approval by the relevant institutional ethical committee.

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SAFE LIMITS: AN INTERNATIONAL DIVE SYMPOSIUM

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PHONE NUMBERS 1-800-088-200 (Australia) 61-8-373-5312 (International)

The DES number 1-800-088-200 can only be used in Australia.

For access to the same service from outside Australia ring ISD 61-8-373- 5312.

PROJECT STICKYBEAK

This project is an ongoing investigation seeking to document all types and severities of diving- related accidents. Information, all of which is treated as being **CONFIDENTIAL** in regards to identifying details, is utilised in reports and case reports on non-fatal cases. Such reports can be freely used by any interested person or organisation to increase diving safety through better awareness of critical factors.

Information may be sent (in confidence) to:

Dr D. Walker

P.O. Box 120, Narrabeen, N.S.W. 2101.

DIVING INCIDENT MONITORING STUDY (DIMS)

DIMS is an ongoing study of diving incidents. An incident is any error or occurrence which could, or did, reduce the safety margin for a diver on a particular dive. Please report any incident occurring in your dive party, but do not identify anyone. Most incidents cause no harm but reporting them will give valuable information about which incidents are common and which tend to lead to diver damage. Using this information to alter diver behaviour will make diving safer.

To obtain Diving Incident Report forms write to DIMS, GPO Box 400, Adelaide, South Australia 5000.

SPUMS's 25th Birthday

This year has seen SPUMS's twenty fifth birthday, May 3rd 1996. As the Society cannot hold a birthday party, part of this issue is devoted to the story of SPUMS, its birth, childhood, adolescence and entry into adulthood, which I date from the time that SPUMS took a place on various Standards Australia Committees. This was first recognition from a National body that the Society had expertise and knowledge not available anywhere else in Australia. In the future Australian Standards will be produced with input from the equivalent New Zealand body and will be issued, if all goes well, as ANZ standards applicable to both countries.

Of the five foundation members three are still members of the Society. Two of them have been made life members for their services to the Society. All three have been Editor of either the SPUMS Newsletter or the Journal.

It is for the excellence of the Journal that SPUMS is known around the world and this can only continue if people contribute papers for publication. All scientific papers are peer reviewed. "The World as it is" contains papers about current matters which do not qualify as scientific papers but are of interest and importance. For instance this issue contains the first reasonably accurate record of the number of dives undertaken on the Great Barrier Reef in 1994 (pages 72-74). Such a survey has only become possible through legislation requiring records be kept by commercial dive operators. This is clearly a plus for the regulators as there is now, for the first time, a denominator for the diving accidents/dives equation.

The Society exists to pass on information about underwater medicine (the Society's objectives are printed at the top of the opposite page in case any reader has forgotten them). In medicine prevention is said to be better than cure. This has been the guiding light for the Committee since 1971. First came setting up a framework for educating doctors in underwater medicine to fill the yawning chasm of neglect in the undergraduate medical course. A report on setting up a Diploma in Diving and Hyperbaric Medicine, with a clear syllabus, was presented at the first Annual General Meeting (AGM) in 1972. At the same time the diving community, which was often organised as clubs in those days, was told that lectures on basic diving medicine and physics were available, if the club wanted to learn about what went wrong with the ears and the physics and physiology of changing pressures, from doctors who knew what they were talking about. Many clubs in Sydney and Melbourne wanted this information which of course included tips on how to avoid the problems. Some instructors. who had heard these lectures, badgered their organisations into including similar lectures, given by the same doctors, in their instructor training courses. The general standard of knowledge among instructors today is vastly higher than it was 25 years ago and full credit must be given to the excellent educational material produced by the instructor training agencies.

Another aspect of prevention is preventing diving accidents. 24 years ago Douglas Walker started his Project Stickybeak, a study of Australian diving-related deaths, to study what led to diving deaths. It soon became clear that inexperience and lack of training were regular contributors. A book containing twenty years' reports is in preparation for publication this year. Chris Acott has been running DIMS (Diving Incidents Monitoring Study) for some years and his papers are published in the Journal. This issue contains one on buoyancy jackets, which because of design faults and inadequate training continue to provide work for Hyperbaric Units.

As the standard of diver instruction has risen so has the standard of diving of those attending SPUMS meetings. It is no longer necessary to include lectures on simple diving safety in the scientific program as had to be done at least twice in the past!

Prevention has also been fostered by the steady increase in the number of doctors undertaking training in underwater medicine. When SPUMS was born those with a knowledge of underwater medicine in Australia were almost all medical officers of the Royal Australian Navy (RAN) or RAN Reserve and the only training available was provided by the RAN. Now there are over 400 names in the list of SPUMS doctors with training in underwater medicine who do diving medicals in Australia and New Zealand. None of this could have come about without the energy and dedication of the people, all SPUMS members, who helped set up the Hyperbaric Units around Australia and New Zealand and ran, and continue to run, the training courses for doctors and diving medical technicians. Enthusiasm and interest on the part of those doctors who attended the courses must be noted, even if some of them did not join SPUMS.

Most members have no idea of what has been published in the Journal before they joined. How could they know? There was no way of finding out. This is about to change. For the past few years the Editor, ably assisted by Clare Cooper and Liz Zylinski who have done all the hard work, has been preparing an index of all issues of the Newsletter and Journal. It is to be available on a Macintosh disc in the very near future. It will be available in IBM format in Microsoft Access as well but a little later. The cost will be Aust$10.00 including postage. Write to the Editor enclosing your cheque or full credit card details and it will be sent. A very few printed copies will be made because the Editor prefers looking things up in a book!

ORIGINAL PAPERS

DIABETES AND DIVING: CAN THE RISK OF HYPOGLYCAEMIA BE BANNED ?

Michael Lerch, Claudia Lutrop and Ulrike Thurm

In November 1995 seven insulin dependent diabetics and an equal number of matched non-diabetics went out to challenge the opinion of several diving related authorities that insulin dependent diabetics, due to their unpredictable changes in blood glucose levels, should not have a place in the sub-aquatic realm.[1-3]

We conducted, in Port Moresby, Papua New Guinea, an international field study, with particular emphasis on safety, to see whether, by adjusting insulin dosage, carbohydrate and water intake, diabetic divers could dive without risk of hypoglycaemia.

Of special interest were the differences in physiological parameters between the diabetics and their non-diabetic counterparts. Due to the possibility of hypoglycaemia under water, a great emphasis was laid on the blood glucose levels, tested following a set regime before and after every dive in addition to the daily routine checks.

In addition to the blood glucose, haematocrit, blood pressure, pulse rate, occurrence of proteinuria, microalbuminuria and ketone bodies were tested frequently before and after the dives.

To compare the underwater activities of both groups within the trial, dive profiles and mean air consumption were recorded with air-integrated dive computers while they underwent a specially designed open water dive course with a IAHD (International Association of Handicapped Divers) diving instructor (Claudia Lutrop, Cairns, Australia). It was a learn-to-dive course because some of the participants were not certified divers. All the participants, including the certified divers, underwent the same training.

This customised dive course could be one of the answers to diving safety for diabetics. Taking E P Joslin's words "Teaching is treatment" literally, a special emphasis was put on educating the non-diabetic "buddy", as well as the diabetic, in basic diabetic knowledge such as blood glucose level testing, symptoms of hypoglycaemia and its proper treatment on land as well as in and under water, administration of glucose gel under water and glucagon injections out of the water.

Apart from that, and the basic theory of diving, the participants were introduced to a "diabetic dive log" (page 63). This extended version of a dive log helps the diabetic diver and his buddy memorise not only the dive related facts but also the diabetes related facts of a particular dive such as insulin intake, blood glucose level before and after the dive and the amount of carbohydrates eaten.

Material and methods

The subjects were seven insulin dependent diabetics (diabetes duration 0.75-10 years, mean 6.1 years), 4 female and 3 male, and seven non-diabetics, 4 female and 3 male. Their ages ranged from 24-41 years, with a mean of 32 years. Knowledge and experience in diving was evenly spread in both groups. Both groups underwent all tests.

Subject inclusion criteria

Insulin dependent diabetes mellitus (IDDM).

Age 18-65.

Diabetes related education and self-managed insulin regime.

At least 9 months on insulin and a minimum of 4 blood glucose measurements a day.

A current HbA1c-level of 5.5-9.0%. HbA1c = the percentage of glycated haemoglobin, which gives an idea of the stability of glucose haemostasis within the last three months.

No history of hypoglycaemic unawareness.

Fitness to dive (using Undersea and Hyperbaric Medical Society (UHMS) or British Sub-Aqua Club (BS-AC) or Gesellschaft für Tauch- und Überdruckmedizin (GTÜM) criteria.

Adequate physical fitness, a normal PWC 150. (PWC = physical working capacity in Watt/kg body weight at a heart rate of 150/minute.)

Subject exclusion criteria

A diabetes unrelated illness which prohibits diving.

A severe hypoglycaemia (loss of consciousness) within the last year.

Evidence of alcohol or drug abuse.

History of a cardiovascular, neurological or psychiatric illness.

Signs of diabetic retinopathy, nephropathy or polyneuropathy.

Pregnancy.

History of decompression sickness.

Inability to equalise the ears.

Pre-study examinations

DIABETES DIVE LOG

Date:___/___/___

Time	BS blood sugar	Bolus short insulin	long insulin Basal rate	CHO	units/CHO	COMMENTS

Dive-Planning:

	-60	-30	0	After
BZ				
CHO				
Lactat				
Haematokrit				
Fluid				

TIME OF ENTRY:	:
= Time after injection:	
of short insulin	min
of long insulin	min
TIME OF EXIT :	:

DIVE:

No.___ Location:____________________ shore/boat/wreck/drift/night/cavern/other:____________

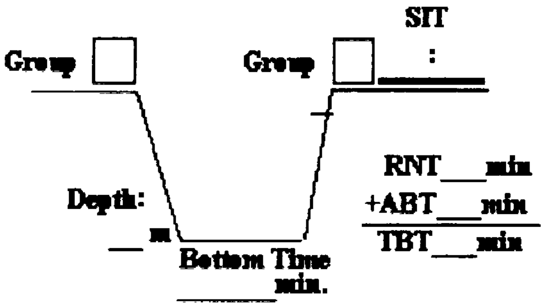
________________________ Visibility:_____m Water temp._____

Weather:_________ Sea Condition:_________ Suit:___________ Weights: ______kg

BUDDY:__________________________informed about:

glucagon ☐ hypo symptoms ☐ glocose-gel ☐ emergency ☐

DIVE PROFILE:



COMMENTS:

____

____

____

____

____

____

____

Accum. Dive Time:____h_____min

Dive Supervisor:____

Diving medical examination.

Electrocardiogram (ECG).

Exercise ECG (minimum PWC 150).

Chest X-ray.

Lung function tests using a body plethysmograph or resistance testing (Oscillation method).

ENT, dental, neurological and ophthalmological examinations.

Urine testing was done for proteinuria with test strips and sulfosalicylic acid and for ketone bodies with test strips. Microscopy was used to identify urinary sediment and the number of erythrocytes, leucocytes etc.

Full blood count.

Documentation of diabetes history and blood glucose diary.

Methods and test procedures

Blood glucose was measured by the One-Touch II, electro-refractometric method using capillary blood from the fingertip.

Haematocrit was measured using a Mini Centrifuge (Bayer Diagnostics), using 9 microlitres of blood in a glass tube spun at 11,500 /minute for 3.20 minutes.

Blood pressure Riva Rocci method. (The diastolic blood pressure was taken at the point when the Korotkow sounds cease).

Pulse rate ascertained by palpation of the radial pulse.

Daily fluid intake was measured in units of 0.4 l.

Proteinuria, microalbuminuria and ketone bodies were measured with Combur 9 test strip (Boehringer Mannheim).

Dive profiles and air consumption were recorded using MARES Genius (ZH-8 Adaptive algorithm) and SUUNTO Eon (U.S. Navy Diving Tables) air integrated diving computers.

Blood glucose testing when diving

On the day of a dive blood glucose levels were determined one hour, thirty minutes and immediately before the dive. Testing continued after the dive. The first test was immediately after removing diving equipment then at least six further tests were done that day. Late night testing (12-15 hours after the dive) was done to assess the effects of muscle storage repletion.

The diving course

11 dives were carried out by each participant. On the first and second days there was one dive, on the third, fourth and fifth days there were two dives and on the sixth day three dives. Maximum depth/time on the first two days was 12 m/45 minutes. The following days maximum depth/time was 30 m/40 minutes. A three minute safety stop at 3-5 m was carried out after all dives.

Before the first dive the participants were instructed to aim for a minimum blood glucose level of 160 mg/dl (8.96 mmol/l) before entering the water. Although there was no fixed maximum level, a blood glucose level of 220 mg/dl (12.32 mmol/l) was targeted to avoid excessive osmotic diuresis with rising blood sugar levels. To achieve this goal the dose of short acting insulin was reduced by approximately 33%. The adaptation of the insulin dose (short and long acting insulin) for the following day was done on a individual basis considering the development of the blood glucose levels during the previous day of diving. The diabetic dive log was used to plan insulin doses, when similar dives to those in the log were proposed for another day. We could make predictions for the adaptation of insulin and carbohydrate intake from the written experiences in the dive log.

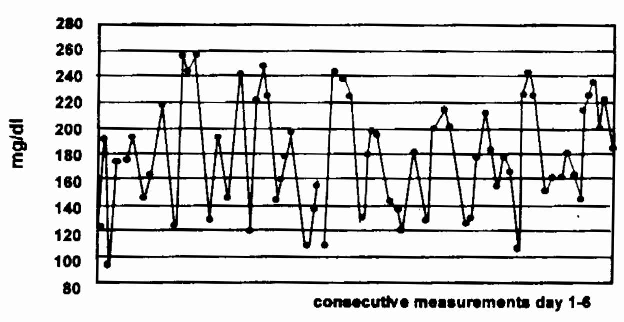
If blood glucose levels dropped during the three measurements before immersion (minus 60 min, minus 30 min. prior to the dive) the subjects were told to eat at least one unit of carbohydrate (1 unit=12 g carbohydrate), even when the set minimum limit of 160 mg/dl (8.96 mmol/l) had been exceeded.

The blood glucose levels before and after the dives in the non-diabetic control group were all within the physiological margins of 60-120 mg/dl (3.36-6.72 mmol/l).

Figure 1 shows the mean values of the blood glucose levels of all diabetics at the same times during the study (before, during and after the dives). It shows that on one hand the overall goal of no severe hypoglycaemia and on the other hand a sufficient blood glucose level before

FIGURE 1

MEAN BLOOD GLUCOSE LEVELS OF 7 DIABETIC DIVERS MEASURED AT THE SAME TIMES ON DAYS 1 (AT LEFT) TO 6



the dives was achieved.

Figures 2 and 3 show the daily doses of insulin (short and long acting) had to be reduced due to the higher energy consumption during the dives as well as the need for higher blood glucose levels before diving and for the prevention of post-exercise hypoglycaemia.

Figure 4 shows that, in addition to the reduction in insulin intake, the daily carbohydrate intake rose significantly during the course. The rise in carbohydrate intake was mostly due to a rise in the daily amount of exercise while diving. Because of the exercise induced higher levels of insulin receptors, especially in the muscle tissues, the amount of insulin in the body was more efficient (falling insulin intake) therefore a higher carbohydrate levels before and after exercise was needed. The carbohydrates were needed after the dive to counter the risk of hypoglycaemia in the phase of muscle glycogen storage repletion which can take up to 12-15 hours.

Due to the higher blood glucose, before and during the dives, with levels above the kidney threshold causing a additional diuresis, the haematocrit levels were significantly higher in the diabetic divers than in the non-diabetic group. When the diabetics drank approximately 1.5-2.0 l, at not more than 1 l an hour, before the first dive of every day this difference did not occur.

The increased mean air consumption of the diabetic subjects (19.7 l/minute) compared with the non-diabetic group (15.8 l/minute) is probably due to there being more experienced divers in the non-diabetic group.

During the whole trial there was no incidence of micro- or macroalbuminuria or ketonuria among the diabetic participants.

During the whole trial no emergency glucose was needed. The emergency glucose dummy was only used in training exercises.

FIGURE 2

MEAN LONG-ACTING INSULIN DOSES FOR 7 DIABETIC DIVERS ON DAYS 1 TO 6

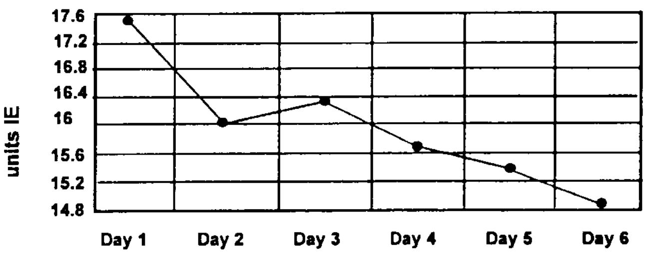


FIGURE 3

MEAN SHORT-ACTING INSULIN DOSES FOR 7 DIABETIC DIVERS ON DAYS 1 TO 6

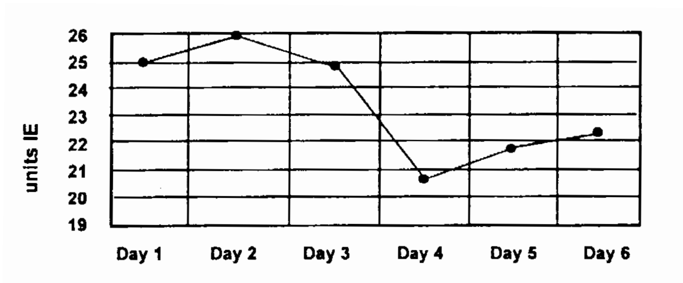
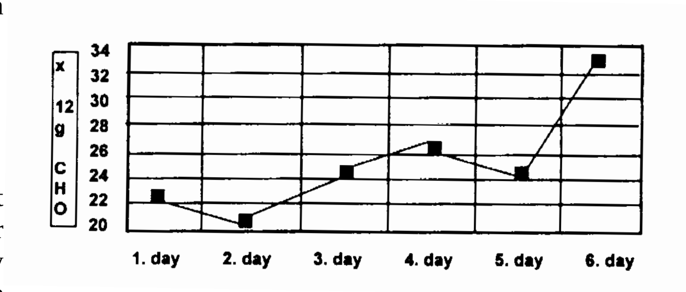


FIGURE 4

MEAN CARBOHYDRATE INTAKE, IN PORTIONS OF 12 g, FOR 7 DIABETIC DIVERS ON DAYS 1 TO 6



Conclusions

The results of this field study verified the fact that the danger of hypoglycaemia for a diver with IDDM in or under water while scuba diving can be minimised by training, experience and following a number of simple rules.[4] These are detailed below.

No scuba diving with manifestations of the complications of diabetes (retinopathies, polyneuropathies, nephropathies etc.).

Limited diving certification (one year), with renewal based on a diving medical and study of the diabetic dive log.

At least one non-diabetic buddy with sufficient knowledge of emergency procedures (blood glucose measurement and glucose administration).

Emergency glucose rations and glucagon in water-tight container in the buoyancy compensating device (BCD).

At least three blood glucose tests before the dive (60 minutes before, 30 minutes before and just before the dive) and another immediately after the dive.

A blood glucose level over 160 mg/dl (8.96 mmol/l) before every dive.

Depth limited to 30 m.

Use the diabetic dive log to accumulate “reference” data for similar dives.

Sufficient hydration (a minimum of 2 l before the first dive but not more than 1 l/hour).

Late testing (12-15 hours) after the dive to detect and prevent hypoglycaemia due to muscle-storage repletion.

Oxygen and emergency equipment at the dive site.

We have demonstrated that diving in tropical waters, while on insulin, can be safe for a healthy diabetic with a stable blood glucose situation when training and experience under non-diabetic “buddy-control “ is given.

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3 Parker J. *The Sports Diving Medical*. Melbourne; J L Publications, 1994

4 Edge C, Lindsay D and Wilmshurst P. Diabetes and diving. *Diver* 1992; 37 (2): 35-36

Key Words

Buddy, diabetes, drugs, environment, fitness to dive, research, safety, training.

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HYPERBARIC RETRIEVALS IN TOWNSVILLE: IS A PORTABLE CHAMBER USEFUL?

Christopher Butler

Abstract

A review of the retrievals of divers with decompression illness (DCI) to the recompression chamber at the Townsville General Hospital (TGH) was conducted for a 2 year period. For the second half of the study a portable recompression chamber was not available for retrievals.

Assuming that portable recompression chamber retrievals were justified in divers with unstable moderate and severe disease, only 1 diver in 108 cases of DCI treated at TGH may have potentially had a better outcome had the facility been available over the second year of the study.

Using patient outcome at discharge as the end point, we cannot demonstrate any superiority of the portable chamber over expeditious sea-level air transport to the hospital based chamber.

Introduction

Recreational diving, by its very nature, tends to be conducted in remote locations. The Great Barrier Reef stretches for some 2, 000 km along the Queensland coast and is one of the world’s premier dive locations. Currently (November 1995) there is only one hospital based hyperbaric unit in Queensland, situated at the Townsville General Hospital (TGH).

All cases of decompression illness (DCI) treated at the TGH over a 2 year period have been reviewed. During the second year of this study, divers were transported without the availability of a portable recompression chamber (PRCC). This has provided an opportunity to assess the usefulness of such a unit in support of a hospital based multiplace chamber.

Methods

A retrospective review of patient records from 25/4/93 to 30/6/95 was conducted. Due to the loss of the chamber life support technician employed by the Queensland Emergency Services, the PRCC (a Dräger DuoCom) became unavailable for diver retrievals on the 30th June 1994. Subsequently divers who would have previously been retrieved and treated during transport were transferred by air at sea-level cabin pressure and then definitively treated in the TGH multiplace chamber.

During the first year of the study the TGH unit's operation was interrupted for a 66 day period while the main chamber was moved to its current location within the hospital. The PRCC during this time was used to transfer patients interstate to other hospital based facilities. This period represents an abnormal use pattern, in that the portable chamber was not being used in support of the hospital based facility. Because of this, all patients managed during the 66 day period were excluded from the study.

Patients

The patients were divided into two groups.

Year 1: 25/4/93 to 30/6/94 (excluding 66 days, 365 days available for treatment) PRCC available.

Year 2: 1/7/94 to 30/6/95 (365 days available for treatment) PRCC unavailable.

All patients who received treatment at TGH for new episodes of DCI were included. Patients were excluded from the study if:

1 They were being treated for recurrence of DCI. These patients were only considered for their initial presentation.

2 They had undergone a "trial of pressure" to establish the diagnosis of DCI, and this proved negative.

3 For whatever reason they did not receive recompression.

Each patient file was reviewed and the following information recorded.

Severity of disease.

This was stratified into 3 groups (Table 1) for the purposes of the review.

1 "Mild Disease" patients who were symptomatic for DCI but no objective signs could be elicited.

2 "Moderate Disease" patients who had symptomatic DCI and signs of a subtle nature. These included positive Sharpened Romberg test, impaired higher function on simple testing, objective sensory changes, mild weakness or changes in deep tendon reflexes.

3 "Severe Disease" patients with life or mobility threatening DCI. These included pulmonary and cardiovascular manifestations, loss of consciousness, bladder or bowel impairment or severe weakness.

TABLE 1

DCI SEVERITY

	Year 1 (PRCC)		Year 2 (No PRCC)	
DCI	Divers	%	Divers	%
Mild	44	50	63	58
Moderate	41	47	41	38
Severe	3	3	4	4
Total	**88**	**100**	**108**	**100**

TABLE 2

DCI STABILITY

	Year 1 (PRCC)		Year 2 (No PRCC)	
DCI	Divers	%	Divers	%
Stable	75	85	95	88
Unstable	11	15	13	12
Total	**88**	**100**	**108**	**100**

Stability of disease

Patients were classified as stable or unstable (Table 2). Unstable patients had deteriorating symptoms or signs at the time of referral.

Location

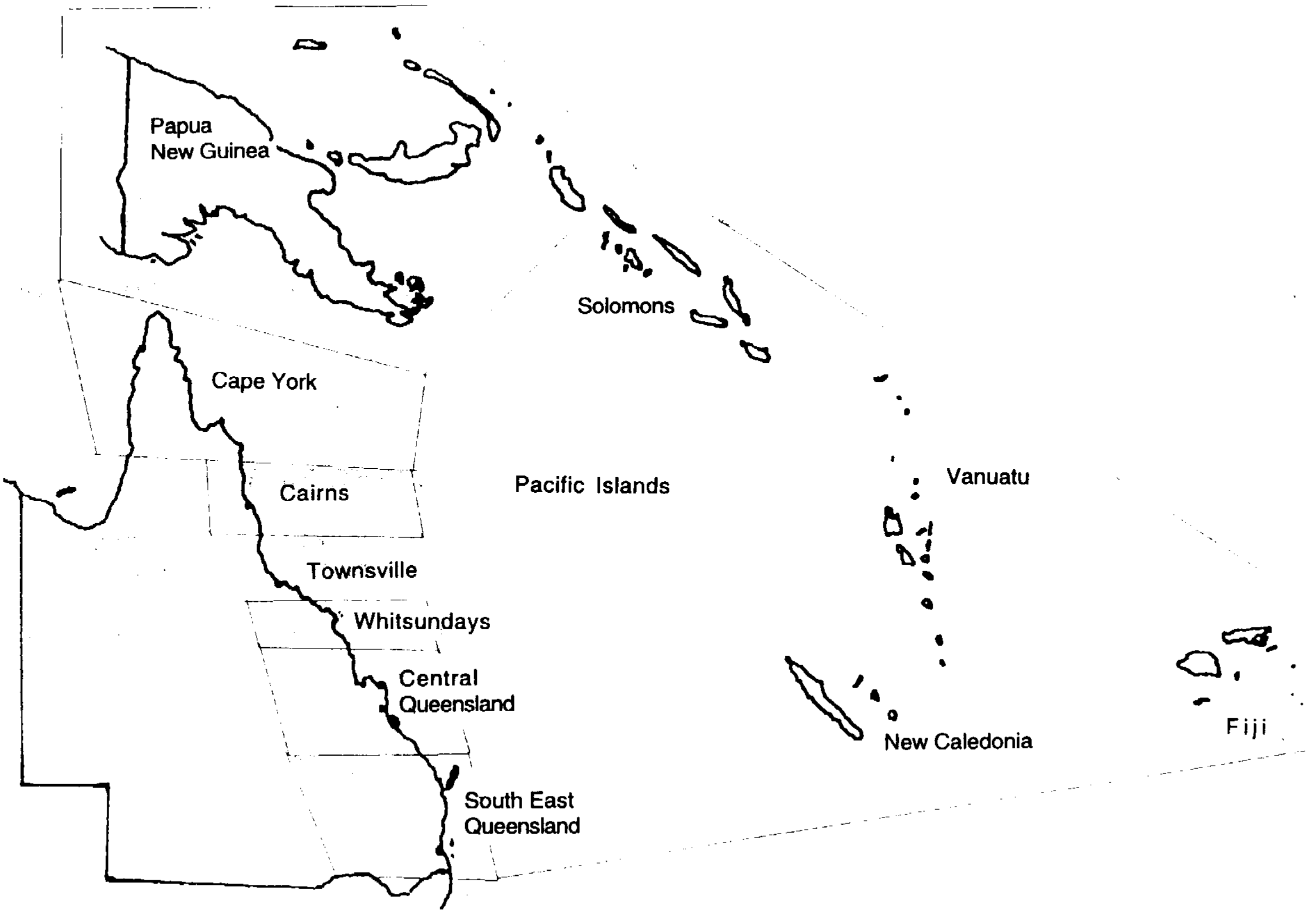
The locations where the diver first sought medical attention were grouped into 8 zones (Table 3 and Figure 1).

1 Townsville.
2 Whitsundays, including Bowen, Airlie Beach, Whitsunday islands, Proserpine and Mackay.
3 Cairns and district.
4 Central Queensland.
5 Cape York and surrounding islands.
6 South East Queensland.
7 Papua New Guinea.
8 Pacific islands (Vanuatu, New Caledonia, Fiji).

Method of transportation

This was either by sea level air transport (helicopter or pressurised fixed wing aircraft), PRCC or road transport.

FIGURE 1
AREAS FROM WHICH PATIENTS WERE RETRIEVED



Results

The cases of DCI that were treated at the TGH hyperbaric unit in the 2 years under review have been classified by location, disease severity, disease stability and method of transport.

In year 2, following the decommissioning of the portable recompression unit, 108 DCI patients were treated at Townsville. Only 24 patients (22%) presented directly to TGH or doctors in the Townsville area.

The majority of the patients transported by air at sea level pressure were managed in that way because it represented the most practical method of transporting them to Townsville. Most of the patients with mild or stable moderate disease presenting to Cairns or the Whitsunday region were transported by road.

If one accepts that use of the PRCC was justified in cases of moderate unstable or severe disease presenting outside the Townsville area, the facility would have been the method of choice for transporting 9 patients in the year following its withdrawal, had it been available.

The outcome at the time of discharge for this group was asymptomatic seven patients, mild residual symptoms one patient and severe residual disease (paraplegia) one patient.

The patient with mild residual symptoms was retrieved from Noumea following initial recompression and so a portable unit would not have allowed for earlier treatment.

It can be seen that if a selective use pattern had been applied to the PRCC (had it been available) during year 2, only 1 patient in the 108 cases of DCI would have potentially benefited from the facility being available. This takes no account of the number of treatments required, and only considers the outcome at discharge.

In year 1, before the loss of the PRCC, 88 divers were treated at TGH for DCI. If the same selection criteria were retrospectively applied for the use of the PRCC (unstable moderate or severe disease), 7 patients would have ideally been transferred in the PRCC.

TABLE 3

PATIENT LOCATION

	Year 1 (PRCC)		Year 2 (No PRCC)	
	Divers	%	Divers	%
Cairns	32	36	40	37
Townsville	25	28	24	22
Whitsunday	8	9	17	16
Papua New Guinea	2	2	12	11
South East QLD	9	10	4	4
Cape York	7	8	2	2
Central QLD	3	3	4	4
Pacific Islands	2	2	5	5
Total	**88**	**100**	**108**	**100**

The outcomes for this group were 1 patient (transferred with the PRCC) discharged with moderate residual weakness, one suffered a relapse after being discharged symptom free, 1 had non-specific fatigue at discharge and 2 were asymptomatic at discharge. Two of the 7 patients considered likely to benefit from transfer in the PRCC were actually transferred at sea level and were asymptomatic at discharge.

Discussion

The pathophysiology of DCI involves tissue damage as a result of bubble formation causing direct tissue injury or ischaemia secondary to impaired perfusion.[1] Intuitively, the outcome from an episode of DCI should be related to the degree of bubble formation and the length of time that the bubbles were in a position to cause tissue damage.

This philosophy has led to the common practice of employing portable recompression chambers to allow the rapid treatment of divers. This has been the standard of practice for the treatment of seriously affected divers in our institution.[2] Although the West Australian experience placed doubt on the benefit of this approach, the use of the PRCC has been recommended by other Australian units.[3,4]

Leitch and Green in a large review of cases of cerebral arterial gas embolism indicated that delay in recompression resulted in a poorer outcome.[5] A study of 49 cases of spinal cord DCI reported by Bull also gives some support to this contention.[6] With severely affected divers, increasing the time from onset of symptoms to recompression correlated with a poorer outcome. However, less severely affected divers tended to have a good outcome regardless of the time to recompression.

TABLE 4

METHOD OF TRANSPORT

	Year 1 (PRCC)		Year 2 (No PRCC)	
	Divers	%	Divers	%
Road	54	61	73	68
Sea level pressure	19	22	35	32
PRCC	15	17	-	
Total	**88**	**100**	**108**	**100**

Kizer came to a similar conclusion in a review of delayed treatment of mainly civilian divers treated in Hawaii.[7] This lends support to the policy of emergency retrieval and treatment of severely affected divers.

The loss of the portable recompression unit for diver retrieval has forced a re-evaluation of this practice in our institution. From the data presented above, the use of the PRCC would not appear to greatly effect patient outcome from DCI in the diving population that was treated in Townsville, provided that expeditious sea level transfer and treatment was available. No attempt has been made to relate the use of the PRCC to the number of recompressions that a diver requires.

It was important to consider the disadvantages of the PRCC in patient management. These chambers take time to load into an aircraft (approximately 40 minutes) and provide poor access to a potentially sick patient. The PRCC was also heavy, bulky and expensive in both maintenance and manpower. Their utility in the helicopter available to us (Bell 412) was limited and we have only routinely deployed them in a fixed-wing aircraft.

Our experience indicates that the PRCC adds little to the management of divers with the pattern of DCI that we treat. Provided that an efficient sea level retrieval system was available, we could not endorse the widespread use of portable units.

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Key Words

Decompression illness, transport, treatment sequelae.

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THE WORLD AS IT IS

SOME DIABETICS ARE FIT TO DIVE, BUT WHICH ONES?

THE AUSTRALIAN EXPERIENCE AND SPUMS POLICIES

John Williamson

SPUMS, the South Pacific Underwater Medicine Society, has at times been accused of advocating that “only perfect physical specimens should dive”! Regarding diabetes and diving, the original SPUMS statement published in 1992,[1] opposed diving for all but the diet-controlled diabetic. It contained no hard supporting data. The paper was followed by some vigorous opposing views[2] and criticism[3], but little more than anecdotal opposing data.

Bryson, Edge and colleagues[4,5] and Dear and colleagues[6] gave notice of data collection in 1994. This and recent early data from Stephen Prosterman, of the Diabetic Association of the Virgin Islands (“Camp DAVI”),[7] lends support to the premise that certain insulin dependent diabetics (IDDM) can dive safely under the right control conditions. Opposing opinions continue.[8,9] On-going data collection from DAVI is promised.[7]

What "decent" Australian data exists, relevant to diabetes and diving? Medline contains none. There are none in the data base of the “DES Australia” phone. This contains detailed records of 1,950 calls since 1987, both Australian and international. Data from 1987-1990 are published[10] and 1991-1995 are in preparation for publication. There appear to be none contained within the “Project Stickybeak” data base, a continuous series of detailed mortality. and morbidity events in Australian and New Zealand diving from about 1969 to the present.[11]

That there are Australian (and thus likely New Zealand) divers with Type I diabetes mellitus is certain.[2,3] There is an interesting new study by Lerch, Thurm and Lutrop from North Queensland which supports diving for selected insulin-dependant diabetics. It is being prepared for publication in the SPUMS Journal (see pages 62-66).

There are extensive worldwide data on both Type I and Type II diabetes mellitus unrelated to diving. In addition consultation with experienced, but non-diving, diabetologist colleagues has occurred. Present evidence is that diving produces a fall in blood glucose levels in diabetics[6,7] and that measurement of peri-diving blood glucose levels is necessary for safety.[4,5] More “hard in-water data” are necessary.

The case against

Diving diabetics, even experienced ones, cannot always be relied upon to measure their peri-diving blood glucose levels.[7]

Irregular food absorption (eg. sea sickness), or even meal timing (eg. alcohol), may occur during diving activities. Conditions may also predispose to insulin or drug administration errors.[8,12]

Hypoglycaemia symptoms usually begin at a blood glucose level of less than 2.5 mM/l (45 mg/decilitre). The onset can be rapid (minutes), will affect central neurological function (judgement, vision, consciousness) and any warning autonomic symptoms which normally precede those of CNS dysfunction (sweating, shaking, palpitations) may be hidden underwater.

Undetected autonomic neuropathy[9] in a diving diabetic may result in masking of warning symptoms of acute hypoglycaemia, impaired baroregulation, with unpredictable cardiovascular effects of immersion.

The superimposition of even mild nitrogen narcosis upon underwater hypoglycaemic symptoms could create a particularly dangerous situation. Any danger is shared by the diabetic's diving buddy, who requires to be non-diabetic and familiar with the signs and management of any diabetic crisis, in-water or out.

The diving medical assessment of non-compliance or instability in a diabetic will often be difficult.

Wearing a MedicAlert bracelet underwater is unlikely to increase safety!

There is some evidence that severe hyperglycaemia (15-20 mM/l or 360 mg/decilitre) may impair cerebral function (Harding 1996, personal communication).

The case for

Both Type I and Type II selected diabetics do dive safely[3-6] under controlled conditions and have done so for years.[6,7]

Some past criteria espoused by diving medicine physicians can still be described as "dogma-rich but data-free" (this applies not only to the realm of diabetes and diving)!

Guidelines that do exist tend to select "the fit edge" of the diabetic population, who are well educated about their own disease, and its control.

Autonomic neuropathy[9] in the absence of other detectable neuropathy in diabetes is very uncommon (Harding 1996, personal communication).

The technology for reliable on-site capillary blood glucose measurements is now available at reasonable cost.[5,7]

Summary

1 While recreational diving for diabetics is quite suddenly something of a bandwagon topic, and while more in-water hard evidence is awaited, what exists is suggesting that, within certain defined boundaries, diving with diabetes (including insulin dependency) may be possible at a risk level acceptable to both the diver and the physician. However, the "worldwide jury" is still out on the subject.

2 That an increased risk exists is indisputable and the diabetic diver must accept and assume at least part-responsibility for this risk, when recreational diving.

3 It is the author's experience that individuals with lifelong medical disabilities, given accurate advice, may know more about what they can and cannot do, than do their healthy physicians. The guided "disabled person" may teach the "able teacher"![13] The author does not understand how else meaningful human data in this challenging area can be safely and ethically obtained.

4 The opinions presented here are the author's. The present SPUMS position with regard to diving and diabetes, to this author's knowledge, remains closer to the stance that insulin dependent diabetics should never dive,

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Key Words

Diabetes, safety.

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A STUDY INTO THE NUMBER OF DIVES CONDUCTED ON THE GREAT BARRIER REEF IN 1994

David Windsor

Introduction

There has been an almost total lack of statistical data on the numbers of visiting divers or individual dives conducted on the Great Barrier Reef. It is difficult therefore to establish any meaningful trend or assess the impact or revenue generated by the Dive Tourism Industry.

A study of diver numbers was commissioned by the Great Barrier Reef Marine Park Authority in 1993. This study was found to be statistically inaccurate because of the lack of response from permit holders, particularly those who operate large dive tourism businesses. In addition the questionnaire was felt to be too complicated and sought to obtain too wide a range of data.

As a result of the perceived potential of the initial study, the Association of Marine Park Tourism Operators (AMPTO) and DIVE Queensland approached interested bodies with a view to completing the study. It was felt that with industry support a majority of operators would support the project and that this could be done on a very limited budget with the support of DIVE Queensland and AMPTO.

Support was sought from the Great Barrier Reef Marine Park Authority (GBRMPA), the Queensland Travel & Tourism Corporation (QTTC), the Division of Workplace Health & Safety (WHS) and the Queensland Department of Environment and Heritage (QDEH). Financial assistance was provided by all except QDEH.

In addition to permit holders, operators in SE Queensland were asked to participate in the study

Methodology

The GBRMPA data base of permit holders was accessed. This provided a list of 1,242 individuals or companies with permits in the following categories, general tourism, diving and both.

Examination of the data revealed that there were large numbers of permits issued to the same businesses but in the names of each of the partners or shareholders in the companies. By removing the duplications it was possible to arrive at a list of 532 permit holders of whom 243 indicated some involvement in diving.

A simplified form was drawn up and mailed, together with a supporting letter from DIVE Queensland, to all 532 persons or companies holding the relevant Great Barrier Reef permits, plus an additional 22 operators who do not require GBRMPA permits.

Completed forms were collated and a direct approach was made to those who did not respond by mail. This was conducted by direct contact, or by phone if direct contact was not possible.

Findings

Of the 532 questionnaires mailed 225 were returned completed. Of these, 121 were from the holders of general tourism permits (total permits 289) who indicated no diving took place in their operation. A further 86 permit holders who did not respond were then approached and confirmed that they did not conduct diving activities. With 207 out of a total of 289 (71.6%) permit holders in this group indicating no involvement in diving it was decided that this was indicative of the group and no further contact was made with these permit holders.

Of the 243 permit holders with permits for general tourism and diving 104 responded to the mail-out. The remaining 139 were approached directly and it was possible to obtain data from all but 21 operators. These were all small operators and their figures would have little impact on the overall findings. They have been disregarded for the purposes of the study

TABLE 1

DIVING PERMIT HOLDERS WHO CONDUCT DIVING

Little or no diving (including non-respondents)	86	36%
Some Diving	42	17%
Major Diving	53	22%
Majority Diving	62	25%
Total	**243**	**100%**

Areas of operation

Because most operations vary the sites at which they dive dependant upon the weather and other factors such as current, visibility, etc, it was not possible in this study to pinpoint the actual numbers of divers who visited individual reefs with the exception of the following areas, Cod Hole, Yongala and Coral Sea (Holmes/Flinders etc).

It was possible to sectionalise the reef (Table 2) for the purpose of this study.

TABLE 2

AREAS STUDIED

Cairns
Townsville
Whitsundays
Capricorn/Bunker Groups
SE Queensland (non GBRMPA permits)

Resort courses

Table 3 gives the numbers of people taking resort courses.

TABLE 3

RESORT COURSES BY AREA

Cairns	83,000
Townsville	4,500
Whitsundays	34,000
Capricorn/Bunker Groups	5,500
SE Queensland (non GBRMPA permits)	2,500
Total	**129,500**

Openwater certifications

Table 4 shows the number of certifications.

TABLE 4

CERTIFICATIONS BY AREA

Cairns	22,000
Townsville	3,000
Whitsundays	7,500
Capricorn/Bunker Groups	1,800
SE Queensland (non GBRMPA permits)	2,200
Total	**36,500**

Recreational dives (including training dives)

Table 5 shows the number of recreational dives in the various areas.

TABLE 5

RECREATIONAL DIVES (INCLUDING ALL TRAINING DIVES)

Coral Sea	42,000
Cod Hole	52,000
Yongala	18,500
Cairns	720,000
Townsville	17,000
Whitsundays	214,000
Capricorn/Bunker Groups	59,000
SE Queensland (non GBRMPA permits)	38,500
Total	**1,161,000**

Overall total dives

Table 6 shows the total number of dives on the Great Barrier Reef in 1994.

TABLE 6

TOTAL NUMBER OF DIVES ON THE GREAT BARRIER REEF IN 1994.

Coral Sea	42,000	3.3%
Cod Hole	52,000	4.0%
Yongala	18,500	1.4%
Cairns	803,000	62.2%
Townsville	21,500	1.7%
Whitsundays	248,000	19.2%
Capricorn/Bunker Groups	64,500	5.0%
SE Queensland (non GBRMPA permits)	41,000	3.2%
Total	**1,290,500**	**100.0%**

Financial implications

Based on the average cost of a resort course being $65, the average cost of an openwater course being $375, the average daily rate on a live-aboard diving vessel being $180 and the average day boat rate being $120, it can reasonably be estimated that the average cost per dive is $80.. This indicates that the total value of the Diving Industry to Queensland in direct expenditure is of the order of $103,240,000.

Summary

From the data presented by operators it appears that

1 1,290,500 dives are undertaken in Queensland waters each year.

2 943,000 dives are conducted by trained divers.

3 150,000 open water training dives are conducted.

4 68,000 speciality and ongoing training dives are conducted.

5 129,500 resort courses are conducted

6 that approximately 60% of all diving that occurs on the Great Barrier Reef takes place in the area from offshore Innisfail to Lizard Island.

Acknowledgements

This study was commissioned by The Great Barrier Reef Marine Park Authority, assisted by DIVE Queensland Inc., Division Of Workplace Health & Safety, Queensland Travel and Tourism Commission and the Association of Marine Park Tourism Operators. It was completed in May 1995.

Key Words

Diver numbers, environment, recreational diving, training.

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WAIVERS
EFFECTIVE OR NOT?

Michael Gatehouse and Tom Wodak

It is increasingly common for Australian and overseas dive charter operators to require divers to sign a document (frequently called a *waiver*, *release*, or *indemnity*, or some combination containing one or more of those words), which purports to deprive the diver of any rights they may otherwise have to sue the charter operator even if the charter operator's negligence has been the cause of the injury or loss.

In Australia as a general rule, where the charter operator is a sole trader or partnership, a diver can release the charter operator from all liability, including any right to sue for negligence, by signing a properly drafted waiver.

The situation will probably be different if the waiver is subject to the laws of Western Australia as that State has enacted statutory provisions supplanting the common law position which exists in the rest of Australia.

The position overseas is not straightforward and the efficacy of waivers signed in or subject to the laws of non-Australian jurisdictions would usually involve the consideration of complex questions of international law.

An effective waiver is one expressed in language which is clear and unambiguous, and specifically covers claims brought in negligence. If there is any ambiguity or defect in the drafting of a waiver, the courts generally construe the documents strictly and against the party seeking to rely on it (in this instance the charter operator), in order to restrict its operation.

Provided the waiver is written with clarity, Australian courts will generally interpret and give effect to the document according to its ordinary meaning. Courts usually approach this interpretive function by construing the document as a whole, giving due weight to the context in which the clause containing the waiver appears.

Whilst Australian courts have yet to determine specifically the effectiveness of a waiver in respect of diving litigation, some guidance as to the likely approach can be gleaned from recent decisions. Both cases involved sporting and risk inherent adventure activities. The conclusion reached demonstrates that Australian courts may well be prepared to hold that an injured diver had waived the right to sue a charter operator by signing a properly drawn waiver.

In the first of these cases the Defendants owned and operated a gymnasium. The Plaintiff, who was keen to take up competitive body building, purchased a gymnasium membership. He signed an agreement incorporating a waiver in the following terms:

"I acknowledge that during all such times whilst on the premises both my property and my person shall be at my own risk and I will not hold (the gymnasium) or its instructors liable for any personal injury or loss of property whether caused by negligence of (the gymnasium), its servants or its agents."

The Plaintiff had previously sustained a back injury and knew from experience the condition would recur if he performed squats. The gymnasium designed and supervised a body building program for the Plaintiff which included squats. The Plaintiff complained he was unable to perform squats as a consequence of a pro-existing back injury. He was informed he would have to do them but that they could be done in a way which would not affect his back condition. Placing his trust in the expertise of the gymnasium, the Plaintiff performed squats. He suffered back symptoms and so informed his instructor who promised to look into the problem, but otherwise took no action. The instructor did not advise the Plaintiff to cease performing the squats. The Plaintiff continued with his program, including squats, and eventually sustained a serious back injury requiring surgical intervention.

The Plaintiff sued the gymnasium in negligence. The court found the gymnasium had been negligent but dismissed the Plaintiff's claim by upholding the validity of the waiver which he had signed on the grounds it constituted a bar to his right to sue for that negligence. The Plaintiff appealed but the Court of Appeal found no fault in the decision of the trial Court and the appeal failed.

The second decision resulted from a claim brought following a parachute training accident. During a training jump the pilot employed by the parachuting school negligently flew his plane too close to the Plaintiff who was forced to take evasive action as a consequence of which she was seriously injured. The court found the pilot and the parachuting school were both entitled to rely on the waiver which the Plaintiff had signed in which she agreed to relieve both Defendants of *"...all liability however arising ... from parachuting."*

An attempt by the Plaintiff to have the waiver declared by the Court to be unconscionable, harsh or oppressive (and thus unenforceable), failed.

The Court was satisfied that the waiver was expressed with clarity, was not ambiguous and had been signed by the Plaintiff in full knowledge that parachuting was a highly dangerous sport. Indeed, given the inherent risks involved, the Court considered it was reasonable for any person providing parachuting training to require its students to sign such a waiver.

Had the Defendants in either case been incorporated (that is traded as companies) or the contract subject to Western Australian law, the consumer protection provisions of the Commonwealth *Trade Practices Act* or the Western Australian *Fair Trading Act,* the waivers would almost certainly have been rendered ineffective.

The *Trade Practices Act* applies throughout Australia, and to dealings between corporations (companies) and consumers. It has no application where the entity providing the goods or services trades as a sole trader or partnership. The Western Australian *Fair Trading Act* applies where Western Australian Courts exercise jurisdiction, that is within the State or where the laws of Western Australia apply, for example where an agreement is subject to the laws of that State.

Both Acts imply into any contract for the provision of domestic services (which would include recreational scuba diving), warranties that the services contracted for would be supplied with *due care and skill.* Any clause which purports to limit or exclude the operation of either Act is void and of no effect.

Apart from such statutory provisions, courts have traditionally declined to enforce waivers which are not expressed clearly and without ambiguity, or which fail to specifically refer to liability arising in negligence. Any comments or representations made by charter operators or their employees or agents prior to the signing of a waiver such as "Don't worry, it is .just a formality and doesn't mean anything" may prevent the operator from relying upon it.

As a general rule, a waiver cannot operate as such unless it has been incorporated into a contract between the signatory and the party seeking to enforce it. Frequently a contact between a diver and an overseas charter operator will be concluded through a travel agent prior to the diver's departure from Australia. If, prior to concluding the contract. the diver had not signed the waiver, or agreed to sign a waiver in a particular form of which the diver was then aware, it is unlikely to be enforceable in Australian courts.

The circumstances in which a diver is asked to sign a waiver may well bear upon the disposition of a court to uphold the validity of it. Evidence of duress being exerted on the diver may lead a court to conclude the diver and the charter operator were not dealing with each other at arm's length when the waiver was signed. In one recent case in the USA a court refused to allow a charter operator to rely on a waiver which an injured diver had been asked to sign only when the dive vessel was well out to sea and the diver about to enter the water.

It is clearly preferable to resolve any questions concerning waivers prior to arrival at a diving destination. To this end it is strongly recommended that, before booking an interstate or overseas diving trip, any diver who has a concern about signing a waiver should request the charter operator or resort owner to forward copies of the proposed waiver documentation which they will require the diver to sign before diving. Once such material has arrived, the prospective diver can peruse it, and decide whether he or she is willing to sign the waiver (and if necessary obtain appropriate legal advice). If the diver is not prepared to sign the waiver, there is still the opportunity to investigate other diving alternatives, with other resort owners or charter operators whose terms of business are regarded as acceptable.

It must be acknowledged that reliance on waivers is becoming more and more normal practice. Indeed a charter operator or resort owner who does not seek to rely on some form of waiver may, by that fact alone, give rise to some concern as to the nature of the operation being conducted. With the passage of time and an increasing understanding of the likely attitude of courts to the use of waivers, there is likely to be some standardisation in the drafting of these documents. Of course, every case is determined by courts on the facts peculiar to a particular case, but already there is a degree of confidence with which one can say how a court is likely to look at a dispute which relates to the construction of a waiver.

Finally, those who organise diving related conferences should undertake enquiries into the proposed usage of waivers and ensure that any promotional material discloses in as much detail as possible the contents of any waivers which delegates may be asked to sign if they intend diving during the conferences.

Key Words

Legal, recreational diving.

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SPUMS 24th ANNUAL SCIENTIFIC MEETING AND ANNUAL GENERAL MEETING
13th to 19th APRIL 1997
at the
QUALITY RESORT WAITANGI, BAY OF ISLANDS, NORTHLAND
NEW ZEALAND

Theme
PATHOPHYSIOLOGY AND TREATMENT OF DECOMPRESSION ILLNESS

Spums Workshop
FIRST AID MANAGEMENT OF DIVING ACCIDENTS

Guest Speakers

Professor Richard Moon, Duke University, Durham, North Carolina, U.S.A. Current President, Undersea and Hyperbaric Medical Society.

Dr James Francis, until recently Director, Institute of Naval Medicine, Alverstoke, United Kingdom.

Richard and James are acknowledged as among the world's leaders in decompression illness. Both were major contributors to the 4th edition of *The Physiology and Medicine of Diving* edited by Peter Bennett and David Elliott. Richard Moon is also the Medical Director of DAN (Diver Alert Network) International. This meeting gives SPUMS members an opportunity to hear two outstanding international speakers.

Conference Convenors
Dr Michael Davis and Associate Professor Des Gorman

For further information contact:
Dr Michael Davis
Hyperbaric Medicine Unit
Christchurch Hospital
Private Bag 4710, Christchurch, New Zealand.
Fax +64 3 364 0187
e-mail at hbu@smtpgate.chhlth.govt.nz

Diving Workshops

The diving at The Poor Knights Islands is considered to be amongst the finest temperate water diving in the world. Water temperatures will be about 20°C.

Delegates will travel to the Poor Knights Islands on 3 days on board a large high-speed catamaran, Tiger IV, which can carry around 250 passengers. During the journeys small group workshops, equipment demonstrations and hands-on training sessions related to the workshop theme of the First Aid Management of Diving Accidents will be conducted.

Conference Week Activities

This is a beautiful maritime park region of New Zealand, which is also an area of considerable historical importance. For the non-diver, there is a wealth of land and water-based activities with something for everyone.

The Quality Resort Waitangi is an ideal family venue. A diverse and exciting children's programme has already been developed to suit all ages, as well as excellent baby care facilities.

Bring the whole family for a wonderful New Zealand Holiday!!

Pre- and Post-Conference Tours

Two contrasting and outstanding diving venues will be offered. The Three Kings Islands, situated some 30 miles North of New Zealand, and Fiordland, on the West Coast of South Island.

In addition, there is an immense range of holiday opportunities in New Zealand that Fullers Northland's travel division will be able to advise delegates on.

For all travel and New Zealand domestic enquiries, please contact:
Fullers Northland
PO Box 145, Paihia, Bay of Islands, New Zealand.
Fax +64 9 402 7831

PLEASE HELP US TO MAKE THIS A GREAT MEETING BY RETURNING THE NOTICE OF INTENT ENCLOSED WITH THIS JOURNAL.

SPUMS NOTICES

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY DIPLOMA OF DIVING AND HYPERBARIC MEDICINE.

Requirements for candidates

In order for the Diploma of Diving and Hyperbaric Medicine to be awarded by the Society, the candidate must comply with the following conditions:

1 The candidate must be a financial member of the Society.

2 The candidate must supply documentary evidence of satisfactory completion of examined courses in both Basic and Advanced Hyperbaric and Diving Medicine at an institution approved by the Board of Censors of the Society.

3 The candidate must have completed at least six months full time, or equivalent part time, training in an approved Hyperbaric Medicine Unit.

4 All candidates will be required to advise the Board of Censors of their intended candidacy and to discuss the proposed subject matter of their thesis.

5 Having received prior approval of the subject matter by the Board of Censors, the candidate must submit a thesis, treatise or paper, in a form suitable for publication, for consideration by the Board of Censors.

Candidates are advised that preference will be given to papers reporting original basic or clinical research work. All clinical research material must be accompanied by documentary evidence of approval by an appropriate Ethics Committee.

Case reports may be acceptable provided they are thoroughly documented, the subject is extensively researched and is then discussed in depth. Reports of a single case will be deemed insufficient.

Review articles may be acceptable only if the review is of the world literature, it is thoroughly analysed and discussed and the subject matter has not received a similar review in recent times.

6 All successful thesis material becomes the property of the Society to be published as it deems fit.

7 The Board of Censors reserves the right to modify any of these requirements from time to time.

MINUTES OF THE SPUMS EXECUTIVE COMMITTEE TELECONFERENCE

held on 11 February 1996

Opened 1900 Eastern Standard Time

Present

Drs A Slark (Past President), S Paton (Treasurer), C Meehan (Secretary), J Knight (Editor), Dr G Williams (Public Officer), C Acott, R Walker, J Williamson (Committee members) and Dr M Davis (NZ Chairperson).

Dr D Gorman (President) joined the meeting at 2110._Drs D Davies (Education Officer) and J Williamson (Committee member) left the meeting at 2030.

1 Minutes of the previous meeting (25/11/95)

Read and accepted as a true record. Proposed Dr M Davis, seconded Dr J Williamson.

2 Matters arising from the minutes

2.1 North American Chapter update on mailing, bank account and new committee

The Treasurer will liaise with the North American Chapter to discuss and finalise the closing of their bank account as it is no longer needed. The monies therein will be transferred to a new account to be set up in New Zealand, which will be utilised to cover incidental costs incurred in connection with the 1997 ASM in New Zealand.

The American Chapter is in the process of finalising, its new committee.

2.2 Update on legal advice in connection with Fiji ASM 1995 finance finalising

A solicitors letter was read commenting on several issues that had arisen with regard to the finalising of the Fiji ASM 1995 account with Allways Dive Expeditions. At the last committee meeting it was reinforced and documented that the amount previously offered was the final settlement. Legal advice was sought to clarify several associated matters. All the members present agreed with the solicitor’s comments with the exception of Dr Acott who requested that it be documented that he expressed strongly his concern with regard to SPUMS becoming involved in a legal battle with Allways Dive Expeditions. In view of the fact that Dr Gorman had not yet been connected, it was decided to delay further discussion of the matter until later in the meeting. Attention was also drawn to a recently received letter from Allways Dive Expeditions threatening legal action if the matter was not finalised within fifteen days.

2.3 Maldives ASM 1996 update

Concern was expressed with regard to the dependability of audiovisual equipment in remote areas. Dr Williams and Dr Acott agreed to investigate the cost of SPUMS purchasing its own slide projector as well as a hard plastic case for its transportation and storage. A limit in cost of $3,000 was set. Proposed Dr Davies, seconded Dr Williamson

There was also a discussion about the conference account which was looking to be overdrawn in the near future if further registration fees did not arrive and expenses continued.

There has been some confusion generated by invitation to join SPUMS in the conference registration booklet, with a note that if joining SPUMS in 1995, the fee would be $80, as compared to $90 if joining in 1996. This reflects the change in the membership fee that arose in January 1996, and was not an "early bird special". Those members who have renewed SPUMS membership at the lower rate are to be invoiced for the difference.

2 4 New Zealand ASM 1997 update

Dr Davis is exploring the possibility of having a trade display at the 1997 ASM as well as offering an opportunity to take a technical diving course.

2.5 Update on proposed formalities at the Gala Dinner

The tone of the Gala Dinner will be slightly more formal. The President, Dr Gorman, will give a short speech including special thanks and acknowledgments. Drs Williams and Acott will present a few special awards, including recognition of the best free paper. Dr Williams to organise a book prize for this award.

2.6 Asthma Project. Dr Douglas Walker. Letters from Dr Walker dated 12/1/96, Project Proteus background information 12/12/95, Letter from PADI dated 11/12/95.

The committee agrees that SPUMS will give Dr Walker its full support and encouragement in regard to the outlined projects. At this stage SPUMS is not able to offer any financial support.

It should be noted that Drs Davies and Williamson had to leave at this stage.

Item 5.1 Establishment of the SPUMS library, was briefly discussed with Dr Davies before he had to leave Minuted details can be found under "item 5 other business"

2.7 Indemnity policy for SPUMS

A suitable indemnity policy for SPUMS is at present being researched.

2.8 Reprinting of schedules for SPUMS Diving Medical and Statements of Purposes and Rules

Drs Knight and Meehan are co-ordinating this. All committee members are requested to read each of these booklets closely and suggest any changes they deem necessary. Any change to the Constitution requires a motion and acceptance at the next AGM.

2.9 Role of convenor to be defined and guidelines written

Dr Acott is in the process of finalising this.

2.10 Update on "Ex-Presidents of SPUMS" Committee

There was no further update on the matter at this time as Dr Gorman had not yet joined the teleconference due to a delay in his travel arrangements. A motion proposing this new committee will be presented at the next AGM.

2.11 Commencement date for the increase in the Honorarium for the Editor

The committee agreed that the commencement date of the increase should be backdated to the start of the financial year, which was 1 July 1995. In future the honorarium will be reviewed yearly at the ASM and any alteration will then be prospective and take place at the start of the new financial year following the ASM. Proposed Dr Davis, seconded Dr Acott

Dr Knight is in the process of producing an index of SPUMS Journals going back to 1971. It is proposed that this should be available electronically. Dr Meehan will have this facility shortly.

3 Treasurer's Report

The Treasurer's Report was read by Dr Paton. It was moved that the report be accepted, Moved Dr Knight, seconded Dr Meehan.

A discussion was raised with regard to a precedent, which has been created with the commencement, in October 1994, of an honorarium for the Editor. It was noted that SPUMS now has one paid member of the Executive and that there is a need to look at how much work is also done by other members of Executive. SPUMS is in a very healthy financial situation at present and would be able to cope with the additional cost involved in expanding its present policy. It was decided to discuss this issue further at the face to face committee meeting to be held at the ASM in April.

The Treasurer, Dr Paton, at this time notified the committee of her intention to stand down as Treasurer at the next AGM. Because of health matters, in her family, she is not in a position to renominate as Treasurer this year and will be leaving the Committee. She feels she will be unable to continue with the amount of work involved as Treasurer of SPUMS. The committee gave Dr Paton a vote of thanks and appreciation for all she had done on behalf of SPUMS over the last few years as Treasurer and as a committee member. The healthy state of the SPUMS finances mirrors her devotion to her job. A further vote of thanks will be made at the 1996 AGM in Maldives.

4 Correspondence

4.1 Invoice from Dive Australia for membership application

It was decided that SPUMS would not apply for membership of Dive Australia at this stage.

5. Other Business:

5.1 Establishment of a SPUMS Library (Dr Knight)

SPUMS accepts with gratitude the offer of Dr Carl Edmonds to pass on his diving medical library to SPUMS. Dr Davies has offered to act as librarian. Dr Knight will communicate our gratitude to Dr Edmonds and finalise the details.

5.2 Request from Workplace Health and Safety in Cairns to recommend a protocol for the management of a diving related accident on a dive vessel.

This is the theme of the 1997 ASM in New Zealand and a full protocol will then be updated. At present it is recommended that if any person develops symptoms after diving, the cause of which is not obvious then it is to be assumed that the symptoms are diving related and a diving physician should be contacted for advice.

5.3 Conference questionnaire from Fiji

This was briefly perused.

5.4 It was suggested that a DIMS form be included in every Journal

It should be noted that at this time Dr Gorman was connected to the teleconference.

5.5 Finalising of the finances of the Fiji ASM (item 2.2) was continued.

Further discussion was entered into. A further vote was taken on whether to pay the outstanding monies demanded by Allways immediately, or to write them a letter reinforcing that our earlier decision to meet them half way as a sign of good faith, and pay 50% of the requested money, was our final decision, and that we have had legal advice which supports this decision.

A vote was taken and after some further discussion it was decided 6:5 to finalise the matter immediately by paying Allways the full amount requested. It was noted that the Committee was not happy about the situation and that it is not a popular or unanimous decision. The decision was reached in the interest of the long term relationship and to avoid any further unpleasantness, and not because of a belief that SPUMS as a society was in any way liable. It was also noted that the legal advice given to SPUMS gave us a confident position to pursue, but we did not wish to do so in view. of the attitude indicated above.

The meeting closed at 2150

CONSTITUTIONAL AMENDMENTS

1 The motion, proposed by Dr Jim Marwood, item 8.2 of the Agenda for the Annual General Meeting published in the March 1996 issue of the Journal, “That at this and subsequent annual general meetings opportunity be given for members to raise matters of concern for which prior notice has not been given.” was passed by the 1996 Annual General Meeting of SPUMS.

As this matter concerns a change to the Rules of the Society the Committee will place a motion before the 1997 Annual General Meeting of SPUMS to alter the constitution to enact the motion, provided that the membership approves the motion in the manner laid down in the last paragraph of this notice.

The following amendments, 1 to 12, to the Rules of the Society, which were published in the March 1996 issue of the Journal, were passed by the 1996 Annual General Meeting of SPUMS.

1 That typographical errors in Rules 7.2.1 (b), 7.2.3, 7.2.3.(b), 10 (f), 12 (a), 33 (a), 39 and in the heading of Meetings of Committee and resolutions of committee on page 15, be corrected.

2 An amendment to Rule 3 (e)

That the words “appointed on” be replaced by “appoint a”. The amended Rule 3 (e) would then read (changed words in italics)

(e) Any corporate organisation in sympathy with the aims of the Association may be elected by the Committee as a corporate member of the Association and it may *appoint a* delegate to attend meetings of the Association.

3 An amendment to Rule 4 (a)

That the words "Australian College of Occupational Medicine, P.O.Box 2090, St Kilda West, Victoria 3182" be replaced by "Australian and New Zealand College of Anaesthetists, 630 St Kilda Road, Melbourne, Victoria 3004." The amended Rule 4 (a) would then read (changed words in italics).

(a) Any person seeking full membership or associate membership or corporate membership may apply by writing to SPUMS Membership *C/o Australian and New Zealand College of Anaesthetists, 630 St Kilda Road, Melbourne, Victoria 3004.*

4 An amendment to Rule 4 (c)

That the words "Editor (or the Secretary)" shall be replaced by the word "Secretary" and that the words "kept by him" be deleted. The amended Rule 4 (c) would then read (changed words in italics).

(c) Upon notification by the Treasurer that membership has commenced the *Secretary* shall enter the applicant's name in the register of members.

5 An amendment to Rule 4 (d) (ii)

That the word "his" shall be deleted. The amended Rule 4 (d) (ii) would then read.

(d) (ii) terminates upon the cessation of membership whether by death or resignation or non-payment of subscription or otherwise.

6 An amendment to Rule 4 (e)

That the words "Editor (or the Secretary)" shall be replaced by the word "Secretary". The amended Rule 4 (e) would then read (changed words in italics)

(e) The *Secretary* shall also inscribe the name of any life member or honorary member in the register of members and shall delete the name of any person ceasing to be a member from the register immediately after such person ceases to be a member.

7 An amendment to Rule 11 (a) (vii)

That "Rule 8 (d) (iii)" be added after the word "under". The amended Rule 11 (a) (vii) would then read (changed words in italics)

(a) (vii) Announcement of the newly elected Committee and the holding of any ballots necessary under *Rule 8 (d) (iii)*;

8 An amendment to Rule 16

That Rule 16 be deleted and replaced by the following words

16. A question arising at a general meeting of the Association shall be determined on a show of hands unless a poll is demanded. A declaration by the Chairman that a resolution has been carried or lost, and an entry to that effect in the Minute Book of the Association is evidence of that fact. Motions, other than those conferring membership, passed at general meetings shall have no effect until approved by the full membership. A notice of all motions passed shall appear in the next issue of the Journal. Approval by three fourths majority of the members, as specified by Rule 37, shall be assumed if no member informs the Secretary, in writing, of an objection to the motion or motions within one calendar month of the publication of that issue of the Journal. If an objection is received a postal ballot shall be held (Rule 20).

9 An amendment to Rule 17 (b)

That the words "specifying the member's intention in writing". The amended Rule 17 (b) will then read (changed words in italics)

(b) All votes shall be given personally or by proxy *specifying the member's intention in writing*.

10 An amendment to Rule 22 (c)

That the word "its" be deleted and replaced by "the Association's". The amended Rule 22 (c) would then read (changed words in italics)

(c) In the event of a casual vacancy in any office referred to in sub-clause (a), the Committee may appoint one of *the Association's* members entitled to vote to the vacant office and the member so appointed may continue in office up to and including the conclusion of the annual general meeting next following the date of that person's appointment.

11 An amendment to Rule 37

That Rule 37 be deleted and replaced by the following words

37. The Statement of Purposes and these Rules may only be altered, rescinded and/or added to in the following manner: by a three fourths majority of the full members and life members who, being entitled under the Rules so to do, vote in a postal ballot, if required, as specified in Rule 16.

12 Amendments to Rules 29, 41 and their headings.

That the words "branch" and "regional branch" be replaced by "Chapter". The amended Rules 29 and 41 would then read (changed words in italics)

***Chapters* to provide information**

29. Any *chapter* of the Association shall furnish to the Treasurer or the Committee, within a reasonable

time, account of any financial transactions if requested by the Treasurer or the Committee to do so.

Chapters

41. (a) There shall be *chapters* of the Association for the purpose of organising meetings, field excursions and activities consistent with the objects of the Association. C*hapters* may charge members to cover costs. Each *chapter* shall maintain proper accounts.

(b) A *chapter* of the Association may be established at any place to further the objects of the Association in that place.

(c) Any person wishing to establish a *chapter* shall apply in writing to the Secretary who shall submit the application for approval by the Committee.

(d) Each *chapter* shall be directed by a chapter sub-committee of at least two members.

(e) Each *chapter* shall be governed by these Rules. The action of *chapters* shall be subject to the overriding authority of the Committee of the Association, which shall do everything to assist *chapters* in their operation.

(f) Should the Committee resolve that the activities or conduct of any *chapter* are not in accordance with the best interest of the Association, the Committee may withdraw its approval and the *chapter* shall cease to be a *chapter* of the Association forthwith. Such action shall be submitted for approval at the next annual general meeting of the Association.

(g) The records, accounts (and funds) of all *chapters* are the property of the Association and in the event that a *chapter* ceases to exist, the funds held by that *chapter* shall be forwarded to the Treasurer of the Association forthwith.

12 Proposed that the following new rule be added and that Rules 29-42 be renumbered.

Presidents' Committee.

29 This standing committee will be composed of life- or ordinary members who have served at least one year as the President of the Society. The Committee will meet at the Annual Scientific Meeting of the Society, at the member's expense, and at the same time as the Executive Committee at one other time during the year, at the Society's expense. The Presidents' Committee will also be able to conduct telephone conferences. Chairmanship of the Committee will be the responsibility of the immediate past-President and minutes will be kept by members in rotation. The Presidents' Committee will answer directly to the current Society President and be responsible for the development of actual and draft Society policy on issues identified by the Society. The Presidents' Committee will report its activities in the Society Journal and provide an annual report to the Society at the Annual Scientific Meeting.

The amendments will not come into effect until approved by the general body of members. Any member who objects to Dr Marwood's motion or to any of the amendments should notify the Secretary of SPUMS, Dr Cathy Meehan, C/o Australian and New Zealand College of Anaesthetists, 630 St Kilda Road, Melbourne, Victoria 3004, Australia, in writing before August 1st 1996. If any member objects a postal ballot will be held. If no objection is received it will be assumed that the membership has voted in favour of the amendments.

Cathy Meehan
Secretary of SPUMS.

LETTERS TO THE EDITOR

DIVING RELEASES AND WAIVERS

106 Bent Street
Northcote
Victoria 3070,
20/1/96

Dear Editor

As a doctor and a diver I took my SPUMS Journals with me to read while I was on holiday in Gizo in the Solomon Islands in July 1995. I booked and paid in advance through a travel agent and my payment included six boat dives. I arrived in Gizo yesterday afternoon.

I read the March issue of the SPUMS journal which discusses releases and waivers which divers may be required to sign before being allowed to dive. On page 52 of that issue, an article states that on occasion, forms may be signed "under duress" after the diver has boarded the boat. In my case the dive operator handed the forms to the divers before boarding the boat, but AFTER the divers had arrived on the island. This letter is written on the back of one of the forms. (see page 84)

My reading of the release is that it releases the dive operator from all responsibility, both civil and criminal, once the diver boards the boat. The diver (and his/her heirs and executors) agree not only not to sue if something goes wrong, but also agree not to press charges against the dive operator, even if he/she is criminally negligent.

I questioned the wording of the waiver and I was met by a barrage of emotional responses by the dive operator and his employee:

1 We have never had an accident in 11 years. (I am sure their safety record is excellent).
2 This agreement does not stand up in court. (See page 18, SPUMS March 1995).
3 Everybody signs it, you are the first person in two and a half years to object. (I used to sign these forms, before I read the offending Journal).
4 If you are not happy to sign then you cannot be a very good diver. (I think I am a competent diver, but I do not think that kind of statement should be used to persuade a diver to sign a release).
5 It just means you have to be responsible for your actions. (It does mean that I have to be responsible for my actions, and that the dive operator does not have to be responsible for his or her actions.
6 Just stop being stupid and sign, nothing will happen. (That is not the point).

I was told that if I did not sign I could not board the boat (ie. no snorkelling nor even spending the day on a tropical island). I asked if I could be refunded my money and go to the dive operator down the road. I was told no refunds.

I did sign a form but added underneath my signature that I had signed the form "under duress" after arriving on the island and being told my money could not be refunded. The dive operator's employee tore the form up and told me to stop being so stupid, that he left the States to get away from people like me. In the pathetic and time honoured female way I burst into tears, I realised I had backed myself into a corner, made a fool of myself, upset other people, and missed out on a day's diving in idyllic conditions with a reputable company with an excellent safety record.

I will of course sign the form tonight and hopefully get my six dives. I am concerned, however, that:

1 these forms protect reputable diving companies from unscrupulous divers, but do not protect reputable divers from unscrupulous dive operators.
2 the forms are not necessarily signed voluntarily.

I hope that this letter will spark some debate. Have I made a fool of myself and missed out on a days diving for nothing or do I have a valid point?

That is the end of the letter I wrote from Gizo on 17/7/95. The outcome was better than I expected. After I posted my letter I wandered down the road to the other dive shop on Gizo, Dive Solomons, run by an Australaian called Troy Griffiths, which does not require such releases. When my situation was explained to him Troy very kindly let me dive at a heavily discounted rate.

Unfortunately I was not able to get a refund from Adventure Sports but apart from that everything worked out well. My copy of the March SPUMS Journal went with the divers on the boat! Perhaps the gist of those articles could be published in "Divelog".

Elizabeth Christie

Key Words

Legal, recreational diving.

Editorial comment

Adventure Sports Gizo were sent a copy of Dr Christie's letter. Their reply was that they had acted on NAUI (National Association of Underwater Instructors) advice and that some of Dr Christie's statements were incorrect. They enclosed a copy of a letter to them from NAUI, which NAUI did not want published as it was

Continued on page 84

ADVENTURE SPORTS GIZO

P.O. BOX 21 GIZO, SOLOMON ISLANDS

WAIVER AND RELEASE AGREEMENT

Read carefully before signing:
For and in consideration of permitting me (print name), (1)
of (address)
Certification no. Agency Level
to participate in boat, skin and scuba diving activities and/or instruction provided by (2) NAUI, NAUI AUSTRALIA LIMITED, ADVENTURE SPORTS GIZO LIMITED and their servants or agents whether qualified Divemasters or otherwise and all activities and /or training in the Western Province, Solomon Islands, with scheduled activities to begin on (enter date) (3) 19.

I state and agree as follows:
I hereby voluntarily release, discharge, waive and relinquish any and all claims or causes of action for personal injury, property damage or wrongful death occurring to me and arising as a result of engaging in boat, skin and scuba diving activities and/or instruction and any activities incidental there, wherever or however such injuries may occur and for whatever period of time said activities or instructions may continue, and I do for myself, my heirs, executors, administrators and assigns hereby release, waive, discharge and relinquish any actions and causes of action which may hereafter arise for me or my estate, and I agree that under no circumstances will I or my heirs, executors, administrators and assigns prosecute, present any claim for personal injury, property damage or wrongful death against any of those identified in (2) above, as a result of the negligence or otherwise, of those parties in (2) above.

I have been fully advised of the hazards and dangers incidental to engaging in the activity and/or the instruction of skin and scuba diving and that dives may go below 40 metres (140 feet) (even though this is the maximum depth recommended by most sport diving associations) and that dives may be led by persons qualified only as dive leaders or guides, and I hereby assume all such risks and dangers attendant to those activities, including negligence, if any, of those parties named in (2) above.

BY SIGNING THIS AGREEMENT, I RELEASE ADVENTURE SPORTS GIZO LIMITED AND THE OTHER PARTIES IN (2) ABOVE, FROM ANY CLAIM OR CAUSE OF ACTION I, OR MY ESTATE, MAY HAVE FOR PERSONAL INJURY, PROPERTY DAMAGE OR WRONGFUL DEATH ARISING FROM BOAT, SKIN AND SCUBA DIVING ACTIVITIES AND/OR INSTRUCTION, WHETHER CAUSED BY THE NEGLIGENCE OF SAID PARTIES OR OTHERWISE. I AGREE TO HOLD ADVENTURE SPORTS GIZO LIMITED AND THE AFOREMENTIONED PARTIES HARMLESS FOR ANY INJURY OR DEATH WHICH MAY OCCUR TO ME DURING BOAT, SKIN AND SCUBA DIVING ACTIVITIES AND /OR INSTRUCTION.

I hereby declare that I am of legal age and am competent to sign this waiver and release agreement or that my parent or guardian will sign this document on my behalf if I am a minor.

I HAVE READ THIS AGREEMENT, UNDERSTAND IT, AND I AGREE TO BE BOUND BY IT.

Signature of Participant: Date:

Witness (Name):
Signature:

Signature of Parent / Guardian:
(where student or diver is a minor)

---

private correspondence. Further letters to Adventure Sports Gizo have not been answered so we cannot present their views. NAUI has recently produced a less restrictive waiver, but a request for permission to reprint it in the SPUMS Journal has not been answered.

Members and associates who attended the Annual Scientific Meetings at Castaway and Paradise Islands all had to sign very similar waivers in order to dive. For a summary of the legal position of diving waivers and advice about what to do see pages 74-76.

DIVING INJURIES IN NEW SOUTH WALES

The Old Butterworks
PO Box 35, Tai Tapu
New Zealand
27/2/96

Dear Editor

I read with considerable interest the retrospective paper by Mike Bennett on New South Wales diving injuries.[1] He states that in this group of divers there was no statistical evidence of improved outcome with a reduced interval between onset of symptoms and hyperbaric treatment. However in Figure 3, 9 of 48 divers (19%) treated within 24 hours had residual symptoms whereas 14 of 44 divers (32%) treated after 24 hours had residual symptoms. Simple Chi-squared analysis of these figure suggest this difference may be statistically significant, quite the opposite of Bennett's conclusions. The same is true using a 12 hour cut off.

There are several problems both with the data and its interpretation. Firstly only 92 of the 107 divers are shown in Figure 3. Where are the other 15? Secondly, the statistical methods used and the actual results of these analyses are not stated. This is unacceptable even in a quasi-peer reviewed journal such as this. In fact, neither are my own casual attempts at statistical analysis valid for these data.

A third problem is alluded to in the paper and is very important in the context of his discussion, namely that many of the sicker patients, those transported by helicopter, fall within the early referral group. This would markedly bias likelihood against finding a correlation between the time interval to treatment and the quality of outcome (severity of residual symptoms). Therefore any prospective study needs to consider admission status in the analysis of outcome.

My own conclusion from the NSW data is that there is reasonable preliminary evidence that early referral results in improved outcome. This now requires confirmation in a prospective, multi-centre epidemiological study. A previous paper has rightly been critical of hyperbaric units throughout Australasia for not providing adequate outcome data[2] and Dr Bennett is to be commended for his attempt to correct this deficiency.

We should also not overlook the fact that 75% of Bennett's divers made a full recovery and there were very few with major residual problems. This speaks volumes for the effectiveness of good hyperbaric management even in the delayed referral patient.

Mike Davis

References

1 Bennett M. The retrieval of diving injuries in New South Wales. *SPUMS J* 1995; 25 (3): 142-147
2 Gorman DF and Harden M. Outcome after treatment for decompression illness in Australasia. *SPUMS J* 1993; 23 (3): 165-168

Key Words

Decompression illness, letter, transport, treatment sequelae.

Department of Diving and Hyperbaric Medicine
Prince of Wales Hospital, High Street
Randwick, New South Wales 2031
7/5/96

Dear Editor,

Many thanks for the opportunity to reply to Dr. Davies' astute letter. I must take full blame for the mysterious disappearance of 15 cases in the compilation of Fig.3. in the article. This figure in fact only refers to the cases classified as DCI and so those labelled CAGE are not represented. Somehow in the course of preparing the article, I wrote an incorrect caption for this figure and for this I apologise.

The question as to analysis of the data is an interesting one. I made the decision not to include details as I felt that, in the context of a retrospective review of imperfect data, reviewed by a single author and without any measure of validity concerning outcome classification (particularly in view of the mixture of record review and telephone interview), to do so in a formal way might over-value the work. To perform statistical techniques on poor data and make conclusions can sometimes be less productive than using such data for discussion and hypothesis generating only. It was my purpose to set the scene for more exacting prospective work and to provoke some outrage by the suggestion that time may not be an important determinant for success in treatment of DCI. It is gratifying to see that someone has read the paper with sufficient interest to challenge my assertions.

I too analysed the data using a Chi-square methodology but achieved rather different results. These may be summarised as follows: 9 of 48 (18.8%) divers treated within 24 hours had incomplete resolution as compared to 14 of 46 (30.4%) divers who were treated later than 24 hours. There is an 11.6% greater incidence of residual problems in the group treated after the longer interval, however this difference is not statistically significant. Chi-square with 1degree of freedom is 1.74, with a corresponding $P>0.1$. We may be 95% confident that the true difference lies between 29% fewer problems in the group treated less than 24 hours or as much as 5.6% fewer in the group treated after an interval of longer than 24 hours. Analysis of those cases treated within 12 hours compared to the remainder is even less convincing (9.4% difference in favour of shorter interval group, Chi-square

1DF, 0.83; P>0.75. 95% Confidence Limits of difference 28% fewer incomplete resolutions in <12 hour group to as much as 9.2% fewer in the >12 hour group). It should be stressed that the second analysis is on somewhat rocky statistical ground in view of the small numbers involved in one of the groups and there is a reasonable case for use of a more conservative approach using conditional probabilities, such as Fisher's exact test. These calculations were the basis of my statement concerning the lack of statistical support for improved outcome with early retrieval and treatment.

I wholeheartedly agree that the presence of many of the more acutely unwell patients in the shorter delay to treatment groups is a substantial bias against finding a positive correlation between shorter times to treatment and improved outcome. It was my intention to make this point in the final paragraph of the discussion in my paper and I thank Dr. Davies for making this clear if I did not do so.

Finally, I wonder if we know sufficiently well the natural history of relatively minor grades of DCI to establish just how good a 75% resolution rate is in these patients?

Mike Bennett

Key Words

Decompression illness, letter, transport, treatment sequelae.

LIGNOCAINE AND DCI

PO Box 35
Tai Tapu
New Zealand
27/4/96

Dear Editor

I read with great interest Dr Simon Mitchell's informative review of lignocaine use in decompression illness (DCI). As well as the potential protective mechanisms described, I wonder whether he has considered the action lignocaine might have on the neuropathic process itself. Damaged nerves tend to produce new sodium channels and lignocaine appears to suppress sodium channel formation. It has been suggested that lignocaine may work in neuropathic pain by preventing this "wind-up" phenomenon.

Could the action of lignocaine in DCI, therefore, be due at least in part to symptomatic suppression of this phenomenon, not only in pain pathways, but also other abnormal sensory changes? To take this a step further, has anyone reported the use of lignocaine in the suppression of chronic pain syndromes that undoubtedly occur in some patients following neurological DCI?

Mike Davis

Key Words

Decompression illness, drugs, treatment.

438 Scenic Drive
Waiatarua, Auckland
New Zealand
16/5/96

Dear Editor

I would like to thank Mike Davis for his constructive questions. In my literature review I restricted discussion of lignocaine's possible protective mechanisms to those which provided rational explanations for the protective phenomena that have been observed, viz: preservation of the somatosensory evoked response (SER) and reduction in infarct size, both following in vivo cerebral arterial gas embolism (CAGE) or cerebral ischaemia. It seems unlikely that the rapidly apparent preservation of the SER, for example, could be accounted for by down-regulation of sodium channel formation in compromised neurones.

Dr Davis begins his second paragraph by suggesting that "in part", the "action of lignocaine in decompression illness (DCI)" may be attributable to down-regulation of sodium channel formation. It is important to emphasise that apart from anecdote, no action by lignocaine in DCI per se has been demonstrated. I am reluctant to speculate on the mechanism of effects that have not yet been reported. However, I agree that a putative analgesic action by lignocaine in DCI patients can be based on reports that this drug is analgesic in both neuropathic pain[1] and post-operative pain.[2] Down-regulation of sodium channels may well contribute to this action. A purely analgesic effect by lignocaine in DCI is probably undesirable as it will merely mask the underlying pathology.

In answer to Dr Davis' final question, I am not aware of any references to the use of lignocaine in chronic pain syndromes following neurological DCI.

Simon Mitchell

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Key Words

Decompression illness, drugs, treatment.

BOOK AND VIDEO REVIEWS

DANGEROUS MARINE CREATURES Second Edition 1995. ISBN 0-941332-39-X
Carl Edmonds
Best Publishing Company, PO Box 30100, Flagstaff, Arizona 86003-0100, USA. Fax 1-520-526-0370
Price from the publisher US$ 24.50. Packing and postage extra.

If you have any dealings with the sea, with diving, fishing, surfing, boating or you just treat people who have, then this book is essential for your library.

As a general practitioner on the Queensland coast I have been using previous editions of Carl Edmonds' book for the past twenty years. It was first published in 1975 as "Dangerous Marine Animals of the Indo-Pacific Region", republished as "Marine Animal Injuries To Man" and in 1989 republished under the present title. This reissue is soft covered and contains 275 pages.

The author describes his book as a "field guide for medical treatment" and in the introduction states that it is intended for clinical reference, not for light reading. Yet he confesses that he was unable to resist temptation and had included more general information on marine animals to enable the reader to appreciate their beauty.

The contents of the book are comprehensive and cover not only marine animals but also marine infections and dermatitis. In this edition marine injuries have been streamlined into four definite groupings: marine animals that cause trauma, venomous marine animals (stinging), marine infections and dermatitis and poisonous marine animals. There are fewer miscellaneous sub-sections. A final section contains six appendices covering resuscitation, tourniquets, anaesthesia, allergy and anaphylaxis, antivenoms and advice and finally venoms and toxins.

Each group of creatures is comprehensively introduced before each member of the group is described and illustrated with a colour photograph. Common names as well as scientific names are included. This is followed by the geographical distribution, seasonal incidence, points of general interest, clinical features of the injury, prevention of the injury, first aid and finally medical treatment. This is specially boxed so as to not confuse non-medical readers. Numerous interesting case histories are included for dramatic illustration of various injuries.

Being well indexed, the book fulfils its intent as a useful and quick reference book for any marine related injury.

True to his promise the author adds more information about the marine creatures to try and contradict the book's title.

The book is up to date, easy to read, humorous and full of fascination to anyone with an interest in the sea. It should be on the bookshelf of all SPUMS members

John Parker

OXYGEN FIRST AID IN DIVE ACCIDENTS
DAN (USA) PAL version
Available from DAN Australia, PO Box 134, Carnegie, Victoria 3163. Tel 03-9563-1151. Fax 03-9563-1139.
Recommended price $Aust 30.00, postage and packing extra.

This 30 minute video comes from DAN America. It covers the times when oxygen is recommended for treating diving accidents, the basic physiology of oxygen uptake and CO_2 production with inert gas take up and excretion leading to air embolism and decompression sickness, using the DAN oxygen equipment and how to use oxygen safely. One of the minor blemishes for international distribution of this video is the fact the USA fails to use the international colour, black with white shoulders, for oxygen preferring to stick to its outdated green for oxygen. However the pin index system used in the DAN equipment is international allowing the the use of the DAN equipment around the world.

The video has many good points to outweigh the minor irritation of seeing green oxygen cylinders. It emphasises at its opening that first aid, including cardiopulmonary resuscitation (CPR), training is a prerequisite for taking an oxygen course.

The conditions when oxygen is recommended are diving accidents, near drowning, respiratory distress, unconsciousness, hypoxia and "when in doubt give oxygen" which covers all my indications. The physiology is potted but sticks accuratelly to essentials. The review of the oxygen equipment would keep the procedures for setting up and administering oxygen clearly in the viewer's mind. Two outlets from the first stage regulator can support a demand flow system, but the kit only provides one such system. Presumably cost dictated this choice. A second breathing casualty has to manage on a constant flow system, variable up to 25 lpm, with a less efficient mask supported by a reservoir bag. However the demand valve has no inflation capability so cannot be used for non-breathing patients. These have to be handled with the old standby of mouth to mouth ventilation, but using mouth to mask with an oxygen inlet into the mask. All in all this trade off of a lower oxygen percentage for an easy and well known method of ventilation is sensible. Another good point is the demonstration of how to make the two masks provided fit smaller faces and still seal. A good point is the repeated demonstrations of how to stow the cylinders during use so that they do not fall over and hit the patient. Due emphasis is given to the need for care when handling oxygen so as to avoid fire or explosion.

This video should be seen by every diving doctor, everyone who has taken an oxygen administration course and anyone who might have to deal with a diving accident, which is every diver.

John Knight

Hyperbaric Technicians And Nurses Association

Two conferences At The Hotel Grand Chancellor (ex-Sheraton) Hobart

Oxygen, "Understanding the Risk" 28th and 29th August 1996

A two day Seminar on the use of medical oxygen. This will be of special interest to all who handle oxygen equipment.

Invited speakers from Australia and overseas will present on this complex topic. Subjects to include:

Oxygen cleaning
Fire hazard
Oxygen analysis
and much more.

Dr Bill Hamilton will be a speaker and due to his knowledge and background he will undoubtedly have some useful information for the technical diving community.

Details available from:
Bob Ramsay or Steve Goble,
Hyperbaric Medicine Unit,
Royal Adelaide Hospital,
Adelaide, South Australia 5000.

Phone (08) 222 5514
Fax (08) 232 4207

4th Scientific Conference of Diving and Hyperbaric Medicine 30th and 31st August 1996

Following on from their highly successful Melbourne Conference the HTNA is again providing a scientific meeting of growing International standing.

The Hyperbaric day is the 30th. and the diving day is the 31st.

The overseas invited speakers this year are:
Professor Dirk Bakker, University of Amsterdam
Dr Bill Hamilton
Dick Clarke, Carolina Hyperbarics

Details available from:
Sean Rubidge
Hyperbaric Unit
Royal Hobart Hospital, Hobart.

Phone (002) 388 322
Fax (002) 347 684

BREATH-HOLD DIVING
AN INTERNATIONAL SYMPOSIUM

to be held on 6th and 7th of December 1996 in Paris
sponsored by the FEDERATION FRANCAISE D'ETUDES ET DE SPORTS SOUS-MARINS (FFESSM) and the WORLD UNDERWATER FEDERATION (CMAS)

The symposium is to study all forms of breath-hold diving, and the teaching and training courses for each, to increase knowledge of incidents and accidents for better prevention.

Papers are called for on the following subjects

Breath-hold diving physiology
Pathophysiology of incidents and accidents of breath-holding diving
Characteristics and constraints of underwater competitive sports: synchronised swimming, underwater fin swimming, underwater hockey, target shooting and spear fishing
Specificities of pure breath-hold diving; static test, dynamic test, constant weight, variable weight and "no-limits"; possibility of records and/or of competitions
Organisation and security for deep diving
Training and ventilation control techniques for breath-hold diving
Psychological aspects of breath-hold diving

For further information contact Dr Michel Leloup, Commission médicale FFESSM Ile-de-France, 21 rue Voltaire, 93100 Montreuil, France.

SPUMS ANNUAL SCIENTIFIC MEETING 1995

AN EVALUATION OF BUOYANCY JACKET SAFETY IN 1,000 DIVING INCIDENTS.

Chris Acott

Abstract

There were 154 incidents involving buoyancy jacket use, misuse and malfunction in the first 1,000 incidents reported to the Diving Incident Monitoring Study (DIMS). Forty eight of these incidents involved morbidity. This is 10% of the total morbidity reported in the time period. The buoyancy jacket, or buoyancy compensating device (BCD), incidents included divers being unable to exhaust their BCD, others being unfamiliar with the use and operation of their BCD, confusion between the inflation and deflation mechanisms, spontaneous inflation of the BCD by a poorly maintained or faulty power inflator, failure of inflation mechanisms, leaks from BCDs and inflation hoses, inadequate buoyancy and inflation of the BCD restricting the diver's respiration. Appropriate preventive strategies include an emphasis on a pre-dive BCD check, increased separation of the deflate and inflate mechanisms, annual servicing and post-dive maintenance of BCDs, an accessible dump valve that will exhaust air at a rate at least equal to that of maximum inflation, an education program to accompany the purchase or hiring of a BCD and an emphasis on buoyancy control in diver training. In particular, trainees should be taught how to achieve buoyancy control without the use of a BCD, how to slow an uncontrolled ascent and to "overlearn" the response of weight belt release in an emergency.

Introduction

A buoyancy jacket, often called a buoyancy control device (BCD), is an important component of buoyancy control in diving. During the past 20 years, the use and design of BCDs has changed considerably. The "horse collar" style, which relied on oral inflation for surface buoyancy, has been replaced by a waistcoat style jacket that has both oral and power inflation mechanisms. These enable divers to adjust their buoyancy both on the surface and underwater. This style of BCD does however have the potential to change a diver's buoyancy and depth very rapidly. Consequently, it is not surprising that BCD problems have been cited as a cause of both morbidity and mortality in recreational diving.[1-3] In an analysis of 100 scuba diving deaths, BCDs were reported to be a major contributor to diving accidents.[3] These accidents were attributed either to an overinflation or to a failure of the inflation mechanism. However, this report lacked both objective data and a detailed analysis.

The safe use of any diving equipment is dependent upon an adequate knowledge of its function and the common problems encountered during its use. Identification of the common errors in the use of equipment may suggest corrective strategies based on a change in equipment design and should lead to the reduction or elimination of the effects of these errors.

Incident reporting is a study of error and unintentional events. It is a method of identifying, classifying and analysing error in the context of contributing and associated factors.[4,5] It is not a new concept, being first used during World War Two to improve military air safety[6] and now is an established part of safety in aviation,[7,8] the nuclear power industry[9] and anaesthesia.[5,10,11] The specific application of such an assessment to BCD use will identify common, as well as potentially dangerous, recurring errors and show where corrective strategies are necessary.

Method

A diving incident form was designed in 1988[12] and has since been modified. These forms have been distributed throughout Australia and New Zealand. A diving incident is defined as "any error or unplanned event that could, or indeed did, reduce the safety margin for a diver on a particular dive". An error can be related to anybody associated with the dive and can occur at any stage during the dive. An incident can also include equipment failure.

Divers are encouraged to fill in one of these forms as soon as they have witnessed, or have been involved in, an incident. Anonymity is assured by the design of the questionnaire. This allows for accurate reporting without personal identification and legal risk. Once reported, the data are collected and analysed and if any identifying feature is present, it is removed.

Data on all incidents associated with the use of a BCD in the first 1,000 diving incidents reported to the Diving Incident Monitoring Study (DIMS) were examined.

Results

There were 154 BCD incidents reported to DIMS in the first 1,000 incidents. Forty eight of these incidents resulted in morbidity (Table 1). These cases constitute 10% of the total morbidity reported in this time period.

The 79 incidents which were due to problems with

TABLE 1

48 CASES OF MORBIDITY ASSOCIATED WITH BCD INCIDENTS

Morbidity	Number
Decompression sickness	17
Cerebral arterial gas embolism	12
Pulmonary barotrauma	10
Salt water aspiration	4
Near drowning	2
Ear or sinus barotrauma	2
Not specified	1

TABLE 2

79 BCD INCIDENTS DUE TO PROBLEMS WITH THE POWER INFLATION MECHANISM

Problem	Number	Morbidity
The inflation mechanism failed	31	9
Confusion between the deflate and inflate buttons	25	10
Spontaneous activation of the BCD power inflator	15	6
Diver did not know how to use the oral or power inflator	7	2
Confusion between the inflate and deflate buttons	1	1
Total	**79**	**28**

TABLE 3

31 CASES OF INFLATION MECHANISM FAILURE

Cause	Number	Morbidity
The power inflation mechanism was not connected	11	2
A low air situation	5	3
The inflation mechanism jammed	5	1
The diver was unable to locate the inflator	5	1
An out of air situation	3	1
Inflator hose puncture	2	1
Total	**31**	**9**

the inflation mechanism are ranked in order of decreasing frequency in Table 2 and the causes of the underlying inflation mechanism failures are listed in Table 3. The remaining 75 reported BCD problems are listed in Table 4.

TABLE 4

MISCELLANEOUS PROBLEMS ASSOCIATED WITH BCD USE IN 75 DIVERS (EXCLUDING THOSE INCIDENTS THAT INVOLVED THE POWER INFLATION MECHANISM)

Problem	Number	Morbidity
Rapid ascent caused by a BCD problem.	73	37
BCD causing buoyancy problems at a "safety" or decompression stop	26	16
The BCD provided inadequate buoyancy	16	9
The BCD leaked	7	0
A problem was caused by inflation of the BCD at entry	5	0
The diver was unable to exhaust the BCD to abort the ascent after weight belt dislodgement	4	3
The air cylinder was not secure in the BCD's back pack	4	0
Dump valve malfunction	4	0
The BCD was too large or uncomfortable to wear	3	1
Inflation of the BCD restricted the diver's respiration	1	0
Total	**143**	**66**

Note that problems, and morbidity resulting, are not mutually exclusive.

The two most common factors contributing to the BCD incidents were failure to deflate the BCD (89 incidents, 41 of which caused harm) and divers not knowing how to use their BCD (71 incidents, 26 of which caused harm). The diving qualifications of the divers involved in the inflation BCD incidents are listed in Tables 5 and 6.

The factors contributing to the 89 incidents of inadequate BCD deflation and associated morbidity are listed in Table 7. In 40 of these incidents, the divers did not know how to use their BCD. The qualifications of these divers are listed in Table 8.

TABLE 5.

QUALIFICATIONS OF 89 DIVERS UNABLE TO DEFLATE THEIR BCDs

Qualification	Number
Diving student	6
Basic	14
Open water	38
Advanced	20
Divemaster	6
Diving instructor	1
Untrained	2
Not recorded	2

TABLE 6

QUALIFICATIONS OF 71 DIVERS WHO DID NOT KNOW HOW TO USE THEIR BCDs

Qualification	Number
Diving student	7
Basic	8
Open water	35
Advanced	12
Divemaster	4
Diving Instructor	1
Untrained	2
Not recorded	2

TABLE 7

CONTRIBUTING FACTORS AND MORBIDITY ASSOCIATED WITH 89 INCIDENTS INVOLVING INADEQUATE BCD DEFLATION

Contributing factors	Number	Morbidity
The diver was not familiar with the BCD's functions	40	20
Insufficient time to activate the deflate mechanism	26	12
The diver's buddy was unable to activate the deflation mechanism due to its inaccessible position	9	6
Maximum deflation rate was inadequate	6	1
Deflation mechanism inaccessible to the diver	5	1
Deflation mechanism was faulty	3	1
Total	**89**	**41**

TABLE 8

QUALIFICATIONS OF 40 DIVERS WHERE INABILITY TO DEFLATE THE BCD WAS DUE TO THE DIVER NOT KNOWING HOW TO USE THE BCD

Qualifications	Number
Diving Student	2
Basic	4
Open water	17
Advanced	10
Divemaster	3
Dive instructor	1
Not recorded	3

TABLE 9

CONTRIBUTING FACTORS IN 16 INCIDENTS WHERE THE BCD PROVIDED INADEQUATE BUOYANCY

Contributing factors*		Number	Morbidity
Low air situation		5	3
The diver did not know how to orally inflate the BCD	**	4	2
The power inflator was not connected	**	4	2
The dump valve malfunctioned	**	2	0
Out of air situation		1	1
The diver was unable to locate the inflation mechanism	**	1	1
The inflator hose was leaking	**	1	1
BCD provided inadequate buoyancy while retrieving the anchor		1	1
BCD leaking	**	1	0

*** These contributing factors are not mutually exclusive.**

**** Could have been prevented by a pre-dive check.**

The contributing factors in the 16 incidents (and consequent morbidity) in which the BCD provided inadequate buoyancy are listed in Table 9.

Thirty nine of the total 154 incidents could have been prevented if the divers had checked their BCD prior to diving. Eight of these preventable incidents caused harm to the diver. These incidents are listed in order of

TABLE 10

39 INCIDENTS WHICH COULD HAVE BEEN PREVENTED BY A PRE-DIVE BCD CHECK

BCD Incident	Number	Morbidity
Inflator hose was not connected correctly	11	2
Diver did not know how to orally inflate the BCD	4	2
Air cylinder was not secured in the BCD	4	0
Dump valve malfunction	4	0
BCD harness was not correctly fastened	3	0
BCD was an inappropriate size	2	1
Inflator hose was not secured in an accessible position	2	1
Deflation mechanism malfunction	1	1
BCD leaking	7	0
Leaking inflator hose	1	0
Total	**39**	**7**

decreasing frequency in Table 10.

In addition to the 154 reported BCD incidents, there were 9 “out of air” and 2 “low on air’ problems that were caused by the diver’s overuse of the BCD power inflator to maintain buoyancy. Four of these incidents resulted in morbidity.

Discussion

Incidents involving a BCD are frequently reported to DIMS and often cause harm. However, all of the incidents reported here could have been prevented by use of one or more of the following:

a the purchase or hiring of a BCD being accompanied by a relevant education program;
b changes in design of some BCDs and some features of all BCDs;
c a meticulous pre-dive BCD check;
d all introductory recreational diver training programs putting greater emphasis on the importance of buoyancy control;
e washing the BCD with fresh water after every dive;
f having the BCD serviced annually; and
g emphasising the need, and overlearning the correct way, to release the weight belt in an emergency.

These incidents and proposed corrective strategies are summarised in Table 11.

Having the power inflate and deflate mechanisms close to each other, as on all of the currently commercially available BCDs, is dangerous. This was demonstrated by the frequent occurrence of, and consequent morbidity from, incidents arising because a diver had difficulty distinguishing the inflate and deflate knobs. In addition, the often reported inability of a diver, or diver’s buddy, to activate either mechanism in an emergency suggests that these mechanisms should be separated and secured on different, but standardised, sides of the jacket. This would make them accessible during an emergency and it would improve the ability of divers to control their buoyancy. This is particularly important during an emergency air sharing ascent. Especially so if the second stage of the donor’s spare regulator is part of, or attached to, the BCD’s power inflator hose. The separation of the opposing functions would also mean that divers could be trained to inflate the jacket on one side and to deflate on the other, so reducing the risk of an error.

Inability to exhaust air from a BCD was not confined to the novice diver and was the main cause of morbidity in this study. These incidents were inevitably associated with a rapid ascent and often resulted from the diver either being unfamiliar with the use and functions of a BCD (this was not confined to novice divers) or confusion between the deflate and inflate buttons. In some cases, the error was failure of, or inability to locate, the deflate mechanism. Some incidents arose as a consequence of divers being unable to adjust their buoyancy adequately at a decompression or a “safety” stop.

Appropriate preventative strategies for all of these incidents include relevant educational programs (to accompany the purchase or hiring of a BCD), the separation of BCD deflate and inflate mechanisms, a change in BCD design to allow easier access to the deflate mechanism and an emphasis in recreational diving training programs on buoyancy control. In particular, the changes in buoyancy that occur in the last 4 m of an ascent must be emphasised, along with the specific teaching of techniques to slow an uncontrolled ascent.

The incidents of spontaneous jacket inflation were due either to poor maintenance or a design fault. These incidents could be minimised by:

a a meticulous pre-dive check of the power inflator;
b an accessible dump valve that is able to exhaust air at a rate at least equal to that of maximum inflation;
c addition of a cut off mechanism to the power inflator;
d annual servicing of the BCD;
e washing the inflator in fresh water after every dive ; and
f training programs stressing methods of slowing an uncontrolled ascent.

The 39 incidents that arose from, or involved, a “failure to check” indicate that a pre-dive BCD checking

TABLE 11

THE PROPOSED CORRECTIVE STRATEGIES.

BCD incidents	**Corrective strategies**				
The inflation mechanism failed	Checking			Buoyancy training	Washing
Confusion between the inflate and deflate mechanisms	Checking	Education	Design changes		
The power inflation mechanism was not connected correctly	Checking				
BCD inflation due to spontaneous activation of the BCD inflator	Checking		Design changes		Washing
The diver was unable to locate the power inflation mechanism	Checking	Education	Design changes		
The diver was unable to vent the BCD	Checking	Education	Design changes		
The diver was unfamiliar with the BCD's functions	Checking	Education			
The BCD provided inadequate buoyancy	Checking	Education			Servicing
The BCD leaked	Checking				
The BCD was too large or uncomfortable	Checking				
When inflated the BCD restricted the diver's respiration	Checking	Education			
Dump valve malfunction	Checking		Design changes		
The BCD caused buoyancy problems at a decompression or "safety" stop		Education		Buoyancy training	
Maximum deflation rate inadequate			Design changes		
The diver was not able to locate the deflate mechanism	Checking	Education	Design changes		
Leaking inflator hose	Checking				
The air cylinder was not secured in the BCD's backpack	Checking				

Description of strategies (in order of importance in prevention of BCD incidents).

Checking	A meticulous pre-dive BCD check.
Education	The purchase or hiring of a BCD being accompanied by a relevant education program.
Design changes	Changes in design of some BCDs and some features of all BCDs.
Buoyancy training	All introductory recreational diver training programs putting greater emphasis on the importance of buoyancy control.
Washing	Washing the outside of the BCD with fresh water after every dive.
Servicing	Having the BCD serviced annually.

protocol needs to be developed and taught to trainee divers. This inspection protocol should include a check that:

a the there is no salt or debris encrusted on the power inflation mechanism;
b the inflator is connected;
c the oral and power inflation mechanisms work;
d the inflator hose does not leak;
e the inflator's mouth piece is functional;
f the inflator and deflator are secured and accessible;
g the BCD fully inflates and does not leak;
h the deflate mechanism works and no components are worn;
i the dump valve works;
j the air cylinder is secured in the back pack;
k the BCD is comfortable and all security belts are fastened; and
l when fully inflated, the BCD does not restrict respiration.

Eight incidents involved inadequate buoyancy on the surface and all resulted in morbidity. None of these divers removed their weight belt and in 4 of the incidents the diver did not know how to orally inflate the BCD. It is clear that the release of a weight belt and oral inflation techniques should be overlearnt in basic diver training programs.

There were 7 incidents in which the divers did not know how to inflate their BCD. These incidents would be prevented by thorough education and a pre-dive check.

Most power inflation failure incidents would have been prevented both by securing the inflator in an accessible position and a thorough pre-dive check. However, the highest rate of harm arising from power inflation failures was associated with either a low on air or an out of air situation and would have been prevented by appropriate air supply management.[13]

The reported incidents in which the diver overused the power inflator to maintain buoyancy and those in which the divers were unable to control their ascent after their weight belt became dislodged are indicative of divers using their BCD as their main, or even sole, means of buoyancy control. This is poor diving technique and can be avoided by better training. It is my opinion that the use of a BCD should only be taught after a diving candidate can demonstrate good buoyancy control in shallow water without the use of a BCD.

Conclusions

This study shows that BCD incidents are not uncommon in recreational diving and that BCD misuse is associated with a high incidence of morbidity.

An educational program should accompany the purchase or hiring of a BCD.

Modifications are needed in BCD design. The inflation and deflation mechanisms need to be separated and placed on either side of the jacket. All jackets should have an accessible dump valve that can exhaust air at a rate equal to that of maximum inflation.

Buoyancy training is an important aspect of recreational diving. Emphasis is needed on the predictable changes in ascent rate, especially in the last 5 metres of an ascent, methods that will decrease the rate of an uncontrolled ascent and on techniques of buoyancy control that do not rely on a BCD.

A BCD needs to be washed thoroughly with fresh water following use and serviced annually.

Recreational diver training should emphasise the importance of releasing the weight belt in emergency situations.

Acknowledgement

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Key Words

Equipment, buoyancy, safety, incidents.

The original version of this paper was presented at the XXIst Annual Scientific Meeting of the European Undersea Biomedical Society at Helsinki in 1995.

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TWENTY FIVE YEARS OF SPUMS 1971-1996

John Knight

This paper is an expanded version, to bring it up to SPUMS's twenty fifth birthday, of the paper presented at the 1995 Annual Scientific Meeting.

I am indebted to Carl Edmonds and Bob Thomas for information about the early years of SPUMS. Any mistakes after 1975, when I joined the Committee, are mine.

SPUMS was founded, on Monday May 3rd 1971, over a drink or two, in the Wardroom of HMAS PENGUIN by Carl Edmonds, Bob Thomas, Douglas Walker, Ian Unsworth and Cedric Deal, whose names appear in the first constitution as Foundation Members.[1] Others, about twenty in all, mostly associated with the Royal Australian Navy (RAN) School of Underwater Medicine (RANSUM) and the Underwater Research Group, a Sydney diving club which had been formed in the days before submersible pressure gauges, were nominated as Charter Members. An aim seems to have been to provide a diving holiday with discussion of diving medical topics making it tax deductible. Ian Unsworth, who was the inaugural Secretary, later spoilt this cosy arrangement by putting a notice in the Medical Journal of Australia that the Society had been founded and soon there were over 60 members. The annual subscription laid down was $ 2.00. In November 1971 there were 40 paid up members, 64 by May 1972 and 75 by May 1973. The March 1996 issue of the Journal was sent out to 1,128 members and associates.

In the early days of his time at RANSUM Carl Edmonds had let it be known around the diving world that those with diving injuries could be sure of help if they contacted RANSUM. In those days, and for some time later, the Diving School maintained a 24 hour telephone watch, which was the number made available. This system worked well until the telephone watch was stood down as an economy measure. Then people had difficulty getting through and the RAN had to be approached to sanction the service and see that the gate sentries at HMAS PENGUIN, the after hours switch board keepers, knew what to do to contact the duty diving MO. It took time and political pressure to achieve the Divers Emergency Service (DES) which opened for business in 1984 (Figure 1) with a dedicated Sydney number thanks to pressure from individual members of SPUMS, the Committee and the Australian Underwater Federation.[2] DES moved to Adelaide in 1986 and now has a toll free number.

After being threatened with legal action, when we refused to endorse a diving expedition using the SPUMS name without permission, the Committee decided to incorporate the Society. This involved the Victorian

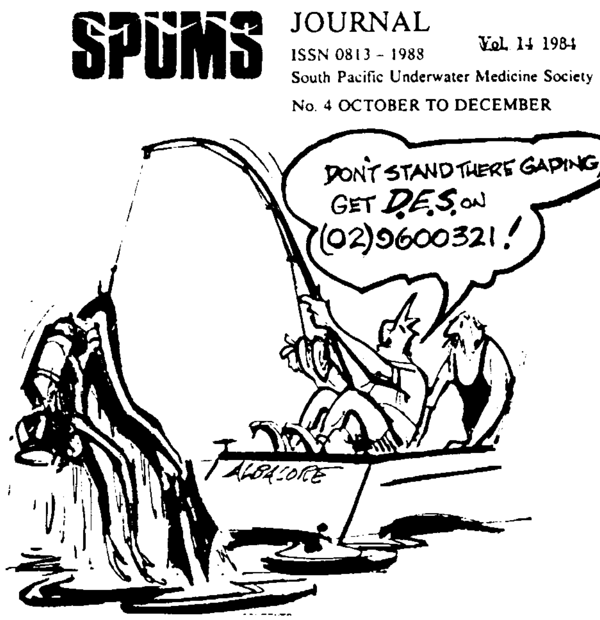


Figure 1. SPUMS J cover 1984; 14 (4):

Corporate Affairs Commission as the official address of the SPUMS Journal was 80 Wellington Parade, East Melbourne (it just happened to be the address from which my practice was carried on). What with lawyers being literal in following the suggested constitution provided by Corporate Affairs and resisting Chris Lourey's and my attempts at preserving our existing constitution as much as possible it took about a year to finalise. It was adopted in 1990. As a result of being incorporated in Victoria at least one member of the Committee, the Public Officer, has to reside in Victoria.

Up till 1990 the Society's address was that of the Secretary. Subscriptions were sent directly to the Treasurer. When these offices changed hands many members did not notice the new addresses and John Doncaster, Treasurer 1982-5, was still getting subscriptions sent to him three years later in spite of Grahame Barry's address being printed on the reminder notice!

In July 1990 the Society decided to use the Science Centre Foundation (SCF), in Sydney, as its postal address. But by December 1990, dissatisfied with the service from SCF, and its price, the address was changed to the College of Occupational Medicine in St Kilda West, Victoria. This lasted until the College decided to become a Faculty of the Royal Australasian College of Physicians, and moved to Sydney. In September 1993 our address became The Australian and New Zealand College of Anaesthetists (ANZCA) at the Royal Australasian College of Surgeons, Spring Street, Melbourne. The anaesthetists then bought their own building in St Kilda Road, Melbourne and moved in January 1994. We hope that SPUMS has now stopped moving.

Aims of the Society

The objectives of the Society have never changed. They are:

1 To promote and facilitate the study of all aspects of underwater and hyperbaric medicine
2 To provide information on underwater and hyperbaric medicine
3 To publish a newsletter or journal
4 To convene members of the Society annually at a scientific conference.

Information about underwater medicine

The 1970s and 1980s saw considerable activity in diver education. There were meetings in Sydney and Adelaide where Bob Thomas was the principal speaker. In Victoria there were meetings at "Oceans" in Melbourne, in Frankston and Portsea where there were hundreds of divers in the audiences. In 1981 there was a similar meeting in Perth. The last of these diver oriented meetings was held in Rockhampton in 1986 organised by Chris Acott who then lived in Rockhampton.

Other smaller meetings for members, but open to anyone, were also held in Melbourne and Sydney. These were restarted by Darrell Wallner in 1991 but they appear to have petered out.

It is a sad fact that as the Society has grown its contacts with ordinary divers has lessened. Perhaps this is because better teaching means that divers have little to learn about diving medicine, but I doubt it. I think it is because members feel that the Committee should organise such meetings. Unfortunately the success of these diver education meetings depends on enthusiastic local publicity involving local dive shops and local SPUMS members. It is always possible to import speakers but nothing can replace local involvement.

In the early 1980s members suggested to the Committee that SPUMS should run courses in underwater medicine as it was difficult to get places on the RANSUM courses. The Committee decided that trying to duplicate the RAN course from SPUMS resources was not feasible. It was felt that the correct role for SPUMS was to approve courses which met or exceeded the standards set by the RAN. This was to be done by the Censors, appointed to assess candidates for the Diploma of Diving and Hyperbaric Medicine, who were the President, the Secretary and the Director of a hyperbaric unit. The opening of the Royal Adelaide Hospital Hyperbaric Unit in 1986 and its courses reduced the pressure on RANSUM places. Since 1990 the Censors have been the President, the Director of a hyperbaric unit and the Education Officer.

New Zealand formed its own Chapter in 1985 with an inaugural meeting at Great Barrier Island where I was the guest speaker. They have had annual scientific (and diving) meetings ever since.

In 1990 Ray Rogers asked if we would allow a North American Chapter. This was agreed to and Lori Barr and Steve Dent joined him as the North American Chapter executive. They did sterling service at DEMA meetings bringing the Society to people's attention. Ray had to resign as Chairman in 1992, when Lori took over. Unfortunately Lori and Steve put in their resignations from the North American Executive in early 1995, so the Chapter is in abeyance.

At present SPUMS is represented on four Standards Australia Committees, those dealing with occupational diving, recreational diving, working in compressed air and therapeutic hyperbaric chambers. The AMA is represented by Dr Ian Millar, a SPUMS member, on the same committees and Dr Harry Oxer, another SPUMS member, represents the Australian and New Zealand Hyperbaric Medicine Group (ANZHMG) on the therapeutic chamber committee.

Diving Medicals

Medical Standards for divers appeared for the first time in the second Newsletter.[3] They have appeared at intervals ever since.

For a number of years the Society was unpopular with the recreational diving industry. We were accused of being anti-dive instructors. I think these views arose because SPUMS has always advocated a diving medical for every prospective diver before the first dive of the course. Many instructors considered that this was a waste of time and money, which could better be spent in their

shops. Some statements from diving doctors, who were SPUMS members but were not then on the Committee, drawing attention to the practice of some instructors who sent prospective divers. who had failed a medical with one doctor, to see another doctor with instructions not to mention their asthma (Figure 2) probably did not go down well and the blame was put on the Society rather than the members concerned. Whatever the causes, distrust of SPUMS by the recreational industry lasted into the 1990s but been alleviated during Des Gorman's presidency. Unfortunately a rift has developed between the technical diving community and SPUMS in the last few years.

At the same time Bob Thomas was attacking the competence of GPs who failed to look in people's ears before certifying them fit to dive. Carl Edmonds published a paper, *MMM the Mickey Mouse Medical*, in 1986 which demonstrated that, among other things, the doctors surveyed were unable to pick the correct treatment for four common diving illnesses any better than 50% (guessing level).[4] They had to choose the correct treatment for decompression sickness, air embolism, marine animal injury and pneumothorax from four answers, recompression, medical or surgical, surgical or 100% oxygen and recompression.

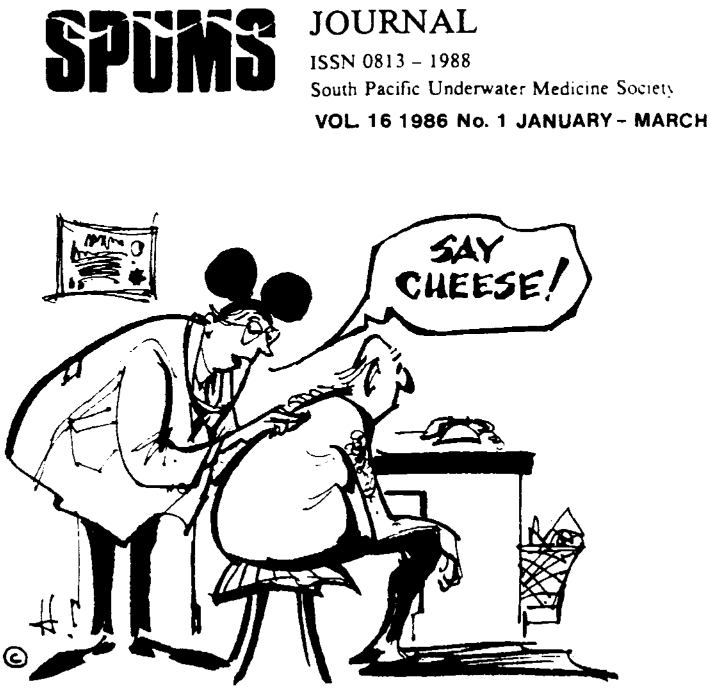


Figure 3. SPUMS J cover 1986; 16 (1):

In 1989 Standards Australia started the process of preparing a Standard to cover recreational diver training. SPUMS applied for a place on the Committee and I was appointed to fill it. Among the comments on the proposal standard was one from a PADI instructor who advocated adopting the PADI training scheme as the Standard! However this did not meet with the committee's approval and the standard was eventually published as AS 4005.1 in 1992. Unfortunately the Committee, after agreeing, in December 1991, that the medicals should be done by doctors trained in underwater medicine, as advocated by SPUMS, refused to accept this condition at its next meeting. The Queensland Government however legislated to enforce the requirement when they brought in regulations for the recreational diving industry.

The Queensland government's insistence on proper training for doctors doing diving medicals rapidly increased the number of such doctors, thanks in large part to the Diving Medical Centre long weekend courses run by Bob Thomas and Carl Edmonds. These and courses run each year by the Fremantle hyperbaric unit were approved by the Censors as providing the necessary minimum knowledge to do diving medicals properly. The legislation and the increased number of trained doctors also influenced dive shops towards relying on medicals rather than questionnaires. The legislation was used by SPUMS to push the Australian Medical Association (AMA) into accepting that doctors doing diving medicals should have the proper training.

Since 1986 SPUMS has published a list of doctors with appropriate training in underwater medicine.[5] At first it was limited to those trained by RANSUM. Since then seven other courses have been approved by the Censors. The Diving Doctors list now appears as a supplement to the Journal and covers New Zealand as well as Australia. The March 1996 list contained the names of 347 Australian and 63 New Zealand doctors.

Diploma of Diving and Hyperbaric Medicine

From the first a diploma of diving and hyperbaric medicine had been planned. At the first Annual General Meeting (AGM) the sub-committee investigating the feasibility of establishing a Diploma in Diving and Hyperbaric Medicine reported. Their syllabus[6] had a close resemblance to the list of contents in Diving and Subaquatic Medicine.[7] It was suggested that the diploma course should include a nine month correspondence course, to supplement the RANSUM basic and advanced courses and the Prince Henry Hospital (PHH) Hyperbaric Medicine course, and a four weeks hands-on attachment to RANSUM. It was thought that the RAN would back the Diploma as a useful yardstick. As well there had to be affiliation with a university so that the Diploma had academic status. The subcommittee, Bob Thomas, representing the Officer in Charge, RANSUM, Ian Unsworth, as Director of the Prince Henry Hyperbaric Unit, and Rex Gray. representing the SPUMS committee was instructed to institute the Diploma. For non-doctors there was to be a Certificate in Underwater Technology to be looked into by a sub-committee of John Pennefather (scientist), Frank Blackwood (technician), Fred Ashmore (administrator) and Bob Thomas, all of RANSUM. This certificate never proceeded beyond investigation.

By late 1974 it had become clear that neither of the two universities in New South Wales would be interested in sponsoring a diploma as they had just divested themselves of such things and were only going to issue degrees. So SPUMS took the brave step of issuing its own Diploma of Diving and Hyperbaric Medicine. This was the first non-naval certification of diving medical competence and for many years the only post-graduate qualification. The Foundation diplomates included Jimmy How of the Republic of Singapore Navy, as well as Geoff Bayliss, Carl Edmonds, Rex Gray, Chris Lowry, Bob Thomas and Ian Unsworth, for the Society has been international since its inception. Other overseas Foundation Diplomates were Drs Kee Peng Leong, Tai Lung Ho, Made Subrata, Harijonto Mahdi, Hartono and Gene Chan. Originally the requirements for the diploma by examination were the two RANSUM courses and the PHH course and a treatise suitable for publication. All the foundation diplomates had at least 2 years experience in diving medicine.[8] The first Diplomas by examination were awarded in 1975 to Chris Acott, Gavin Dawson and John Knight. The requirements for the Diploma now include six months diving or hyperbaric medicine experience and appear in every issue of the SPUMS Journal.

In 1989, when the number of hyperbaric units in Australasia had risen to 10 (there had been three in 1974) SPUMS reviewed their staffs and awarded diplomas to those qualified to receive them. Since then there have been one or two diplomas awarded by examination each year.

In 1991 the Directors of the various Australasian hyperbaric units formed the Australian and New Zealand Hyperbaric Medicine Group as a sub-committee of SPUMS. They and the Hyperbaric Technicians and Nurses Association (HTNA) have held three, very successful, Annual Scientific Meetings, in Darwin, Perth and Melbourne, and the fourth will be in Hobart in August 1996.

The Newsletter and Journal

The first newsletter appeared in May 1971, with Carl Edmonds as editor. When he went on exchange service with the USN in 1973 Bob Thomas, who succeeded him as the Officer in Charge at RANSUM, took over. Carl edited a few issues when he came back and then Douglas Walker, as the only volunteer was elected Editor of the Newsletter in 1974. In September 1976 he changed the title to Journal/Newsletter. By 1979, owing to printing problems, the Journal/Newsletter was months in arrears and I volunteered to get it printed and posted in Melbourne with Douglas supplying me with editorial material. The October to December 1979 issue had the title SPUMS Journal for the first time.

I have been responsible for the format of the Journal ever since, and since 1990, when Douglas Walker did not nominate as Editor, I have been responsible for the contents.

The Newsletter and its successors were, and still are, the Society's main contact with the majority (over 90%) of members and associates. For nearly twenty years only about 5% of the membership has attended the Annual Scientific Meeting (ASM). The figures are rubbery because Allways counts total passengers and usually about one third are not members or associates.

That is why we struggle to extract the text from every speaker so that his or her talk can be published in the Journal. We go so far as to tell the guest speaker that the invitation is contingent on the delivery of the texts before the meeting. This policy was forced on us by the failure of the guest speakers in 1984, 1986, 1987, 1988, 1991 and 1992 to provide texts of their lectures. Some lectures could be reconstructed from our recordings and some speakers provided previously published papers on the topic which could be cut and pasted into shape for publication. Our members who contribute to the scientific proceedings have also been guilty of not providing the text (even after hearing this presentation in Fiji one New Zealander's contribution to the Asthma Workshop had to be reconstructed from the tapes).

An index of all the articles that have appeared in the SPUMS Newsletter and the Journal has been compiled on the editorial Macintosh and will be available on disc for both Mac and Windows.

Committee

In all only 43 people have been elected to the committee in the 25 years between 1971 and 1995. A very low turnover indeed. Thirteen of them are no longer members. The list appears on pages 98-100. Those marked with * were New Zealand Chapter representatives.

The Society awarded life membership to Carl Edmonds in 1988, Douglas Walker in 1989, Chris Lourey in 1990 and John Knight in 1993. At the 1996 AGM David Elliott, three times guest speaker at ASMs and a member since 1982, was nominated for life membership to be voted on in 1997.

Annual Scientific Meetings

1972

In June 1972 the first AGM was held at Heron

COMMITEE MEMBERS OF SPUMS

1971-72

President	Carl Edmonds
Secretary	Ian Unsworth
Treasurer	Fred Ashmore

1972-73

President	Carl Edmonds
Secretary	Ian Unsworth
Treasurer	Fred Ashmore
Editor	Carl Edmonds
Members	Rex Gray
	Bob Thomas
	Douglas Walker

1973-74

President	Carl Edmonds
Secretary	Ian Unsworth
Treasurer	John Pennefather
Editor	Bob Thomas
Members	Jim Hazel
	William Lucas
	Frank Blackwood
	Chris Lowry

1974-75

President	Carl Edmonds
Secretary	Ian Unsworth
Treasurer	John Pennefather
Editor	Douglas Walker
Members	Jim Hazel
	William Lucas
	Frank Blackwood
	Chris Lowry

1975-76

President	Carl Edmonds
Secretary	Jim Hazel
Treasurer	Phillip Rubenstein
Editor	Douglas Walker
Members	John Knight
	Geoff Mcfarlane
	Ian Unsworth

1976-77

President	Ian Unsworth
Secretary	John Knight
Treasurer	Bill Rehfisch
Editor	Douglas Walker
Members	Victor Brand
	Ray Leitch
	Chris Lourey

1977-78

President	Ian Unsworth
Secretary	John Knight
Treasurer	Bill Rehfisch
Editor	Douglas Walker
Members	Victor Brand
	Ray Leitch
	Chris Lourey

1978-79

President	Ian Unsworth
Secretary	John Knight
Treasurer	Bill Rehfisch
Editor	Douglas Walker
Members	Victor Brand
	Ray Leitch
	Chris Lourey

1979-80

President	John Knight
Secretary	Chris Lourey
Treasurer	Bill Hurst
Editor	Douglas Walker
Members	Victor Brand
	Bill Rehfisch
	Darryl Wallner

1980-81

President	John Knight
Secretary	Chris Lourey
Treasurer	Bill Hurst
Editor	Douglas Walker
Members	Victor Brand
	Beryl Turner
	Darryl Wallner

1981-82

President	John Knight
Secretary	Chris Lourey
Treasurer	Bill Hurst
Editor	Douglas Walker
Members	Victor Brand
	John Doncaster
	John McKee

1982-83

President	John Knight
Secretary	Janene Mannerheim
Treasurer	John Doncaster
Editor	Douglas Walker
Members	Victor Brand
	John McKee
	Harry Oxer

1983-84

President	Chris Lourey
Secretary	Chris Acott
Treasurer	John Doncaster
Editor	Douglas Walker
Members	David Davies
	John Knight
	Janene Mannerheim

1984-85

President	Chris Lourey
Secretary	Chris Acott
Treasurer	John Doncaster
Editor	Douglas Walker
Assistant Editor (Co-opted)	John Knight
Members	David Davies
	Peter McCartney
	John Williamson

1985-86

President	Chris Acott
Secretary	David Davies
Treasurer	Grahame Barry
Editor	Douglas Walker
Past President	Chris Lourey
Members	John Knight
	*Allan Sutherland
	John Williamson

1986-87

President	Chris Acott
Secretary	David Davies
Treasurer	Grahame Barry
Editor	Douglas Walker
Past President	Chris Lourey
Members	John Knight
	Peter McCartney
	John Williamson

1987-88

President	*Tony Slark
Past President	Chris Acott
Secretary	David Davies
Treasurer	Grahame Barry
Editor	Douglas Walker
Deputy Editor (Co-opted)	John Knight
Members	Des Gorman
	Chris Lourey
	Peter McCartney

1988-89

President	*Tony Slark
Past President	Chris Acott
Secretary	David Davies
Treasurer	Grahame Barry
Editor	Douglas Walker
Deputy Editor (Co-opted)	John Knight
Members	Des Gorman
	Chris Lourey
	Peter McCartney

1989-90

President	*Tony Slark
Past President	Chris Acott
Secretary	David Davies
Treasurer	Grahame Barry
Editor	Douglas Walker
Public Officer	John Knight
Members	Des Gorman
	Chris Lourey
	Peter McCartney

1990-91

President	Des Gorman
Past President	*Tony Slark
Secretary	John Robinson
Treasurer	Grahame Barry
Editor	John Knight
Public Officer	John Knight
Members	Chris Acott
	Darryl Wallner
	John Williamson
Education Officer (Co-opted)	David Davies

1991-92

President	Des Gorman
Past President	*Tony Slark
Secretary	Darryl Wallner
Treasurer	Grahame Barry
Editor	John Knight
Education Officer	David Davies
Public Officer	John Knight
Members	Chris Acott
	Sue Paton
	John Williamson

1992-93

President	Des Gorman
Past President	*Tony Slark
Secretary	Darryl Wallner
Treasurer	Sue Paton
Editor	John Knight
Education Officer	David Davies
Public Officer	John Knight
Members	Chris Acott
	Guy Williams
	John Williamson

1993-94

President	Des Gorman
Past President	*Tony Slark
Secretary	Cathy Meehan
Treasurer	Sue Paton
Editor	John Knight
Education Officer	David Davies
Public Officer	John Knight
Members	Chris Acott
	Guy Williams
John Williamson	

1994-95

President	Des Gorman
Past President	*Tony Slark
Secretary	Cathy Meehan
Treasurer	Sue Paton
Editor	John Knight
Education Officer	David Davies
Public Officer	John Knight
Members	Chris Acott
	Guy Williams
	John Williamson

1995-1996

President	Des Gorman
Past President	Tony Slark
Secretary	Cathy Meehan
Treasurer	Sue Paton
Editor	John Knight
Education Officer	David Davies
Public Officer	Guy Williams
Members	Chris Acott
	Robyn Walker
	John Williamson
New Zealand Chapter Representative	Mike Davis

1996-1997

President	Guy Williams
Past President	Des Gorman
Secretary	Cathy Meehan
Treasurer	Robyn Walker
Editor	John Knight
Education Officer	David Davies
Public Officer	Guy Williams
Members	Chris Acott
	Vanessa Haller
	Michal Kluger
New Zealand Chapter Representative	Mike Davis

Island. The first dive showed that most of the members had very different ideas about how to dive safely from the Foundation Members! Before the boat had lost way there were splashes all round. The boat supervisor had no list of buddies nor their time of entry. When the vessel anchored it was clear that there was quite a current running but people were jumping in without checking. Bob Thomas and his buddy, Phil Rubenstein, stayed together all through the dive and were the only ones to achieve this. They went up current and then came back to the anchor line. They were first back and it was two hours later that the last of the divers was picked up a mile and more down current. The intervening time was spent searching for and collecting divers from all round the horizon. The scientific program was hurriedly changed to “Diving safety, what not to do” which was illustrated by examples from the morning’s dive! According to Bob Thomas the weather was less than ideal and the only entertainment equipment on the island was a single cracked ping-pong ball.

The minutes of that meeting record that, after as many alternatives for the site of the 1973 meeting as there were people present (about 20), including chartering a live-aboard and cruising the Barrier Reef, had been offered, Norfolk Island, Lord Howe Island and Fiji were chosen for further investigation.

A system of regional sub-groups and representatives was set up at the instigation of Peter Nicholl of Queensland. The sub-groups were to consider local problems and keep people in touch throughout the year and generally foster interest. This laudable initiative was certainly never very noticeable in Victoria. Representatives were recorded for Queensland (Peter Nicholl), Victoria (Phil Rubenstein), South Australia (Fred Gilligan), Papua New Guinea (Jay Morton), New Zealand (Tony Slark), Singapore (Jimmy How), Malaysia and Indonesia have handwritten entries that I cannot decipher.

1973

The 1973 AGM was held at the Broadbeach International Hotel, Surfers Paradise, Queensland on 17-18th November. Like the other AGM held in Australia before the present constitution was adopted, too few members (14) attended to form a quorum. Once again there were many suggestions for the site of the 1974 AGM. In those days and later the AGM had the task of choosing the site. At this meeting the first constitution was replaced by a new interim constitution to last until confirmed at the next AGM when a quorum might be present. The new constitution said that all members of the Executive Committee must reside in the same capital city. This eventually proved to be impossible to maintain. There was a fee increase to $15.00 for members and $10.00 for associates. There was to be an entrance fee. As far as I know it was never collected although the idea was resurrected in the 1980s.

1974

At an executive meeting in May 1974 it was suggested that the AGM should be held in Australia, to make it easier for members and associates to attend and the conference somewhere outside Australia. This is an idea which has been raised regularly, but the few occasions this has been tried the AGM has not been well attended. At this committee meeting three committee members were assigned to vet applications as there was waiting time for membership. In those days one had to have a proposer and seconder for membership and they were approached for information about the candidate. This scrutiny of prospective members had been abandoned by 1976 when I took over as Secretary.

That executive meeting selected Bali for the 1975 and New Zealand for the 1976 AGM.

I have seen a provisional conference timetable for an unknown year (probably 1974) from June 18th to 24th. The venue was to be the Isle of Pines. I suspect that the program was for the benefit of the tax man as the conference is described in the Newsletter as “a group of SPUMS members visited the Isle of Pines”.[9]

The 1974 AGM and conference was held in Suva, Fiji. This was where SPUMS had its first major diving injury. The baggage master, a NSW police sergeant diver, blew a round window while diving and was invalided back to Sydney. Beyond the minutes I have no other details of that conference.

1975

In spite of the Bali decision the 1975 AGM was held at Port Vila, New Hebrides (now Vanuatu). That was when I was elected to the Committee. The standard of the meeting can be judged by the fact that the scientific program included two displays of slides taken at “last year’s meeting”. The AGM rejected the New Zealand venue on the grounds that the water was too cold and opted for the Isle of Pines for 1976. Limitations on the number that could be accommodated or dive meant that the Committee had to reject the decision during the year.

1976

The 1976 AGM was held at Mana Island. The organisers, Jim Hazel and other Sydney members, had overestimated the number likely to attend and to fill the rooms, which they had booked and paid for, rounded up any diver who had the money regardless of SPUMS membership. Once again the attitude of some to safe diving was worrying. The scientific sessions were held on one side of a curtain and on the other was the bar, full of noisy drinkers. Once again we were treated to slides of last year's meeting. The AGM was memorable for the verbal explosion by the President, Carl Edmonds, when he resigned because too many members were treating the ASM as a diving holiday paid for by the tax payers. Neither Jim Hazel, the Secretary, nor Phil Rubenstein, the Treasurer, had come to the meeting nor had they sent reports. As the only member of the committee there who was willing, I was elected Secretary and Bill Rehfisch was elected Treasurer. Ian Unsworth was elected President (sleeping partner variety) if he was willing to serve. Accepting election as Secretary I pointed out that I was a firm believer in the committee system and my ideal committee had three members, one off sick, one overseas and myself making the decisions.

One of the decisions I made was to rewrite the constitution to reduce the number of members needed to form a quorum at an AGM. It had been 25% of the membership which was reasonable when the membership was 40, but unattainable with a membership of 200. It was changed to 10% or 25 whichever was the smaller. To counterbalance the increased ease of passing resolutions at the AGM all decisions of the AGM had to be approved by a postal ballot of the membership.

1977

In 1977 the AGM and Annual Scientific Meeting (ASM) was at Truk and no slides of the previous meeting appeared on the screen. We were there because Anthony Newly, who had just started Allways Travel, came to me with the idea at an almost unbelievable price for a charter. I had met Anthony in 1974 when he was a student on the course the Royal Australian Naval Reserve (RANR) diving team in Melbourne, on instructions from Navy Office, ran for the Underwater Instructors Association of Victoria (UIAV).

Some months after we had booked, Air Nauru rang up and apologised that they had forgotten to include the return journey in the price. Then later they rang again with more apologies that they had only charged for getting back to Nauru! In spite of these increases the price was well below any other way and really quite reasonable. The emphasis (or theme) of the meeting was on education and diving safety. For the first time, contents gauges and buoyancy devices were compulsory. The first day's diving was interesting as very few of the divers had used their new buoyancy devices before and a number came to the surface when they first tried to use it. One turned his Fenzy on but not off so had a Polaris ascent. He was really quite lucky as he had hopped in wearing bathers with his wet suit weights on his weight belt and needed to be brought back to the surface! The meeting was a mini diving medicine course, with Royal Navy and US Navy films on diving physiology and decompression diseases and lectures on these topics and on diving safety. This certainly needed attention as five people ran out of air underwater during the conference. No one came to any harm because we had 5 safety divers, one for each boat. Each hovered above his group of six and watched. Their octopuses brought the airless divers to the surface and back to the boat safely. When these incidents were discussed at the evening meeting one of the members said "Every diver runs out of air at least once a year"! Bob Cumberland, a senior Melbourne diving instructor, who had never run out of air in over twenty years of diving, verbally tore him to shreds and after that people started looking at their contents gauges.

1978

For the 1978 meeting in Suva we had an overseas guest speaker for the first time. Glen Egstrom lead us through the mechanical and mental problems of diving safely. Every meeting since has had invited guest speakers and more recently the meetings have had official topics and workshops.

It was obvious that buoyancy compensators (BCs) were still not properly understood by some of the members. One couple had bought two compensators from their local dive shop just before they left for Fiji and had never been instructed in their use. One BC had a scuba feed and the other relied on the diver's puff. The husband wore the one without the scuba feed attachment, but had the inflator hose waving from his first stage. The wife wore the one with the scuba feed. Neither ever put any air into their BC, which did not matter to the husband for he was a strong swimmer and kicked all the time. The wife was a weak swimmer and kept on stopping her leg movements. Every time this happened she sank. On one dive, when the bottom was at around 300 m or more, I watched her sink in spurts from 10 m to 30 m completely unnoticed by her husband. I swam down, blew into her compensator and dragged her towards the surface to prevent a tragedy. Her husband was most irate at my interference.

1979

In 1979 the ASM was held in Port Vila again and Jeff(erson) Davis, who wrote *Diving Medicine* with Fred Bove, was the guest speaker. At this meeting I was elected President because Ian Unsworth did not wish to continue in office and Chris Lourey, not to be confused with Chris Lowry, took over as Secretary. Here it was that we met the two belt diver, who needed two weight belts joined end to end to reach round his middle, for one could not call it a waist.

1980

The 1980 meeting included a two day conference in Singapore hosted by SPUMS and the Republic of Singapore Navy. This introduced us to the amazing world of the diver fishermen who picked up dynamited fish from sea going ships. They used surface supplied air, homemade equipment and paid no attention to decompression tables. They often got bent and even if paralysed they stayed aboard until the holds were full. So it might be 2 weeks or more before they presented for treatment. Jimmy How and his team found that treatment even after this interval often improved them dramatically. The Singaporeans had organised an effective rehabilitation program which often returned these paralysed people to employable condition.

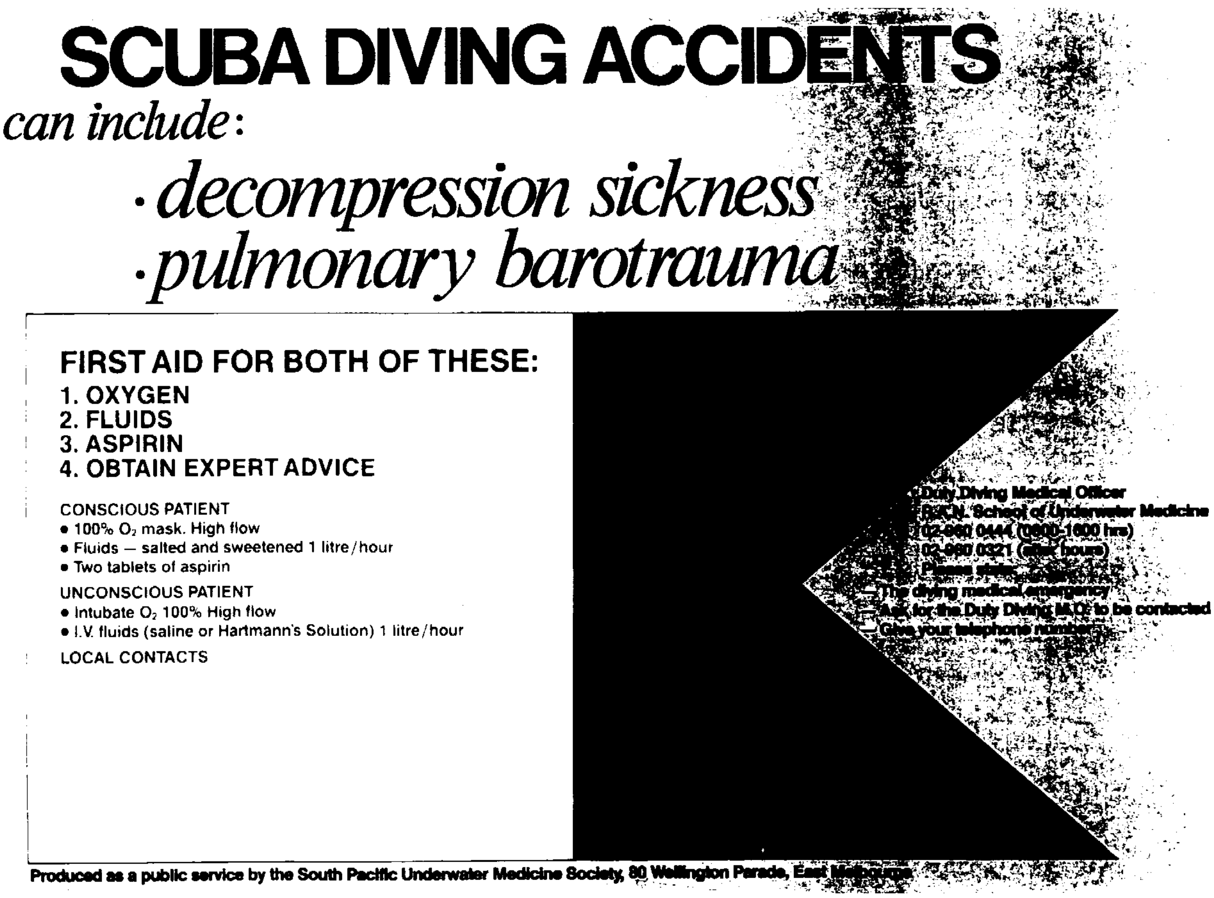
The ASM was on Palau Tioman, an island off Malaysia, for a week. Here our guest speaker was John Miller, an expatriate Australian from America. Before he went to the USA to become a Professor of Anaesthesia he had worked with Carl Edmonds at RANSUM. He was an excellent lecturer and drinking companion. From a discussion, Development of a National Plan, at this meeting came a poster[10] which SPUMS sent to every hospital in Australia giving the first aid treatment for diving illnesses (Figure 4). This emphasised getting expert advice from RANSUM. On the background of flag alpha was the first aid advice, oxygen, fluids and aspirin (the latter is no longer recommended) and obtain expert advice. In the swallowtail was the telephone number of RANSUM and what information to give.

1981

1981 saw SPUMS at Madang; one malarial area after another. Fred Bove was guest lecturer. Bruce Bassett was also there and gave a presentation on his modification of the USN tables, which had been prompted by finding large numbers of bubbles in divers who had been decompressed on USN no-stop tables and then taken to 10,000 ft for an hour. This was to simulate what might happen to a USN SEAL diver involved in clandestine operations. Later John Lippmann and I produced the Bassett tables, 3 fudge factors in the first dive and 5 in the second, in a "no thought required" form.[11] All one had to do was put one's finger on the correct depth and then run it sideways to the elapsed time and then down to the repetitive group letter and once there sideways again to the surface interval time and down to the new depth. It never caught on as the dive shops only made a dollar a copy (in spite of their 100% mark up) which made it not worth stocking when you could make $5 or more on other brands. Now computers allow much longer underwater times than square dive tables and are even more profitable.

1982

1982 brought David Elliott out to SPUMS for the first time to lecture in the Philippines. That new 4 star hotel was built without hot water as the owners considered that no one would need hot water in that climate. Our lectures were in an open sided games room, which was pleasant, at the top of a hill, which was not as the beer was at the bottom. Unfortunately the room could not be



darkened until the sun went down which made seeing slides early in the afternoon very difficult. In spite of the problems it was a very successful meeting.

1983

1983 we were to have used the Regent of Fiji, with its black sand beach, as a base for off shore diving. But a cyclone swept one and a half metres of water through the hotel some weeks before we were due to arrive and the ASM had to be shifted to the Fijian. Here the reefs were hardly worth the bother of diving on, but the guest speaker, Brian Hills gave an excellent, and believable, account of the problems of decompression and decompression sickness (DCS). He introduced us to his thermodynamic theory which explains, as well or better than any other theory, why the Torres Strait pearl divers did not have the expected incidence of DCS given the depths they dived to and the time they spent on the bottom. Their first stop was deep, 21 m (70 ft) or so and they were able to reach the surface far faster than the USN tables would have allowed. The USN would have spent a long time at shallow depths treating the bubbles that their first long pull would have caused. The different profiles did not mean that the Torres Strait divers were DCS free, far from it, but they should have bent on every dive according to the USN tables.

1984

In 1984 the ASM was at Phuket, an island in the Andaman Sea off Thailand. The guest speaker was Ramsay Pearson, Surgeon Captain in charge of the Royal Navy's Underwater Medicine. His and the other lectures failed to beat the attractions of the sunshine and the island. It was our least successful scientific meeting, and none of Ramsay's lectures could be published as he never handed over any text.

1985

1985 saw SPUMS at Bandos Island Resort in the Maldives. The guest speakers were Carl Edmonds and Struan Sutherland, who spoke of his work on envenomation and enlightened us with a dissertation on hydroponics. The meeting produced our first diagnosed case of DCS at a meeting. Carl preferred to treat him with surface oxygen rather than use the chamber which had not been used for a long time. The patient's symptoms went with oxygen, but not his altered mental state. He continued to threaten to sue Carl and SPUMS for negligence until he was recompressed in Australia, then he apologised and said that he had not been himself! A helping of barbecued tuna produced a textbook case of scombroid poisoning the night before we left the island.[12]

1986

1986 brought Andy Pilmanis from Santa Catalina Island off California to Moorea as guest lecturer. He had interesting messages to impart but no eye for the clock. With a portable acrylic pressure chamber just large enough to take a depth gauge I was able to confirm that SPUMS members' gauges conformed to the British and American pattern, one third read shallow, one third were about right and one third read deep.

1987

SPUMS went to Honiara, Solomon Islands, in 1987 when Tom Shields was the guest speaker. His informative presentations included the National Hyperbaric Centre in Aberdeen and diving in Scapa Flow, where the German fleet was scuttled rather than be handed over to the British by their crews. Many of the ships lie in over 50 m and so are associated with a steady stream of diving accidents. Unfortunately Tom failed to bring his text with him and like Ramsay resisted all written encouragement, so the members missed out again.

1988

In 1988 SPUMS returned to Mana Island with Bob Thomas and Bill Runciman as speakers. They provided excellent lectures of considerable interest. Unfortunately they spokes from slides and memory and failed to provide texts, so their lectures could not be printed in the Journal. It was at this meeting that Chris Acott, Allan Sutherland and John Williamson did a pilot study of diving incidents[13] which provided the groundwork for the current DIMS (Diving Incident Monitoring Study) run by Chris Acott. A survey of the members' ability to use the tables for repetitive dives showed dismal results, with a large proportion of lecture attendees failing to return the simple questionnaire.[14]

1989

The 1989 AGM was in Port Vila, Vanuatu, with Jimmy How, from the Republic of Singapore Navy, as the guest speaker. He brought his texts with him so the members who did not attend could read his presentations in the Journal.

1990

1990 saw the ASM in Palau, after a long flight from Australia which was made bearable by the fact that the front part of the plane was set up as a bar area where one could stand and chat and drink. The guest speaker was Greg Adkisson, recently returned to the USN after serving as an exchange officer with the Royal Navy at the Institute of Naval Medicine. At this meeting Ray Rogers presented the story of the development of the PADI tables with their repetitive groups controlled by the 60 minute half-time tissue.

At this meeting we heard a presentation from the Science Centre Foundation (SCF) offering to act as a secretariat for a fee. The Committee later decided to use the SCF, but found the service too expensive and unsuited to our requirements. The services of the SCF were terminated in November 1990.

1991

In 1991 SPUMS went back to the Maldives but to a different island. The Karumba resort did have excellent meeting facilities but we had poor weather as the monsoon had started. The topics were *Fitness for diving*, *Equipment*, *Buoyancy control devices*, *Diving emergency procedures*, *Decompression procedures* and *Diving accident investigation*. Glen Egstrom, the guest speaker. gave excellent presentations on each topic, excluding *Decompression procedures*. In addition there were reviews of cases from two hyperbaric units and papers from the recreational diving industry.

1992

In 1992 the ASM was devoted to the Barrier Reef and held in Port Douglas. The guest speakers were most of the staff of AIMS and many from GBRMPA (Great Barrier Reef Marine Park Authority). Unfortunately not as many members as expected came to Port Douglas, which seems to be a common thread running through the annual meetings held in Australia. Once again it was impossible to get their texts from some speakers.

1993

1993 saw SPUMS back in Palau with David Elliott as guest speaker. The theme of the meeting was *The long term effects of diving* and for the first time there was a workshop, to consider SPUMS policy on *Free ascent training*. This exotic, but expensive, location attracted a good turnout suggesting that, in spite of everything else, the thing that matters to members who attend the ASM is the diving.

1994

In 1994 the ASM had no guest speaker as Peter Bennett had to cancel too late for us to find a replacement. The theme was *Causes and management of diving accidents* and the workshop was on *Diving computers*. Excellent papers made up for the less than exciting diving. The registration fees that normally pay for the guest speaker, among other things, were used to provide St Mary’s Hospital, Vunapope, with two oximeters.

1995

The meeting at Castaway Island, Fiji, was the best attended ever. SPUMS took over the whole resort and late bookers were accommodated on nearby islands. Fred Bove was back as guest speaker dealing with the theme of *Fitness to dive* and the workshop was on *Asthma*. The excellent presentations were set off by very pleasant diving.

1996

David Elliott returned to share the limelight with Bill Hamilton. The venue was Paradise Island in the Maldives. Here SPUMS was a small proportion of the hotel population. The diving was rather spoilt by strong currents and too much plankton, but the quality of the presentations compensated for that. The theme was *Technical diving* and the meeting was almost completely a long workshop.

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Key Words

Diver emergency service, general interest, history, medical standards, meetings, qualifications.

Dr John Knight FANZCA, Dip DHM, who joined SPUMS in 1972, has been a Committee member, Secretary and President of SPUMS as well as Assistant Editor and, since 1990, Editor of the SPUMS Journal. He has been either elected or co-opted to the Committee continuously since 1975.

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DIABETES AND DIVING

Fred Bove

Diabetics who are not insulin dependent do not have a problem with hypoglycaemia. So diving is appropriate for non-insulin dependent diabetics who are controlled by diet or an oral agent. Perhaps they should not take the oral agent, or be sure to eat breakfast, the morning that they are diving minimise the risk of hypoglycaemia but it is rare in this group.

I consider that insulin dependent divers should not dive. The danger is that exercise can produce hypoglycaemia, which can cause unconsciousness and unconsciousness underwater is often fatal. However some insulin dependent diabetics do dive. There are unstable diabetics and some with complications who have particularly severe problems and should not even consider diving.

The YMCA in the US, which was the first agency to train divers and have a certification program, reduced emphasis on diver training and was superseded by NAUI and PADI as the two major training organisations. Now they have reorganised their diver training program and are training handicapped divers. They train paraplegics and quadriplegics and other divers who are handicapped. They consider diabetes as a handicap and their attitude is that handicapped people should be allowed to dive. There is now a program in the US to get insulin dependent diabetics into diving. The program is based on blood sugar estimations before diving. The divers take their glucometers on the boat and do their finger pricks just before they get into the water to be sure that the blood sugar is in the right range. If it is not, they take some glucose or orange juice. Precautions include having glucagon ready in syringes on deck. I do not think that this is an inherently safe program. I hope that we can at least prevail upon the organisers to select out, as too severely handicapped, the divers who are late diabetics (ie have had diabetes for over 15 years), who have no glucagon, poor blood sugar control or autonomic neuropathy with inadequate epinephrine (adrenalin) response to hypoglycaemia. I fear that they may not screen out these subjects.

They also have quadriplegics diving. A quadriplegic, paralysed from the neck down, dressed in full diving gear, is unable to control his progress or buoyancy in the water. They often are driven by currents into reefs and other objects, but some of them enjoy their diving. Unfortunately instructors may think that severely impaired diabetics are just more severely handicapped and more deserving of being trained to dive.

I do not think we should be approving insulin dependent diabetics to dive, unless there is a well organised handicapped diver program to train them.

Audience participation

John Parker

I have read of diabetic patients under treatment in hyperbaric chambers whose blood glucose dropped while normal controls either maintained their blood glucose or it went up. You have only mentioned exercise. Is there a hyperbaric component?

Bove

I do not think there is. One would have to look at the circumstances in which the diabetic was treated. It iscommon for a patient going to hospital for a test or treatment to be told “Don’t eat any breakfast”. But not everybody remembers to tell the diabetic “If you don’t eat any breakfast don’t take your insulin”. So many diabetics show up at hospital with 30 or 40 units of insulin subcutaneously and no breakfast. This person will clearly get hypoglycaemic by 10.30 in the morning. I think that one would have to look at the circumstances of those hyperbaric events to understand them, but I have not seen anything which indicates that hyperbaria per se will lower the blood sugar.

Unidentified speaker

Do you think it is worthwhile testing for autonomic neuropathy?

Bove

The common problems in autonomic neuropathy are orthostasis and severe gastroparesis. Orthostasis is easy to test for, in fact most sufferers would tell you that they feel faint on standing up. If orthostasis is present you know there is autonomic neuropathy. Gastroparesis causes problems with GI motility. These are severe stages of autonomic neuropathy. If one takes a good history, has the patient sit up and measures supine and sitting blood pressure, if the patient is not on anti-hypertensives, a fall in blood pressure would identify autonomic neuropathy without going through formal tilt testing.

Guy Williams

As a general practitioner I have noticed that insulin dependent diabetics will describe instability with stress, anxiety and emotional factors. Diabetics are not just biochemical or physiological preparations. They certainly have times when blood sugar control is worse than usual. In diving there are stressful moments.

Bove

I do not think it is fair to make a blanket statement that all diabetics are emotionally unstable. A lot of younger diabetics are emotionally labile because of the chronic stress of having to be dependent on a daily injection. Some teenagers rebel, do not regulate insulin properly and get severe hypoglycaemic episodes. But there are many people who are insulin dependent diabetics who are not emotionally unstable. There are top class players in many sports who are insulin dependent diabetics.

Unidentified speaker

There are a few diabetics who are emotionally unstable but even stable people, on occasions, at times of high stress, exams or whatever, will describe sudden hypos which are uncharacteristic in thoroughly level headed people.

Bove

Some endocrinologists doubt whether these are indeed hypoglycaemic events and hold that they are just odd feelings, not necessarily associated with hypoglycaemia. There is a whole literature now on post-prandial symptoms because hypoglycaemia is not a common cause of these symptoms. Those who have symptoms, usually autonomic symptoms, after eating do not have low blood sugar that correlates with their symptoms. I agree that there are times, when one can get unpredictable hypoglycaemia in otherwise well controlled diabetics. The YMCA program is a carefully constructed plan of adapting the insulin and testing blood sugars in order to get these subjects in the water. I would not use hypoglycaemia alone as a reason to exclude diabetics because for the most part that can be accommodated.

Key Words

Diabetes, safety, training.

Dr A A (Fred) Bove was the Guest Speaker at the 1995 Annual Scientific Meeting. His address is Chief of Cardiology, Temple University Medical Center, 3401 North Broad Street, Philadelphia, Pennsylvania 19140, U.S.A.

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SAFE LIMITS: AN INTERNATIONAL DIVE SYMPOSIUM

[Continued from SPUMS J 1995; 25 (3): pages 153-179]

AN ASSESSMENT OF RISK FOR RECREATIONAL DIVE INSTRUCTORS AT WORK

Drew Richardson

At PADI, diving accident and fatality reports are closely monitored. This information is collected from accident reports submitted by members for any injury they either witness or are involved in. An association standard requiring this type of reporting is also written into the warranties of professional liability insurance coverage. For these reasons we are able to measure with a reasonable degree of confidence, occupational injuries and incidents for PADI Members. The data in this report represent those accidents collected by PADI that involve injury to a PADI Member experienced while at work. "At work" is defined as activities in and around the training and supervision of divers including both in-water and out-of-water activities. This paper does not include injury experienced by PADI Members outside of the workplace environment (i.e. pleasure diving, etc.)

Over the years, scuba diving has experienced an improvement in its safety record as reflected in Table 1, published by the Divers Alert Network. In comparison with other activities, scuba diving is relatively safe as indicated in Tables 2.1 and 2.2. Dive instructors are producing well-trained, safety conscious divers.

However, what of the professional dive instructor and guide in and around the work place? Occupationally, we face greater exposures than recreational divers at large. We dive with greater frequency, in varying conditions and circumstances while performing specialised tasks, such as multiple ascent training. It is important to recognise that there may be increased risk to the instructor when performing his job. The purpose of this paper is to put these risks in perspective by reporting the actual accidents that professionals at work have experienced during a period extending from January 1989 to December 1993 within the PADI membership.

TABLE 2.1

OCCURENCE OF INJURIES IN VARIOUS SPORTS

Sport	Number of participants	Reported injuries	Incidence (%)
US football	14,700,000	319,157	2.17
Baseball	15,400,000	321,806	2.09
Basketball	26,200,000	486,920	1.86
Soccer	11,200,000	101,946	0.91
Volleyball	25,100,000	92,961	0.37
Waterskiing	10,800,000	21,499	0.2
Racquetball	8,200,000	13,795	0.17
Tennis	18,800,000	22,507	0.12
Swimming	70,500,000	65,757	0.09
Bowling	40,800,000	17,351	0.04
Scuba	2,600,000	1,044	0.04

Source. Accident Facts, 1991 Edition: National Safety Council. Numbers represent individuals who participated in the sport more than once during the year and injury represents someone who was treated in an emergency room of an accidewnt relating to the sport or involving sporting equipment. The scuba numbers reflect reports collected by the Divers Alert Network.

TABLE 1

ESTIMATED DIVING FATALITY RATES 1976 AND 1986-1991

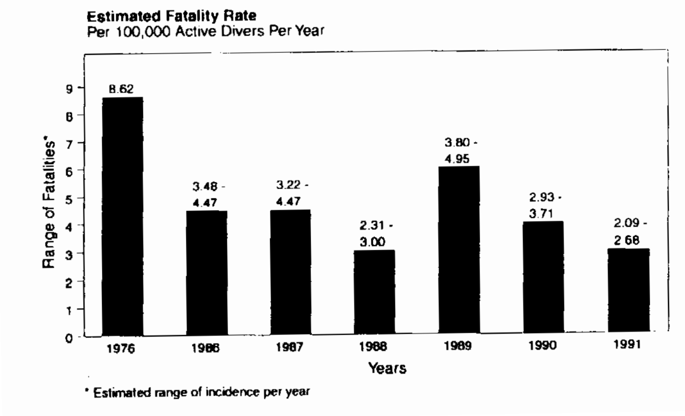
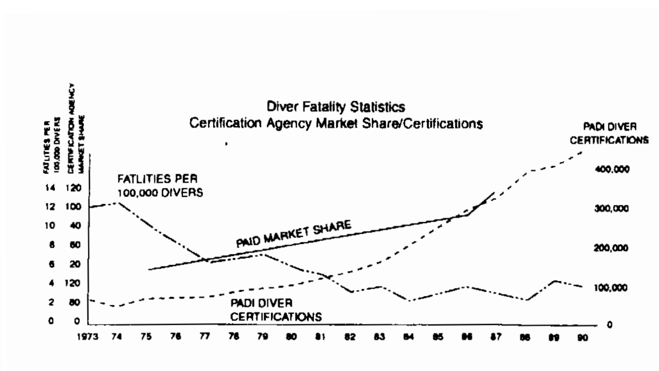


TABLE 2.2

DIVER FATALITY STATISTICS, PADI MARKET SHARE AND CERTIFICATIONS 1973-1990



General working conditions for scuba instructors

Instructors of amateur recreational scuba divers are a distinct group with specialised systems and procedures. Generally, this group's diving operation at work can be categorised as falling into three areas:

1 Performed solely for instructional or educational purposes or diving tours,
2 using open circuit, compressed air scuba, and,
3 conducted within the time and depth limits of no stage decompression air diving, generally less than 30 metres deep.

The working conditions of other groups of divers at work, such as commercial divers, differ widely from those of instructors of amateur recreational scuba divers and therefore, are not comparable. The latter do not use surface supplied equipment or mixed gases, do not engage in diving requiring stage decompression, bells or saturation techniques, do not use or handle construction tools, explosives, burning or welding equipment or perform under heavy workloads. They do not engage in situations exposed to adverse sea conditions or otherwise less than optimal working conditions. The scuba diving instructor may be an employee or independent operator. He is student oriented, diver oriented and training oriented, not task oriented.

The dive site is not generally determined by the location of a particular job as it is in commercial diving, where operations must be conducted under environmental conditions that are often adverse.

The scuba instructor, by contrast, selects a location which is relatively shallow and conducive to training diving students. The scuba instructor is free to use personal judgement and professional expertise in choosing a workplace free from recognised hazards in evaluating any natural or artificial body of water. Scuba instructors also have the ability to discontinue the dive at any point.

PADI Instructors follow well-published codes of practice and guidelines. These divers at work consult the various training standards compendium of the affiliated organization for guidelines and standards. These materials help govern the appropriate choice of the diving site and important measures at the site for safe diving, and have been developed over the last few decades.

PADI membership and activity for 1989-1994

Table 3 outlines the total number of PADI Members by year. PADI members are divemasters, assistant instructors and instructors. The growth in this community went from 27,543 in 1989 to 55,387 individuals in 1993 operating in more than 170 countries throughout the world.

TABLE 3

PADI MEMBERSHIP BY YEAR WORLDWIDE 1989-1993

Year	Members
1989	27,543
1990	35,138
1991	44,252
1992	55,435
1993	55,387

TABLE 4

PADI CERTIFICATION ISSUED BY YEAR AND LEVEL WORLDWIDE 1989-1993

	Entry/OWD	**Other**	**All**
1989	276,065	121,663	**397,728**
1990	304,352	127,282	**431,634**
1991	319,708	146,190	**465,898**
1992	351,443	160,655	**512,098**
1993	384,039	179,033	**563,072**

OWD = Open Water Diver

During this period, PADI Members have conducted training and certified thousands of individuals as reflected in Table 4.

It is difficult to determine the exact number of hours at work or occupational diving exposures for PADI professionals for the period. However, it is reasonable to estimate the number of hours at work during this period at several million.

For example, the number of hours at work may be estimated as follows for each level:

1993 Open Water Diver certifications were 384,039 individuals. To estimate hours at work, first estimate the number of classes conducted. To do this, we must estimate what the average class size is. For this example we have chosen six people per class.

The total number of certifications issued by level divided by the estimated average class size equals the estimated number of classes conducted.

We then take this number and multiply it by the minimum time required to conduct this course by standards as follows:

Estimated number of classes conducted x required minimum course hours equals the estimated hours at work spent by PADI Members for this level of training

In 1993, approximately how much time were PADI members at work training Open Water Divers?

384,039 certifications divided by 6 divers/class = 64,007 PADI Open Water Diver classes conducted in 1993.

64,007 classes estimated x 31 required course hours = 1,984,201.5 estimated hours at work for PADI Members training open water divers in 1993.

The portion of this time spent in and around the water work place may be approximated as follows for the PADI Open Water Diver course:

Five confined water sessions at approximately 2 hours each = 10 hours per course. Four open water training sessions at approximately 3 hours each = 12 hours per course. Approximate number of hours per course spent in and around the water is 22 hours.. Twenty-two water related course hours x 64,007 classes estimated = 1,408,154 hours estimated as water related work for PADI Members training Open Water Divers in 1993.

This rough method could be used for all levels within a year to approximate total hours at work training. In addition to hours at work spent in the training, there is a very large amount of time spent at work in the supervision of already certified divers. Common sense would indicate millions of supervisory dives were conducted among this group for the same period when one considers the daily scuba diving tours that occur as a routine part of employment throughout the world in resorts and dive centres.

Occurrence of work-related injury and fatality 1989-1993

For the period, there were 49 cases where an injury or fatality involving a PADI Member was reported while at work. These reports are summarised in Tables 5 and 6.

Discussion of Table 5 reported fatalities for PADI Members at work 1989-1993

There were four fatalities for PADI Members while at work during this period. The victims were three instructors and one divemaster. One of these fatalities is classified as during training, two occurred while the member was supervising divers on a tour, the other fatality occurred when an instructor was working on a rope tangled in a boat prop. Descriptions of the fatalities are found in Table 7. The fatality rate for the population at work is reflected by year in Table 5 and for the five year period shows a range of 0 percent to .0000363 percent.

Discussion of Table 6 reported non-fatal injuries for PADI Members at work 1989-1993

There were 45 non-fatal injuries to PADI Members at work for the period. They can be generally subdivided into decompression illness (DCI) or other categories. The other categories include any non-DCI injury such as cuts, ear injury and other.

For the period, the injuries are reported as follows:

Decompression Illness	28
(27 instructors, 1 divemaster)	
Other Injuries	17
(12 instructors, 5 divemasters)	
Total	**45**

The victims were 39 PADI Instructors and six PADI Divemasters. Twenty-three injuries occurred during diver training (19 decompression illness, four other). Eleven occurred while the member was supervising divers in water (nine decompression illness, two other), and 11 occurred in other non-diving circumstances as noted. Seven of the decompression illness injuries could be attributed to the instructor making multiple ascents during training. Tables 8 and 9 provide descriptions of each case.

Table 6 describes the rate of DCI for the population by year and also the total injury rate for the population by year. The five year rate of DCI ranged from .000054% to .00020%. The five year rate of injury ranged from .000144% to .00029%.

An assessment of risk in multiple ascents for PADI Instructors at work

To certify an individual as a diver, it is necessary to conduct training ascents. With many students in each open water class and every student being required to master the various ascent skills on any given training dive, an instructor may have to make numerous ascents, especially if he has a large class. After a weekend of escorting several pairs of students to the surface on alternative air source ascents, buddy breathing ascents, emergency swimming ascents and other general ascents, an instructor may begin to feel like that popular toy on a string, a yo-yo.

What additional risks does the instructor face by making multiple ascents during a single training session? Does escorting students up and down through their training as required by industry standards pose additional safety hazards to the instructor? What about the student? These questions have been argued in educational, medical and training circles for some time, with little operational data.

Theoretically, the instructor's risk of DCI in this situation may be greater. In this sense, we can consider it an "occupational risk," which we accept or we choose to

TABLE 5

FOUR FATAL INJURIES TO PADI MEMBERS AT WORK 1989-1993

Fatal injury at work	1999	1990	1991	1992	1993
Other	1	0	0	0	0
During training	0	0	0	0	1
Supervising	0	1	1	0	0
Total deaths	**1**	**1**	**1**	**0**	**1**
Fatality rate for PADI membership	1 in 27,543 0.0000363%	1 in 35,138 0.0000284%	1 in 44,252 0.0000225%	0 in 55,435 0.0%	1 in 55,387 0.000018%

TABLE 6

45 NON-FATAL INJURIES TO PADI MEMBERS AT WORK 1989-1993

Non-fatal injury	1989	1990	1991	1992	1993	Total
DCI while supervising	2	1	3	3	1	10
DCI while training	2	6	6	1	3	18
Other injury while training	0	1	1	0	2	4
Other injury while supervising	0	0	0	1	0	1
Other injury (non-diving)	4	1	1	5	1	12
Total	**8**	**9**	**11**	**10**	**7**	**45**
DCI rate for PADI membership	4 in 27,543 0.000145%	7 in 35,138 0.000193%	9 in 44,252 0.000203%	4 in 55,435 0.000072%	4 in 55,387 0.000072%	
Injury rate for PADI membership	8 in 27,543 0.000290%	9 in 35,138 0.000256%	11 in 44,252 0.000248%	10 in 55,435 0.000180%	7 in 55,387 0.000126%	

stop teaching and find alternative occupations or avocations other than certifying scuba divers. It becomes important, then, to attempt to assess the risk involved with this area.

To evaluate risk, it is important to look at available accident data for instructors and students involved in ascent training. The purpose of this assessment is to share data collected by PADI for its worldwide operations in this area.

In 1993, SPUMS conducted a workshop on Emergency Ascent Training which resulted in a Society Policy published in the *SPUMS Journal* (1993; 23 (4): 136-139). The workshop identified an associated injury rate of approximately 1:100,000 ascents for trainees, and an associated fatality rate of about 1:2,000,000 ascents for trainees.

The scope of the workshop, however, was limited to trainees and not professional instructors. What is the

TABLE 10

AN ASSESSMENT OF RISK FOR PADI INSTRUCTORS AT WORK CONDUCTING ASCENT TRAINING

In the 1989-1993 period, PADI trained 1,635,607 entry level divers worldwide.
Each diver was required to perform a minimum of three emergency ascents.
Therefore, 4,906,821 escorted emergency ascents occurred in this period.
There were 18 cases of DCI in instructors while conducting training reported to PADI for the same period.
If we assume all were the result of Multiple Ascent Training (they were not) this would accommodate under-reporting, if any.
18 cases of DCI reported in Instructors divided by 4,906,821 ascents conducted = 0.0000036.
Injury per 100,00 ascents = 0.0036.

TABLE 7

DESCRIPTION OF REPORTED FATAL INJURIES TO PADI MEMBERS AT WORK 1989-1993

Case	Date	Victim	Level	Age	Location	Category	Details
1	June 1989	Female	Instructor	Unknown	British West Indies	Boat Operation	The Instructor was killed while trying to untangle a line from the ship's prop. The prop was engaged mistakenly with the instructor in the proximity resulting in a fatal laceration to the head.
2	March 1990	Male	Divemaster	Unknown	Jamaica	Supervisory	Divemaster died while supervising divers on a scuba dive. The dive was planned to be conducted on a coral shelf at approximately 80 feet of seawater. It is believed that the divers in the boat were swept past the shelf over a wall. Upon entering the water, the divers swam to reach an expected depth of 24 m (80 feet) and continued to swim where their depth exceeded 280 feet of seawater. This incident resulted in three fatalities, one near drowning and one case of decompression illness. There is speculation that drug abuse may have been a factor. The divemaster was one of the fatalities.
3	July 1991	Male	Instructor	36	Illinois USA	Supervisory	Instructor died while attempting to rescue a diver on the surface. He was serving as a surface divemaster onboard a boat. The diver gave a distress signal and the Instructor jumped in to assist. He was not wearing any scuba or snorkel equipment. The instructor sank beneath the surface before reaching the diver, who was subsequently assisted by another diver.
4	July 1993	Female	Instructor	20	Wisconsin USA	Training Dive	Instructor was conducting a deep dive of an Advanced Open Water course with one student to a depth of 21 m (70 feet). It is not known exactly what occurred as both divers died on this dive.

incidence of morbidity and mortality in the work place for PADI instructors conducting multiple ascent training? From the reports collected, no PADI Members conducting multiple ascents suffered a fatality. However, from the data collected, at least seven cases of DCI may be attributed to multiple ascents; one in 1989, two in 1990, three in 1991 and one in 1993. Given that there were nearly five million such ascents performed during this period, the risk of DCI for the instructor appears real, but extremely low as demonstrated in Table 10.

A PADI Instructor can look forward to making multiple ascents, particularly during PADI Open Water Diver course training dives two, four and, depending on when one elects to perform the emergency swimming ascent, dive five. This also varies if he elects to or not to teach buddy breathing which is an optional skill. To help instructors reduce the risk to themselves, PADI offers the following suggestions:

Never exceed the maximum ascent rate as prescribed by the Slowly Ascend From Every Dive (S.A.F.E.) campaign of 18 m (60 feet) per minute. Slow your training ascents down to within this outer limit. Slower ascents are acceptable.

TABLE 8

DESCRIPTION OF 28 CASES OF DCI FOR PADI MEMBERS AT WORK

Case	Date	Victim	Level	Age	Location	Category	Injury	Details
1	January 1989	Male	Instructor	22	British Virgin Islands	Supervisory	DCI	Same profile 3-4 times a week since June 1987; 21 m (80 ft) 50 min, SI 1 hour 25 min, 18 m (60 ft) for 30 min.
2	September 1989	Female	Instructor	31	Victoria Australia	Training	DCI (multiple ascents)	Multiple ascents in shallow water conducting rescue course.
3	November 1989	Female	Instructor	Unknown	Bahamas	Supervisory	DCI	Bounce dive to 21 m (70 ft) for 6 min, preceded a dive to 23 m (77 ft) for 37 min, SI 2 hours, bounce dive to 18 m (60 ft) for 3 min, dive profile 27.3 m (91 ft) for 37 min, SI 1 hour 56 min, 27.6 m (92 ft) for 36 min, five min safety stop.
4	December 1989	Male	Instructor	42	Victoria Australia	Training	DCI	After conducting PADI Open Water training, instructor experienced mild pain in one elbow.
5	March 1990	Male	Instructor	29	Georgia USA	Training	DCI (multiple ascents)	Open water training dives with poor weather conditions, poor water conditions, worked with students one to one; "many ascents and descents."
6	March	Male 1990	Instructor	37	Jamaica	Supervisory	DCI	Instructor made 3 to 4 dives per day, 7 days per week, for 12-13 weeks; 13.5 m (45 ft) maximum depth, safety stop on all dives.
7	June 1990	Male	Instructor	28	Cairns Queensland Australia	Training	DCI	Student numbers required that the instructor Double Dive. He made 8 dives over 2 days each lasting 30 min, maximum depth 16 m (43 ft).
8	June 1990	Male	Instructor	30	Cairns Queensland Australia	Training	DCI	Two days after conducting PADI Open Water Diver course, pain in left elbow. Dive profile unavailable.
9	September 1990	Male	Instructor	34	Florida USA	Training	DCI (multiple ascents)	Instructor made a series of three dives; #1 pleasure, #2&3 open water training; 27 m (90 ft) for 38 min, safety stop at 3 m (10 ft) for 5 min, SI 24 min, 20 m (65 ft) for 30 min.

Case	Date	Victim	Level	Age	Location	Category	Injury	Details
								SI 25 min, 20 m (65 ft) for 30 min.
10	October 1990	Male	Instructor	30	Papua New Guinea	Training	DCI	Conducted advanced Open Water training over two days. Instructor suffered symptoms upon surfacing.
11	November 1990	Male	Instructor	22	Queensland Australia	Training	DCI	Seven days of multiple dives, two days ashore then four 12 m dives conducting Advanced Open Water program.
12	April 1991	Male	Divemaster	25	California USA	Supervisory	Suspected	27 m (90 ft) dive, no other details available.
13	April 1991	Female	Instructor	33	Townsville Queensland Australia	Training	DCI	Open Water Course numbers required instructor to double dive, four dives day 1; four dives day 2. Each dive approximately 30 min, 16 m maximum depth.
14	June 1991	Male	Instructor	38	Massachusetts USA	Training	DCI	Instructor attempted to slow the rapid ascent of a student from 29 m (98 ft).
15	July 1991	Male	Instructor	35	New Mexico USA	Training	DCI	Profile 19 m (63 ft) for 10 min. Instructor was assisting a student when the student activated low pressure inflator causing a rapid ascent.
16	August 1991	Male	Instructor	33	Washington USA	Supervisory	DCI (multiple ascents)	Open water training dives; multiple ascents; Saturday 13.5 m (45 ft) for 52 min, SI 1 hour 30 min, 12 m (40 ft) for 45 min, 7 Alternative Air Ascents. Sunday 15 m (50 ft) for 48 min, 7 Buddy Breathing ascents, SI 1 hour 30 min, 12 m (40 ft) for 45 min, safety stop for 3 min, 14 CESA ascents.
17	August 1991	Male	Instructor	30	New York USA	Training	DCI	Instructor conducted a search for a lost diver; 15 m (50 ft) for 32 min, 6 m (20 ft) for 60 min, 36 m (120 ft) for 10 min. SIs unknown.
18	October 1991	Female	Instructor	26	Cairns Queensland Australia	Training	DCI (multiple ascents)	Four dives over two days while training open water students. Day 1, 10 m for 35 min, SI 3 hours 15 min, 10 m for 40 min. Day 2 12 m for 35 min,

Case	Date	Victim	Level	Age	Location	Category	Injury	Details
								SI 2 hours 10 min, 10 m for 28 min. Was recovering from gastroenteritis; working very hard and suffering from fatigue.
19	October 1991	Male	Instructor	Unknown	South Australia Australia	Training	DCI (multiple ascents)	Symptoms appeared after ascent training in shallow (5 m) water.
20	December 1991	Male	Instructor	26	Hawaii USA	Supervisory	DCI	Five computer assisted, repetitive dives: 30 m (100 ft) for 18 min, SI 1 hour, 13 m (42 ft) for 35 min, SI 2 hours, 24 m (80 ft) for 19, SI 45 min, 8.6 m (28 ft) for 22 min, SI 45 min, 7.5 m (25 ft) for 42 min.
21	January 1992	Female	Instructor	26	Fiji	Training	DCI	Instructor made three dives over two days while conducting Open Water training. Strong current present and students' buoyancy problems, max depth 15 m.
22	May 1992	Male	Instructor	34	Honduras	Supervisory	DCI	Instructor made multiple dives over multiple days, unknown profiles, last dive to 31 m (103 ft).
23	June 1992	Female	Instructor	27	Townsville Queensland Australia	Training	DCI	Right shoulder pain two days after two Open Water training dives.
24	July 1992	Male	Instructor	23	Cairns Queensland Australia	Supervisory	DCI	Instructor descended with his buddy to secure a descent line. A moderate current meant hard work which caused him to empty his scuba tank. He made an emergency swimming ascent and later developed symptoms of DCI, 18 m for 12 min.
25	January 1993	Male	Master Instructor	42	Victoria Australia	Training	DCI	Running wreck and deep courses during an organised week long trip away. After returning home checked in for treatment of mild symptoms.
26	February 1993	Female	Instructor	23	Hawaii USA	Supervisory	DCI	Instructor was supervising/ guiding divers who were diving with computers. Instructor did not have a computer. Square profiles; 31 m (102 ft) for 24 min, SI 1 hour 23 min, 29 m

Case	Date	Victim	Level	Age	Location	Category	Injury	Details
								(98 ft) for 31 min. Drove to altitude after dives.
27	June 1993	Male	Instructor	35	British West Indies	Training	DCI	Instructor was conducting a photo course, multiple dives over multiple days. Range of dives: Day 1, 6 dives, max depth 30 m (100 ft); Day 2, 6 dives, max depth 30 m (100 ft); Day 3, 2 dives, max depth 28.5 m (95 ft); Day 4, 4 dives, max depth 25.5 m (85 ft); Day 5, 5 dives, max depth 32 m (107 ft); Day 6, 3 dives, max depth 30 m (99 ft) and a commercial flight 25 hours after last dive.
28	October 1993	Female	Instructor	30	Cairns Queensland Australia	Training	DCI (multiple ascents)	Open water course; no problems during training.

Note. Except for Cairns and Townsville (towns) all places named are states or countries.

TABLE 9

DESCRIPTION OF 17 CASES OF OTHER (NON-DCI) INJURY FOR PADI MEMBERS AT WORK 1989-1993

Case	Date	Victim	Level	Age	Location	Category	Injury	Details
1	January 1989	Male	Divemaster	41	Florida USA	Non-diving	Laceration to foot	Divemaster stepped on scupper cover while cleaning boat.
2	May	Male 1989	Divemaster	40	California USA	Non-diving	Muscle pull groin	Divemaster pulled groin muscle while pulling up boat anchor.
3	June 1989	Female	Instructor	40	Texas USA	Non-diving	Fractured nose	Instructor was walking on pool deck, collided with another instructor's tank.
4	November 1989	Male	Divemaster	Unknown	California USA	Non-diving	Laceration to ear	Divemaster slipped and fell on rocky beach.
5 1990	March	Male	Divemaster	40	Bahamas	Non-diving	Fractured leg	Divemaster fell down stairs on boat.
6	October 1990	Male	Instructor	38	Nevada USA	Training	Ear drum ruptured	Instructor was conducting CESA with open water student; injury due to reverse block and forced equalization, 7.5 m (25 ft) depth.

Case	Date	Victim	Level	Age	Location	Category	Injury	Details
7	January 1991	Male	Instructor	Unknown	England	Training	Blood clot on lung	Doctor said blood clot was not diving related, instructor was conducting a pool session prior to presenting to physician.
8	May 1991	Male	Instructor	22	Florida USA	Non-diving	Torn foot ligaments	Instructor slipped and fell on boat.
9	February 1992	Female	Instructor	Unknown	Hawaii USA	Non-diving	Knee injury	Instructor slipped and fell on boat.
10	February 1992	Female	Instructor	Unknown	Hawaii USA	Non-diving	Fractured hand	Instructor serving as boat crew, caught hand in anchor chain/ winch.
11	March 1992	Male	Divemaster	37	Florida USA	Supervisory	Ear injury	Divemaster attempted to slow rapidly descending student to a depth of 18 m (60 ft).
12	April 1992	Male	Course Director	45	Florida USA	Non-diving	Puncture	Stepped on glass on beach. Wound to foot.
13	May 1992	Male	Instructor	33	Florida USA	Supervisory	Laceration to foot	Instructor cut foot on rocks at jetty.
14	March 1993	Male	Instructor	33	Jakarta Indonesia	Non-diving	Aspirated cockroach into lung	Instructor was conducting an academic session and explaining the importance of purging the second stage of the regulator before taking a breath from the regulator. He purged the second stage then took a breath from the Air II. He aspirated a cockroach, which was later surgically removed from his lung.
15	September 1993	Male	Instructor	36	Utah USA	Training	None loss of consciousness	Loss of consciousness at 6 m (20 ft) depth attributed to low blood sugar while conducting an open water class. Instructor was assisted by his students. Instructor has a history of diabetes and has been cleared for diving by his physician.
16	November 1993	Male	Instructor	Unknown	Hawaii USA	Non-diving	Foot injury	While exiting boat at dock, instructor slipped and fell between boat and dock, requiring physical therapy.
17	December 1993	Male	Instructor	29	Virginia USA	Training	Ear injury	Instructor was assisting with a class to 22 m (75 ft) depth.

Always conduct repetitive training dives so each successive dive is to a shallower depth.

When possible, consider conducting the emergency swimming ascent exercise on Dive 4 or 5 instead of Dive 2 when you must also conduct the alternative air source assisted ascent.

Never conduct emergency ascent/multi ascent training at the end of a dive series, or when gas loadings are higher than normal—be conservative.

Consider the benefits of team teaching with another qualified PADI Instructor and splitting up the ascent training, thereby reducing the number of times you personally have to conduct an ascent.

Pace yourself and be conservative by diving well within the limits of the table or computer you are using.

Use common sense, caution and judgement with matters of personal health.

Discussion

It is important to acknowledge there is a risk to the professional dive instructor when performing his job in training and supervision. This paper has attempted to measure this risk so the problem receives a proper analysis. This paper cannot account for those cases that go unreported or undiagnosed and therefore, some under-reporting may be possible. However, the data suggest the occurrence of DCI and other injury are not disproportionately high to the PADI Instructor at work.

Ideally, safety is freedom from risk. Unfortunately, risk is unavoidable in any endeavour, and dive instruction is no exception. However, risk can be minimised and managed by applying good judgment, adopting a safety conscious attitude, and adhering to proven safe diving training practices.

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Key Words

Ascents, deaths, decompression illness, diving industry, instruction, safety, recreational diving, reprints.

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Drew Richardson presented a very similar paper, covering the same data, at the 1995 Annual Scientific Meeting, held at Castaway Island, Fiji.

A RETROSPECTIVE STUDY OF DECOMPRESSION ILLNESS IN RECREATIONAL SCUBA DIVERS AND SCUBA INSTRUCTORS IN QUEENSLAND.

Ariel D Marks and Thomas L Fallowfield

Condensation

A retrospective examination of all certified recreational scuba divers and scuba instructors treated for symptoms of decompression illness at the Hyperbaric Medicine Unit of Townsville General Hospital demonstrated a disproportionate number of instructors treated. No significant differences in diving behaviour were demonstrated between the two groups studied.

Abstract

A consequence of breathing air under pressure is the risk of developing decompression illness (DCI) secondary to the increased partial pressures of nitrogen. Scuba instructors are subject to repeated and large changes of pressure due to the multiple ascents and descents required for student training. It is postulated that scuba instructors are at a greater risk of developing DCI than the recreational diving population as a whole.

This study examined the recreational diving community of Queensland, Australia, including the Great Barrier Reef, with Papua New Guinea and the islands of the Southwest Pacific. The incidence of DCI and the diving behaviour of scuba instructors were compared with those of the recreational diving community to determine if they were significantly different.

Introduction

Scuba diving is a sport, like many others, with inherent risks. One of these risks is the possibility of developing decompression illness (DCI) or “the bends”, ostensibly by exceeding limits of depth, bottom time or ascent rate. While scuba diving may not be safer than swimming or lawn bowls,[1] both the perceived and calculated risks of decompression illness in Queensland divers are low. For example, in 1991, 72 divers were treated in the Townsville chamber and the number of dives made under the auspices of the Great Barrier Reef dive tour operators in the same year was reported as 677,767.[2] If we assume that all the divers treated had been with dive tour operators, which they were not, the rate is 0.00010623 or 106 cases per million dives. We have no knowledge of the number of dives performed annually as “private” dives from Queensland, so we can only deduce that the overall rate of decompression illness is lower than that above. A rare illness indeed.

Attention has recently been focussed on diving instructors and whether or not present training practices put them at a higher risk of decompression illness than recreational divers.[3] There has been a disturbing lack of data addressing this issue.[4] We therefore conducted a retrospective study of all scuba divers and scuba diving instructors treated for decompression illness at the Hyperbaric Medicine Unit of Townsville General Hospital between November 1989 and November 1993. The incidence of decompression illness and the diving behaviour of instructors in this population were compared with those of the recreational diving sub-group, to determine whether there were any statistically significant differences.

Materials and Methods

All scuba divers diagnosed and treated for DCI at the Hyperbaric Medicine Unit of Townsville General Hospital between November 1989 and November 1993 were selected for the study (N=251). This included divers from the Great Barrier Reef, Papua New Guinea and the islands of the Southwest Pacific out as far as Fiji and Nauru.

The study was limited to certified recreational divers and instructors, who used conventional scuba equipment and presented with a sole diagnosis of DCI responding to recompression. The exclusion criteria therefore consisted of:

1 Commercial, military and scientific divers
2 Non-certified divers
3 Divers treated for arterial gas embolism, pulmonary barotrauma
4 Divers presenting with multiple symptomatic complaints not alleviated by recompression
5 Divers not using conventional recreational scuba equipment or breathing gases other than compressed air.

Of the 251 divers treated, 187 met the entry criteria and thus formed the study population. Parameters analysed in this group included:

1 Age and sex
2 Frequency of diving during the previous seven days
3 Profile of deepest dive during the previous seven days
4 Whether symptoms developed during a training dive either as an instructor or as a student.

The Student’s T-test was used to determine whether statistically significant differences existed between the variables collected for the two groups.

Results

The total number of scuba instructors treated for DCI at the Hyperbaric Medicine Unit of Townsville General Hospital between November 1989 and December 1993 was 38 (20% of the study population). The total number of recreational divers treated for DCI during the same period was 149. Of all scuba divers treated over this time period, 74% (187/251) were recreational divers or diving instructors with a diagnosis of decompression illness, responsive to recompression.

Although the total number of scuba instructors and recreational divers diving the Queensland region during this time interval is unknown, rough calculations can still be made. Using data presented by Dr Jeffrey Wilks,[5] an estimate of the percentage of instructors relative to the total certified diving population of Queensland can be calculated. On the 30th June 1991, there were 636 registered instructors in Queensland. A total of 26,883 new certifications were issued in 1991 by these instructors who represented the four major training agencies in Australia (NASDS, NAUI, PADI, SSI). Thus, a very conservative estimate of the number of instructors as a percentage of the certified diving population is 2%. One can safely assume that this percentage has remained almost constant over the years as the number of certified divers can be expected to increase proportionately with the number of instructors.

If the theoretical propensity to develop DCI is equally distributed among all divers regardless of certification level, the expected incidence in instructors as a percentage of the total number of divers afflicted with DCI should be around the estimated 2%. However, as demonstrated by the data collected from the Townsville General Hospital records, the proportion is 20%; about 10 times higher than expected. Thus the incidence of DCI in the instructor population diving in the Queensland area is disproportionately high.

Statistical analysis in the comparison of discrete variables including sex, age, total number of dives in the last seven days and maximum depth showed no significant differences between the instructor and recreational diver groups (Table 1). These factors cannot therefore be implicated in the causation of the difference.

Table 2 shows that most instructors were afflicted with DCI after a training dive, while this was not found to be true for the recreational divers studied.

Neither the instructors nor the recreational divers treated for DCI showed any gender specific differences with regard to age, number of dives in the previous seven days and maximum depth (Table 3). Males accounted for 54% (81/149) of the recreational divers treated for DCI. In the instructor group, males were in the overwhelming majority, accounting for 76% (29/38) of the group.

Discussion

In spite of uncertainties about the actual figures, it cannot be disputed that diving instructors form a small proportion of the total diving population in Queensland. It has been shown that, in 187 treated cases, a group large

TABLE 1

Variable	38 Instructors	149 Divers	T-test
Male	29 (76%)	81 (54%)	
Female	9 (24%)	68 (46%)	
Mean age in years ± SD	27.0 (±6.0)	27.7 (±7.6)	P = 0.59
Range in years	19-47	15-54	NS
Total number of dives in last 7 days			
Mean number of dives ± SD	6.8 (±5.4)	6.3 (±4.9)	P = 0.62
Range in number of dives	0-21	Range: 1-28	NS
Mean maximum depth ± SD	22.9 (±10.9) m	22.3 (±7.9) m	P = 0.71
Range in m	12-56	6-51	NS
Mean bottom time at maximum depth	35.8 (±18.1) minutes	33.2 (±15.2) minutes	P = 0.41
Range in minutes	8-90	5-115	NS

A comparison of discrete variables, including age, sex, number of dives in last 7 days, maximum depth and bottom time, between instructors and recreational divers treated for decompression illness in the Townsville Hyperbaric Medicine Unit. (SD = Standard Deviation, NS = not significant) enough for the application of statistical methods, the diving instructors made up 20%. Clearly, disproportionate numbers of Queensland diving instructors develop decompression illness.

If the risk is related to the number of dives made, a comparison can be derived from Dr Jeffrey Wilks' data on dive numbers for 1991.[5] For that year, the best knowledge for numbers of dives in Queensland gave instructor dives to be 54,594 or 8% of the total. Further deductions by Dr Wilks estimated the number of instructor dives to be 127,200 out of an annual total of one million or 12.7%. Again, the instructors are over-represented.

According to a 1992 report of diving injuries published by the Divers Alert Network (DAN),[6] the percentage of US diving instructors developing and reporting DCI has remained at about 10% between 1988 and 1992; half the incidence found in Queensland. The disparity between these two groups is alarming. While dive table use and practice are identical, it is possible that the average Australian instructor diving on the Great Barrier Reef logs more dives than the average instructor in the USA. Weather and water temperatures may not be as limiting on the Reef as around most of the coastal United States.

Part of the requirement for certification by the various agencies offering recreational scuba training is training in the use of dive tables. Despite comprehensive teaching, practical application, knowledge review questions and modular quizzes in the use of dive tables, divers continue to suffer from decompression illness. In many cases the cause is apparent, with the diver, either knowingly or not, violating the limits laid down by the tables or showing a predisposing factor. In other cases, the diver is apparently well within the tables and without any predisposing factor. With the increased application of multilevel diving and the extensive use of dive computers that allow for complex dive profiles to be continuously recalculated during the dive, divers are able to push their dive times even further, perhaps extending their risk of decompression illness.

By comparison, instructors are required by standards, at least in theory, to exhibit conservative diving practices during all teaching sessions. Instructors are expected to be expert in the use of the dive tables, having received comprehensive training in their use, constantly reinforced thereafter by daily application. While engaged in training, instructors are prohibited from exceeding the limits allowed by the tables and increasing their risk of decompression illness. Consequently, one should expect, if anything, a lower than average rate of decompression illness in instructors during training, assuming that some certified divers "push their limits". Even if one dismisses that expectation, how can one account for the disproportion in the number of instructors suffering from DCI despite following conservative diving practices, which do not differ significantly from those of the recreational diving public?

TABLE 2

PRESENTED WITH SYMPTOMS OF DCI AFTER A TRAINING DIVE

	38 Instructors	**149 Divers**
Yes	26 (68%)	27 (18%)
No	12 (32%)	122 (82%)

A comparison of Queensland divers who presented with symptoms of DCI showing the proportions of training dives either as instructor or student.

By nature of their profession, scuba instructors spend a lot of time submerged, training divers in the basic skills necessary for the proper use of scuba. One could argue that, though instructors may show similar diving practices over a seven day period, they dive far more frequently than the recreational diving public. Frequency of diving, however, is not a theoretical predisposing factor in the development of DCI, provided one is diving within the limits set forth by the dive tables. A more likely explanation centres around the skills in which an instructor must participate in order to certify entry level divers. During training, instructors are required to make multiple ascents and descents with their students. The largest training agency in the world, PADI, requires that each student conduct, with direct contact by the instructor (as recommended by the National Scuba Training Committee in 1978), a controlled emergency swimming ascent vertically from a depth of 9 m or less in open water. The octopus assisted vertical ascent must also be performed with the instructor in contact with each student team. If both of these skills are practised as part of open-water dive number 2, as outlined in the PADI Standards and Procedures Manual, the instructor (assuming a maximum open-water class of eight students without use of an assistant) will make a minimum of 13 ascents and descents on a single dive, barring any problems that may arise with students bolting for the surface or losing contact with the group. If conducted as part of open-water dive number 5, the instructor will make a minimum of 9 ascents and descents with the same class of eight students. If, through poor planning, an instructor is landed with two open-water modules from different classes on the same day, the unfortunate instructor has to make 26 ascents and descents! Any of the above numbers may appear excessive.

The data presented in Table 1 show clearly that instructors are not, in any visible way, exceeding the limits of the tables. Their propensity towards development of

TABLE 3

Variable	Male Instructors	Female Instructors	T-test	Male Divers	Female Divers	T-test
Mean age in years (± SD)	27.7 (± 6.7)	25.0 (±3.4)	P = 0.59	28.4 (± 7.1)	26.9(±6.9)	P = 0.59
Range in years	19-47	20-30	NS	18-54	15-50	NS
Total number of dives in last 7 days						
Mean number of dives ±SD	6.5 (±5.1)	7.5 (±6.5)	P = 0.62	6.5 (±5.4)	6.1 (±4.3)	P = 0.62
Range in number of dives	0-21	1-21	NS	1-28	1-20	NS
Mean maximum depth ±SD	22.1 (±10.3) m	25.0(±12.7) m	P = 0.71	21.9 (±7.9) m	22.6(± 7.9) m	P = 0.71
Range in m	12-56	12-44	NS	6-51	10-50	NS
Mean bottom time in minutes at maximum depth ± SD	36.2 (±20.5)	34.6 (±8.0)	P=0.41	34.7 (±11.5)	31.4(±10.6)	P=0.41
Range in minutes	8-90	25-44	NS	5-115	8-55	NS

Demonstration of the absence of gender specific differences in age and diving parameters between both the instructor and recreational diver groups treated for decompression illness in the Townsville Hyperbaric Medicine Unit. (SD = Standard Deviation, NS = not significant.)

DCI may therefore be related to an excessive frequency of multiple ascents and descents, which, by their very nature, do not fall within the dive tables and are not expected by the limited intelligence of the dive computer.

Numerous hypotheses could be offered to explain the disproportionate incidence of DCI in the instructor population of Queensland. In all fairness, the reports given by divers are known often to deviate from the truth or to be limited in accuracy. Yet, with such a large group, it seems unlikely that all are claiming, for reasons unknown, to have adhered to more conservative profiles than the actual dives. Another possibility is that the high incidence of DCI is not related to multiple ascents and descents, but rather to a chronic, long term absorption of nitrogen in tissues that have an extremely long half-time. Thus the instructors may eventually over a long time period, exceed 100% saturation of these tissues and present with decompression illness. No specific studies that have looked at the long term effects of multi-day, multi-dive profiles are known to the authors. It is noted that the dive tables include a caveat, warning divers that the effects of this kind of repetitive exposure to high partial pressures of nitrogen are presently unknown.

It is interesting that the variables investigated in this study, which included age, depth, bottom time and number of dives in the last seven days before presenting with symptoms of DCI, did not differ significantly between the two groups studied. Of note however, was the high incidence of DCI in instructors after training dives. This should not be surprising, as most instructors spend their diving time conducting training dives, i.e. working, and are at risk of DCI during this time. The number of sport divers who sustained DCI during training exercises is considerably smaller, but of concern since according to dive profile, most did not exceed table limits. It is all the more surprising, since one would not expect sport divers with minimal dissolved nitrogen after a short time at shallow depth to develop DCI, even with a rapid ascent. This brings us back to the possibility of multiple ascents and descents being a primary culprit in the aetiology of DCI. Multiple ascents during a so-called single dive, described as “yo-yo” diving,[7] are identified by commercial diving authorities as a predisposing factor in decompression illness. Australian and North Sea regulations for commercial diving consequently forbid the practice. It is listed as a predisposing factor in a respected textbook of diving medicine.[8]

When one examines the gender differences in diving practices among sport divers, the results indicate that there are no notable disparities, except that more male divers are treated for DCI. Similarly, no significant gender differences were found in the instructor population studies. There was however, an overwhelming majority of male instructors.

This study has gone as far as it can. To elucidate reasons for the different rates of decompression illness between instructors and other divers, much more extensive and reliable protocols for gathering information about diving practices are required. This could be accomplished with dive computers containing the capability of down loading collections of detailed dive profiles. It is apparent from our data that no specific factors have emerged to explain the higher incidence of decompression illness in Queensland diving instructors. However, in the absence of further data, one can speculate or use deductive reasoning. The authors believe that the main difference between the two groups is in diving practice, in that only the instructors regularly perform multiple ascents and descents.

Recreational diving authorities must recognise that diving training procedures put instructors at a higher risk of decompression illness than the general diving population. Further research is needed in this area and recommendations should be developed by the training agencies to avoid continued hardship, disability or, in the extreme, death of the unfortunate diving instructor who is hit by decompression illness.

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Key Words

Ascents, decompression illness, diving industry, safety, recreational diving, reprints.

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SAFE LIMITS: ASSESSING THE RISKS

Harry F Oxer

This paper examines "Safe Limits: assessing the risks" with respect to our experience of almost five years of managing dive accidents in Western Australia. The areas we examined include:

Multiple dives on successive days
Rapid ascents
Multiple ascents
Flying after diving or decompression illness

In Western Australia 175 divers presented with possible decompression illness over a four and a half year period. This is in the context of an estimated 40,000 certified divers in this state, though the number of dives carried out is unknown. We see between 30 and 35 cases who are treated each year, of which usually only one is serious. There are few cases of arterial gas embolism.

We looked at our cases and examined 114 in detail, for which we had very complete records, and follow up. The aim of this paper is to examine our statistics and to cite some cases which illustrate our experience in the categories we are examining in this Symposium. Statistical analysis was carried out using the χ^2 test.

Multi-day diving

Divers are often advised to take a break every third or fourth day, particularly during a diving holiday. However many instructors dive daily without problem, as do many professional divers. Rogers[1] and his co-workers, when testing the algorithm for the PADI Wheel, carried out a large number of multi-day tests, albeit mostly in a dry chamber, and did not find evidence of decompression illness occurring under these circumstances. However statistical analysis of our cases indicates that repetitive diving is predictive of decompression illness in Western Australia (P=0.027).

It is widely believed that one can acclimatise to multi-day diving. There are many reports in the literature, and pearl divers in particular do large series of repetitive dives, and some feel that acclimatisation at the beginning of the dive series is very important.

There may be some scientific basis for this. Ward et al.[2] carried out some experiments, mostly in rabbits, on a substance in the blood called "complement". This substance appears to be involved when symptoms of decompression illness present. They showed that either chemically or by using tiny bubbles they can "de-complement" the blood of rabbits, which are then a much harder to "bend" when subjected again to decompression stress. We know that tiny bubbles are often generated by dives, one suggestion is that these micro-bubbles may be involved in reducing the amount of complement in the blood and thus the likelihood of decompression illness.

Some divers bend despite having apparently complied with the rules, following multi-day diving. The following cases were all treated by us and responded to recompression with remission of their presenting signs and symptoms.

CASE 1

A 17 year old male was carrying out an Advanced Sport Diver Course. He carried out 4 days of diving with all stops and within tables. Three to four hours after his last dive he was tired, lethargic, with joint pains and nausea; on presentation still had these symptoms and was unable to study.

CASE 2

A 17 year old male with considerable experience carried out twelve dives in 7 days at the Abrolhos Islands, diving on his buddy's computer. The next day he was extremely tired and apathetic and presented with pains in his back, wrists and ankles and with balance problems.

CASE 3

A male 33 years old, who had had previous decompression illness at the same dive site, was diving again at the Abrolhos Islands and carried out 6 dives in 3 days within tables and with safety stops. That evening he developed pain in the knees, right shoulder, had difficulty coordinating movements and had numb feet, poor balance, headache and poor concentration.

CASE 4

A 25 year old female with one year diving experience had three, two and one dive on three successive days within the tables with all safety stops. She presented the next day with extreme tiredness, headache, pains in the left shoulder and neck, her hands were tingling and she had blurred vision.

CASE 5

A 25 year old male was diving at Exmouth, and carried out one, two, and three dives over four days. All were within tables, and he did five minutes at five m for each dive. The next day presented with pain in the right shoulder, elbow, thigh and fleeting pains in all joints.

Each of these cases responded to recompression treatment.

Rapid ascent

Rapid ascent is a problem which frequently shows up in our series. Ascent rates are most important. Ascending at the rate of bubbles is a useless exercise. Recommended ascent rates vary but appear to be getting slower. In our series, rapid ascent was significantly associated with dive accidents (P=0.014).

Various ascent rates are recommended. The US Navy recommends 18 m (60 ft) a minute, though this is reported to be a compromise between the 30m (100 ft) per minute ascent rate requested by their SCUBA divers, and the rate at which the US Navy could haul up a tethered surface supplied diver! The Royal Navy and Royal Australian Navy use a 15 m (50 ft) per minute ascent rate. Bühlmann, after careful study, recommended 10 m (33 ft) per minute; most modern computers use this rate.

All ascent rates and stops are really compromises, as ascent should be exponential, getting slower as you near the surface. Decompression stops are a practical way of achieving a similar result. However the problems of maintaining a stop or slow controlled ascent near the surface, when there may be a swell running, make this impracticable at shallow depths. It is common for divers, when they have made their stop, to then ascend rapidly to the surface, although this is the zone where volume increases most with with pressure reduction.

The British Sub-Aqua Club (BS-AC) recommends differing ascent rates which slow as you near the surface. Western Australian pearl divers use 3 m per minute from below 20 m to 8 m. They then perform their stop at this depth and then use 3 m per minute to the surface.[3] One metre in 20 seconds is a very much slower ascent rate than is used by most recreational divers!

In our experience, if a diver has a nitrogen load, i.e. some time has already been spent at depth, then this is followed by rapid ascent even from 10 m or less, it can cause problems.

CASE 1

Three females all with professional backgrounds were carrying out a training course. On their third open water dive in the same day they dived to 22 m (74 ft). It should have been 18 m (60 ft) but the instructor got the depth wrong. They practiced buddy breathing on the bottom for 30 minutes then each was taken up on an individual buddy-breathing ascent. All were anxious and all did this rapidly. None sustained an embolism but all three were seriously bent, and required several treatments, one returning for follow up treatment on a later occasion.

CASE 2

A 29 year old male was carrying out a photographic dive 22 m (74 ft) for 40 minutes when he ran out of air. He buddy-breathed half way to the surface then found he could breathe, so surfaced fast. He later carried out a further 8 m (27 ft) dive for 62 minutes but the next day found he was weak, with a numb left arm and had headache, nausea, and difficulty concentrating.

CASE 3

A 27 year old female on an initial course, carried out a dive at 18 m (60 ft) for 30 minutes, then, as briefed, carried out an unsupervised free ascent to the surface!

She developed aches and pains and difficulty in speaking and rang the Dive Emergency Service. They sent her to a local Perth Hospital where she received oxygen and fluids, and her symptoms resolved overnight. She declined recompression treatment, was advised to take a month off and report immediately if she had any problems.

One week later she continued her dive course, dived to 8 m (27 ft) for 30 minutes and developed severe pain in her knee. She came to us, and when seen was apathetic, could not carry out serial 7's, and in her job as a teacher said she could not concentrate all week.

CASE 4

A 32 year old female was undertaking a Divemaster Course and carried out a dive to 17 m (57 ft) for 54 minutes. She tried to stop at 5 m (15 ft) but ran out of air and surfaced rapidly, exhaling properly.

She developed lethargy, problems with concentration, headaches, aches and pains in her joints, and found she was doing silly things at work. She presented some four days later referred by her general practitioner when she presented looking for a tonic.

Multiple ascents

A number of diving styles require people to make multiple ascents to the surface. In our experience this can cause problems especially if the diver or instructor has acquired a nitrogen load, then is carrying out the ascents later in the dive. We have found that it seems to be a requirement in some forms of training; whether this is in accordance with the organisations recommendations or not, it is being done. Even if the dives are within tables, repeated ascents cause problems presumably by causing gas separation, which is then not reabsorbed even if safety stops are done at the end of the dive.

CASE 1

A male diver had been a professional for 2-1/2 years and a recreational diver for 13 years. He dived for 6 hours, mostly, at 1 to 1.5 m but with bounces to 15 m, and including 15 to 20 ascents. Three hours later he complained of fatigue, headache and tingling with pains in his wrists, ankles, weak legs, apathy, difficulty walking, double vision and balance problems. He needed three treatments, the symptoms recurred and he required a further four treatments.

CASE 2

A male dive instructor carried out 2 dives on a Saturday to 4 m with students, then on the Sunday carried out 4 dives. On the third of these he did multiple ascents to 5 m. At the end of the dive they did 5 minutes at 5 m. Two hours later he had severe lethargy, chest pain, weak arms with tingling and was very apathetic. He came to us the next day.

CASE 3

A 37 year old male undertaking a Dive Master Course dived to 12 m for 45 minutes then did a stop for 5 minutes for 5 m. His surface interval was 2-1/4 hours after which he did 12 m for 75 minutes, but with 7 ascents at the end. That night he developed a headache. The next day he had joint pains, tingling in his back, and pains in his joints with lethargy and slowness of thought.

CASE 4

A 40 year old male carried out a multi-level dive with many ascents to the surface from a maximum of 17 m for 2 hours total time. That night he had pain in his elbows and took analgesics.

He presented to us 10 days later when he was apathetic and withdrawn, had a weak right arm and was unable to balance effectively.

CASE 5

An instructor working out of Exmouth had been treated by us for decompression illness two weeks before. Contrary to our advice he was instructing again and carried out two 9 metre dives totalling 16 minutes, then had a surface interval of 4 hours followed by a 12 metre dive for 45 minutes with a 5 minute stop at 5 m. He then carried out a 9 metre dive totalling 71 minutes and including 6 ascents with free ascent trainees. That evening he developed pain in his elbow with tingling and a heavy sensation. He was apathetic, excessively tired and developed hot and cold flushes.

CASE 6

A 26 year old male dive instructor dived to 16 m for 50 minutes then carried out multiple ascents to 5 m because of student problems. During a surface interval of 2-1/2 hours he developed extreme lethargy and tingling, but carried on with the next dive and went to 10 m for 45 minutes and felt much better at depth. Since then he had found he was unmotivated, lethargic with various tinglings, his balance was terrible and he had numbness in the left arm and leg.

Flying after diving

Hypobaric exposure during flying can be seen as an extreme of the tables, and tables are unreliable at the extremes. Flying after diving seems to show that divers are exquisitely sensitive to small reductions in pressure at this lower oxygen partial pressure. The reasons are not well understood.

Our experience gives us mixed signals about flying after diving. It seems that if it is over 48 hours since the diving it is probably safer to fly, and also after 100% oxygen treatment of decompression illness symptoms, it may be safer. We have evacuated patients from remote islands by commercial flights after treating them, with oxygen, and have not had a recurrence of symptoms. However if the dive is marginal, and flying is undertaken within the first 24 to 48 hours, it certainly appears to be able to bring on or exacerbate the symptoms.

CASE 1

A 25 year old female was diving on the Great Barrier Reef in Queensland on a PADI Advanced Divers Course. She carried out 11 dives in 49 hours. The next day she developed headache, was tired and lethargic, with pain and tingling in the left arm and leg. She flew to Perth the following day and had no changes in flight, and presented to us two days later for treatment.

CASE 2

A 25 year old male was diving in Thailand, he carried out an 18 metre dive for 50 minutes with much swimming up and down then, after a surface interval of 70 minutes, dived to 15 m for 45 minutes again with many ascents. Following this he towed a buddy 50 m to the boat against the wind. Later he felt very unwell, light headed, tingling and lethargy. He went to a doctor and was checked for Dengue Fever. He flew back to Perth the next day as he felt too ill to continue his holiday, and there were no changes in flight. He presented to his doctor still with possible tropical fever. He was referred to us for treatment.

CASE 3

A 25 year old female diving at Bali carried out a series of dives well outside the tables resulting in nausea, feeling desperately tired, mentally slow, tingling. She subsequently climbed a 1700 ft volcano, at the top of which she could not stand! She improved on descent of the mountain, but in the 747 flying back to Perth was too weak to get out of her seat and go to the toilet. She improved on descent and was able to walk out of the aircraft.

CASE 4

A 22 year old male accountant diving at the Abrolhos Islands carried out a series of dives within tables. However within 24 hours he flew to Melbourne and developed symptoms on flight and was treated at the Alfred Hospital.

CASE 5

A 30 year old male was diving in the Solomon Islands, he carried out 8 dives in 3 days including one to 42 m. He did all stops and safety stops, but then suffered several hours of what was termed seasickness with nausea and vertigo.

He flew to Perth the next day with no change in his symptoms, but sought treatment with us.

CASE 6

A 25 year old female diving at the Cook Islands on somebody else's computer, flew out 30 hours later on a Boeing 747 and developed symptoms during flight.

CASE 7

A diver from the Abrolhos Islands who had previously been treated by us found that his tingling recurred two weeks later whilst on a flight to Sydney, the tingling disappeared on descent. We retreated him, however he still had this recurrence of tingling each time he flew for several months later. There were no other problems.

We have treated several cases from Christmas Island and Cocos Islands where the treatment facilities are limited. However they are usually flown after being treated by 100% oxygen and usually more than 48 hours. So far although mostly flying them back on commercial aircraft we have had no changes in symptoms.

Multi-day or rapid ascent?

This case may fall into either category!

A 23 year old female had just completed an initial dive course with four open water dives then went on holiday on the Cocos Islands. Her daily dive profile was:

50 m for 30 minutes
40 m for 40 minutes
45 m for 30 minutes
43 m for 45 minutes. The last five m of this dive had a rapid ascent as she had buoyancy problems.

After this she was too weak to stand, exhausted, chest pain, withdrawn, apathetic and had pain in the left arm, elbow, and right knee. On consultation there was no cylinder of oxygen, and no aircraft on the island, and we were unable to find an available aircraft in the immediate future to evacuate her. On the island they had an oxygen concentrator which will generate about 90% oxygen and she was treated with equipment designed jointly over the telephone. She flew out on a commercial flight two days later and was treated by us. Further symptoms were revealed as her affect improved. She required four treatments, then later three more, and never got rid of all of her residual tinglings, particularly in the legs.

Rapid ascent

The ultimate rapid ascent was perhaps exemplified by a pearl farm diver who did 13 m for 22 minutes then a 30 minute surface interval followed by a 13 m for 18 minutes.

A boat supplying shell to him, having delivered the shell did a fast circle and accelerated away. The propeller caught his hose resulting in instant surfacing. Thereafter the hose was cut, following an instant return to the bottom. He then used his bail out bottle and rapidly surfaced again. It is a tribute to the diver's training that he did not sustain a serious embolism, but certainly did get decompression illness.

Summary

Our experience in Western Australia of patients presenting at Fremantle Hospital Hyperbaric Unit for treatment seems to show that for non professional divers, doing multiple dives on successive days is a factor increasing the danger of sustaining decompression illness.

It seems that ascent rates are particularly important. Rapid ascents are a problem even within tables and even at shallower than 10 m. Once again ascent rates and appropriate stops appear to be the vital factor.

Multiple ascents particularly seem to cause problems in our experience, even in shallow diving and especially late in a dive after taking on a nitrogen load.

Flying after diving can cause a problem, though this seems to be worse in the first 24 to 48 hours and, as reported by others, is related to the depth and severity of the dive. In our experience, patients who have developed decompression illness, and have been initially treated with 100% oxygen usually seem to be able to fly safely, when this becomes operationally essential. We have the one case who got recurrence of minor symptoms every time he flew for some months after otherwise successful treatment.

The message we perceive is that slow ascent rates make for safer diving, and it seems that they will facilitate problem free multi-day, multi-dive situations. The pearl industry has developed this method of enabling their divers to do repetitive dives on repetitive days throughout the pearling season with extremely low incidence of decompression illness. (Slow ascent rates are only one facet of the pearl divers' safe practises, but appear to be of critical significance.)

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Key Words

Ascent, decompression illness, flying, reprints, risk, treatment.

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MULTI-DAY DIVING; THE EXPERIENCE OF THE HYPERBARIC MEDICINE UNIT, ROYAL ADELAIDE HOSPITAL

Steve Goble and Lindsay Barker

Introduction

The advent of dive computers (DCs) along with the increasing number of live aboard dive vessels has encouraged the growth of multi-day, multi-dive holidays. This has important implications for the safety of diving practice, as it may be postulated that repetitive nitrogen loading, with inadequate "off-gassing" may lead to an increased risk of decompression illness (DCI). Moreover, as many of these types of holidays are either interstate (e.g. Queensland) or overseas (e.g. Truk), divers often have altitude exposure soon after part of the dive trip has finished. Anecdotal reports indicate that this type of diving practice may predispose to an increased risk of DCI compared with less intense diving programs. The aim of this survey was to identify cases of DCI which presented to our unit which were preceded by multi-day diving.

Methods

All divers treated for DCI at the Royal Adelaide Hospital (RAH) are asked to fill in a diver's questionnaire. This questionnaire asks for details about; post-dive altitude exposure, environmental conditions, type of decompression table or computer used, dive profiles, types of symptoms, time of symptom onset post-dive, delay to recompression post symptom onset, first aid measures etc. All of the information gathered is transferred to a computer database using DBase III Plus (Ashton-Tate Inc). This database also records treatment profiles, medication etc. We reviewed the database for divers treated between 1st January 1987 and 31st October 1993, noting all divers who had been involved in multi-day diving. We then reviewed these divers' case notes to gather more detailed information. The definition used for multi-day diving was a series of dives with a minimum of two dives per day for a period of at least two consecutive days.

Results

During the period studied 185 divers were treated for DCI. Of these, 62 divers (or 33.5% of total divers treated) had profiles consistent with our definition of multi-day diving. The divers, the majority of whom were male (male:female ratio 4.6:1), had a mean age of 32 years (range 15-52 yrs). While the greatest number were recreational divers, 10 (16%) were occupational divers (fishermen/commercial). Diving experience as indicated by years diving ranged from 1 month to 30 years, with a mean of 8 years. Most divers (47 of 62) presented following dives in their home state; 32 from South Australia and 15 from Victoria (before the Alfred Hospital chamber was installed). The other divers dived in the following areas; Queensland 6, Truk Lagoon 6, Papua New Guinea 1, Solomon Islands 1 and the Maldives 1.

The dive profiles showed that the mean number of dives was 6 (range 4-30) over 4 days (range 2-21), some examples being; a diver who had logged 30 dives over 8 days, maximum depth 32 m, a diver who dived between 38 m and 63 m 2-3 times a day for 6 days, a diver who made five dives over 3 days with the last dive being 37 minutes at 30 m and then flew home only a few hours after the last dive. While a pattern of diving could not be clearly identified from the database, the mean dive depth was to 28 m (range 5-63 m). Dive computers were used by 12 of the 62 divers. It would appear that the profiles used by this group showed more frequent dives, associated with multi-level profiles compared with those divers using dive tables.

Twenty divers ascended to altitude (defined as over 300 m), while 12 flew home in commercial, partially pressurised, aircraft within 36 hours of completion of their diving.

The majority of divers presented with at least two major symptoms; these would consist of joint pain (arthralgia), headache and excessive fatigue. Only 5 of the 62 divers presented with one symptom. Symptoms typically had a mean onset time of 13.2 hours (range 0-100 hours). The mean delay from the onset of symptoms to initiation of hyperbaric treatment was 100.5 hours (range 4 hours to 42 days). There was a fairly close direct relationship between treatment delay and number of hyperbaric treatments in the non multi-day group, but this did not hold for the multi-day dive group. While the above symptoms were the main ones reported by the patients further inquiry revealed a wide range of signs and symptoms. These included; skin tingling, numbness, problems with memory and thinking and pruritus.

We compared these results with those of the entire group of 185 divers, and also against the 123 divers who were not involved in multi-day diving (Table 1). Symptoms were similar in both groups. There was a greater proportion, about double, of computer users and of divers ascending to altitude in the 62 multi-day divers. The multi-day divers mean depth was greater although the range was much the same for both groups. Mean age was similar for both groups though the age range was greater for the other divers. The diving experience range was the same for both groups but the mean years of diving was higher, about double, for the multi-day divers. The non-multi-day group noticed their symptoms on average 6 hours earlier than their multi-day counterparts, and reported for treatment an average of 39 hours earlier. The range of delay was the same for both groups but the mean delay was one third longer for the multi-dive group. Recompression delay is defined as the time from symptom onset to recompression.

TABLE 1

COMPARISON OF MULTI-DAY, MULTI-DIVING AND OTHER DCI PATIENTS

	123 Non-multi divers	62 Multi divers
Computer users	7	12
Altitude exposure	8	20
Mean depth (msw)	19	28
(range)	(4-65)	(5-63)
Mean age (years)	31	32
(range)	(12-58)	(15-52)
Mean years diving	3.5	8
(range)	(1 month-30 years)	(1 month-30 years)
Symptom onset (hours)	7	13.2
(range)	(0- 72)	(0- 100)
Recompression delay		
(hours)	61.2	100.5
(range)	(2 hours- 42 days)	(4 hours- 42 days)

Discussion

The above survey offers interesting information about the demographics and profiles of multi-day diving practice. It does however suffer from all the problems of a retrospective, non-controlled survey. Data examination forms were not universally complete, they are completed by the divers during a treatment and often the patient has trouble remembering a number of the details. Likewise when reviewing patient records it is noted that different medical staff have different styles of history and examination, some will obtain and write down a complete life history, while others glean the bare facts about symptoms and next to nothing about the dive that caused the problem. Despite these misgivings, the survey does illustrate a well defined group of divers who developed DCI following a multi-day diving exposure.

The main points to come from this survey are that these multi-day dive trips tend to produce a significant (about 1/3) proportion of divers who present to the RAH for recompression therapy. This seems to be aggravated by the relatively early exposure to altitude, be it ascending into the mountains or flying at reduced ambient pressure in a commercial aircraft. Other possible factors include the higher number of computer users and the greater number of years experience. Finally, symptom onset tends to be late in this group of divers with a concomitant delay in treatment. All of these could possibly be due to an over-confidence in one's ability.

If the symptoms of these multi-day divers is compared with the Divers Alert Network (DAN) 1992 statistics,[1] the major symptoms are almost identical (pain, numbness, headache and extreme fatigue). While the onset of symptoms in our group and that of DAN was similar, there was a significantly greater delay in recompression treatment. This probably reflects the geographical isolation of many parts of Australia and the South Pacific region.

Although our multi-day groups mean experience in years was some 4.5 years longer than the non multi-day group, the range was the same, so overseas or interstate trips on luxury live aboard vessels are going to attract the experienced fanatic, the weekend club diver and the novice diver. It may be inappropriate to expose the novice diver to the same diving practice as the fanatic who would dive 24 hours a day if it was possible. A newly qualified diver or an infrequent club diver would probably be at a higher risk of DCI when participating in intense multi-day diving trips. Just the increase in physical exercise and associated fatigue is likely to be a factor in assessing risk in these divers.

A significant number of multi-day divers (32%) went to altitude after their diving. Most of these did so within 36 hours and noted the appearance of symptoms while flying home. It seems likely that there needs to be a review of the current recommended restrictions for flying after diving.

It was clear that many of the symptoms were quite vague, e.g. excessive fatigue, concentration problems, memory loss, many patients were content to suffer from these "vague" symptoms for a number of days before realising that they might have a problem and seek treatment. Divers need to realise that these "vague" symptoms actually indicate a neurological problem which needs to be assessed immediately, not three days down the track. Talks with the local recreational diver population also indicate that, among those who have been diving for a number of years there is still a stigma attached to DCI, a feeling of having done something wrong which, in many cases, is totally unfounded. Happily, that attitude is being frowned upon by the training agencies and the newer divers appear to be less reticent about reporting symptoms.

During our review of the dive profiles it became clear that many divers appeared to pay scant regard to dive planning, the most common problem appears to be the almost blanket approach to insert deep dives between shallow dives. It was common to see 1st dive 18 m, 2nd dive 30 m, 3rd dive 22 m etc. While many modern decompression tables allow these types of profiles to be calculated, it seems to us that the old tenet of "always do your deep dive first" is not being regarded quite as highly as it used to be. Surely doing your deep dive first and then doing progressively shallower dives, must reduce your risk.

In our group of multi-day divers we found that 20% of our divers had been using decompression computers, however that is an increasing figure, for instance in 1989 only 20% of all divers treated had been using DCs, in 1993 that figure rose to 50%. That probably reflects more of an increase in their use than anything about their safety. However, it seems that some divers are forgetting basic dive planning principles in favour of just heading off into the deep and letting the DC compute how to get back to the surface.

We are aware that some dive operators actually require all divers to use DCs because the DC gives longer bottom times and computes decompression for a multilevel ascending dive, instead of having to plan a square dive and then do an ascending multilevel dive with possibly less time in the water than the DC user. While that may seem good in theory, good dive planning by the diver, not just the dive master, must still be carried out. Computers are not infallible and if you have not bothered to plan your dive you could be left wondering.

We feel that basic diver training needs to put more emphasis on teaching good dive planning and stressing that the DC is a useful back up but should not be used to control the dive, many do not let the divers know that they are doing something which could be construed as unwise. Also while decompression stop diving is not advised for recreational divers, is it more dangerous than a dive on the edge of the no-stop table? The DCI risk associated with some tables no-stop times is actually more than some profiles that the same table would regard as a decompression stop dive.

A major part of any diving operation is risk assessment. Operations that cater for large numbers of divers obviously will have to consider an overly cautious approach to risk assessment. These operations frequently have to cater for both the new diver and the experienced regular diver. If there are enough dive masters or guides to be able to split into two or three groups then all should be well, provided that there is a separate risk assessment done for each group. However, a risk assessment for the client is all very well, but is anyone adequately assessing the risk for the occupational diver at these dive sites. While I am well aware that the concept of the employed instructor or dive master being an occupational diver is not well regarded by a large part of the industry, until such time as there is definite guidance to the contrary anyone in full time employment, regardless of the industry, must expect to be asked to comply with relevant occupational health and safety legislation.

On a live aboard vessel there are regulations with which all vessels masters and crew must comply. Why should the persons expected to be responsible for the welfare of the customers be any different. Adequate risk assessment may mean having enough dive masters aboard that they dive less than the customers, one must then ask "Is the customer at risk?", possibly, but that is another question. Do not forget the employed diver is diving almost daily, the customer will go home and have a rest.

Having risked upsetting all the live aboard operations, we do realise that many operations are taking steps to prevent many of the problems just mentioned. We believe that many operations have instigated rest days, and are addressing the problem of whether to put deeper dives at the beginning or the end of the trip. That last is an interesting problem, if the deeper dives are at the end of a trip then the less experienced or infrequent diver has a few days diving to polish up skills before moving on to the deeper diving. However by diving deeper at the end of a trip, having absorbed more nitrogen each day, the diver is then at greater risk of DCI if he intends flying home within 24-36 hours.

We also feel that insurance is essential for all divers. Most travel insurances cover the cost of diver retrieval in Australia but will not cover the cost of repatriation for treatment from another country. Medical retrievals from other countries are expensive. For instance the cost of being flown from Fiji to Melbourne for hyperbaric treatment recently cost $26,000.

Conclusions and recommendations

It seems from our study that a significant number of divers report symptoms of DCI following multi-day diving. We conclude that prospective studies are required to elucidate the importance of repetitive diving and its risk of DCI.

A large number of divers with repetitive dive profiles, who subsequently develop symptoms of DCI, are exposed to altitude within 36 hours of diving. We believe that the current recommendations on safe times to fly need to be reviewed.

Diver safety begins with the basic dive course. Basic planning skills need to be adequately taught. And the instructor must be sure that students only qualify when they are comfortable in the water. Modern technology cannot prevent problems in a diver who is uneasy and ill prepared for the dive.

It is also obvious that if problems do arise then an adequate insurance policy is mandatory for potential retrieval to recompression facilities, and in some countries for the cost of the treatment.

References

1 DAN 1992 report on Diving Accidents and Fatalities.

Key Words

Altitude, decompression illness, hyperbaric facility, risk, safety, training, treatment.

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STAGED DECOMPRESSION FOLLOWING NO-DECOMPRESSION DIVING

Geoff Gordon

So far we have all gained insights into the safety of diving, the techniques it uses in diver education and some figures on where divers make errors. The medical people have given us a different perspective on the same set of data; namely why are divers ending up in recompression facilities, what were they doing in order that they earned that long dive notation in their log books. My paper today is rather ethereal in that it attempts to look at what data is currently available in the diving literature to support our current diving practice, and is there any clear evidence that we need to change tack? If we sincerely believe that too many divers are being damaged, we need to develop strategies for reducing even further the published incidence of decompression illness (DCI). If, on the other hand, we are agreed that we are doing alright, then this paper will, I hope, stimulate some thoughts in your minds as to how you might reduce your own risk of developing DCI.

The risk of developing DCI following a single air dive has been long studied. Data derived from the theoretical analysis of risks has been combined with that obtained from the analysis of thousands of actual dives, and at least with respect to the single dive, we are now able to predict the probability of an injury following a single dive (p(DCI)).

The morbidity and mortality suffered by divers in the late 1800s stimulated the British Admiralty to commission work into the nature of those afflictions and how they could be overcome. These studies culminated in the publication in 1908 of the first set of tables that provided guidance to the diver on how to avoid Compressed Air Illness. The credit for this work is attributed to John Haldane. His method of “staged decompression” as he called it, dramatically reduced the permanent injury associated with compressed air work and all but eliminated the fatalities. This method has since grown in popularity with many iterations, the most prevalent adaptation of the Haldane computational algorithm being the US Navy Tables.

Up until the 1970s, nearly all the diving being undertaken was primarily commercial or working diving. Given the task to be undertaken a certain “hit rate” of DCI was accepted. Recompression chambers were immediately available, and the diving was rather repetitive and stereotyped. Since this time however, we have seen an almost exponential growth in recreational diving, that only now may be peaking. Associated with this popularity in recreational scuba diving, treatment facilities have seen a new wave of diving morbidity. Although much debate centres on the incidence of DCI in the recreational diving community (the denominator is not known), the percentage of divers afflicted is clearly much less than that which stimulated the British Admiralty into commissioning Haldane's work, but there are undeniably increasing numbers presenting for the treatment of DCI. Perhaps we need to grapple with this problem again. We may feel comfortable with the published rates for DCI, but the results that are being reported following the treatment of these recreational cases is a serious cause for concern as 60% have demonstrable morbidity, usually neuropsychiatric sequelae, 12 months after treatment. Assessment of the data published by the various treatment facilities suggests that some, say 25 to 50% of those presenting for treatment, could have dived more "safely" and by inference avoided developing DCI. In this regard I see that the effort of this symposium is to address the preventable DCI.

While some researchers in the field of hyperbaric medicine are seeking alternatives to the current treatment algorithms, in an attempt to secure better treatment outcomes, it may be more appropriate to rethink our approach to diving, particularly recreational diving. In this regard, we have an analogous societal problem in the treatment of road trauma. Repeated studies have shown tha,t in road trauma, 18-29% of those dying would not have done so if prompt and appropriate medical care was available early. This is called the Possibly Avoidable Death rate. We know that up to 50% of currently treated cases of DCI occur subsequent to dive profiles that have exceeded what is generally considered safe diving practice, a Possibly Avoidable DCI rate! Secondly, although uniform systems for the management of trauma victims have been introduced into Australasian practice and these have seen a modest reduction in hospital mortality rates, road trauma death rates are still adjudged as too high by our society. The "ambulance at the bottom of the cliff" approach is unlikely to make further inroads into the road fatality statistics. As a result of this society is changing tack in its assault on road trauma with the introduction of new legislation, new vehicle safety standards, education programs to change societal attitudes, all in an attempt to prevent the problem from occurring. This may be the approach we need to take in diving if we want to reduce the morbidity associated with diving: better decompression strategies with appropriate education.

Much data is currently available to support changes to the way we currently approach our diving activities. The reverence that divers have for their tables or, more recently, for the algorithm programmed into their dive computer, is not matched by the robustness of the science applied to their development. As stated previously, the method used as a basis of many of the world's currently used dive tables originated with Haldane in 1908.

He made a number of assumptions and empirical conclusions in the development of his tables, many of which are just not tenable. For instance, he assumed that off gassing was a mirror image of on gassing, that nitrogen uptake is perfusion limited, that there is a tolerable supersaturation, his basic tenet. In essence, his system is really nothing more than a book keeping system for keeping track of inert gas tensions in the body, rather than a model per se. Further, he treated air as 100% N_2 in his calculations (this simplified the tedious calculations and he was using ratios after all), relied on empirical experience to adjust his limits and derived his ascent rate empirically. And this model has been worked on subsequently to assist in the development of safer tables! What makes the various tables different is the number of tissue compartments for which calculations are made, the level of tolerable inert gas supersaturation and the surface interval required for complete nitrogen clearance. Even in something as fundamental as this, there is no agreement. The theoretical nitrogen clearance intervals for the various popular tables are: PADI, 6 hours, USN and Comex 12 hours and DCIEM 18 hours. There are no studies that corroborate any of these intervals as being appropriate to the recreational diver. Indeed most computers, which calculate compartment nitrogen saturations, indicate that after a period of typical recreational diving, some 24 to 36 hours are required before the computer indicates that the tissues are "clean". The development of new dive tables has become largely empirical with little consideration being given to advances in our knowledge of the underlying science. No table adequately attempts to model inert gas elimination, and further, no algorithm will ever be able to model the unpredictable effects that bubbling has on inert gas elimination. Perhaps chaos theory can help!

A number of table developers make a plea that their tables have been tested, but the need to test tables is problematic in itself. To test all of the possible schedules is not possible, and a common procedure has been to consider a schedule "safe" if 10 dives were performed without incident. This objective testing is to establish the incidence, if any, of DCI. Given the binomial nature of dive outcome, (DCI/no DCI) such an outcome only determines that, with 95% confidence, there is an 0 to 30.8% chance that that schedule will produce DCI! If the 99% confidence level is desired this becomes a 0 to 41% risk of DCI. The chances are that the rate of DCI will be close to zero, but as can be seen, it could be higher. Some 370 incident free dives per schedule are required to satisfy a 1% risk at the 95% confidence level. It is futile trying to predict the safety of a decompression schedule based on a few test dives. Running a few tests does not tell us very much. Because of this problem, it may be appropriate to adopt a risk-benefit approach to diving activities, and instead of a schedule being safe, it simply has a greater or lesser chance of causing DCI.

The concept of acceptable risk has been much debated, and it is clear that the acceptable risk varies with the task being performed. For instance, the US Navy may accept procedures with a risk of up to 4% in order to satisfy its operational commitments. A rate of 2% has been considered acceptable in caisson workers, 0.1 to 0.5% for commercial divers whilst a rate of 0% is considered acceptable for recreational and scientific diving.

A number of studies are available which enable us to take a "profile risk" approach to our diving. Previously, it has been generally assumed that DCI occurs only when a critical threshold is exceeded. Observation, however, tells us that DCI is unpredictable and behaves as a statistical rather than as a threshold phenomenon. DCI does become more likely, but seldom becomes a certainty when certain limits are exceeded. Introducing the principle of maximum likelihood attempts to solve this conflict. Likelihood analysis compares the profiles of previous dives on which the time/pressure/gas profile and dive outcome are well documented. This technique allows different profiles to be compared, a bit like a "least squares" fit draws a line of best fit through a set of data points. After a large number of carefully controlled dives are analysed and the model calibrated, it can then be used to calculate new dives. The technique works on discrete (binomial) data, in this instance on the presence or absence of DCI.

The link between the mathematical model and diving data is the dose response curve which relates the risk of DCI to the decompression stress as predicted by the model.

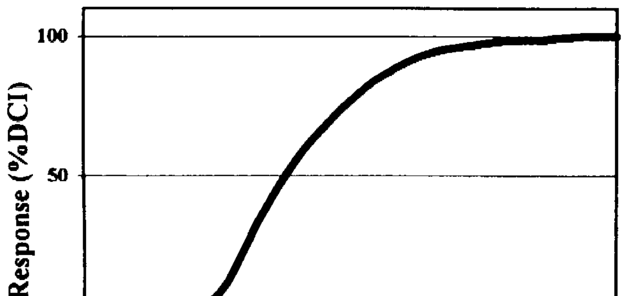

Figure 1. The dose response curve of risk of DCI to decompresssion stress.

The concept of likelihood (L) is extended to a series of observations by multiplying the outcome of the individual responses thus:

L_{trial}= (pDCI, dive 1)(pDCI, dive 2)(pDCI, dive 3)... ..(pDCI dive n)

In maximum likelihood, the p(DCI) is adjusted until the closest agreement exists between it and the observed outcome. For the purpose of this analysis, dose is the pressure history of the diver (dive profile) and response is the occurrence or absence of DCI.

The occurrence of DCI in man is characterised by extreme variability of individual response. In a group of divers experiencing the same dive, seldom do all demonstrate signs of DCI. In all of the animal studies, the fraction of symptomatic animals rises smoothly from zero to 1 over a finite range of decompression stress, so in essence, the absolute value of the likelihood is analogous to the sum of squared errors in analysis of variance.

This technique allows many different types of dive profiles to be combined in order to calibrate a mathematical function (risk function). This is then used to construct a decompression model to either compute a risk for a specific profile or to compute tables to a specified level of risks. The goal of the generated mathematical model is to provide a tool to permit a rational choice between risk and time in the water. This type of analysis has been done and presented in tabular form for the US Navy, Royal Navy and DCIEM tables by Weathersby et al. It allows a useful analysis of the effect of decompression time on the risk of developing DCI.

For instance, look at the following dive profiles. A dive to 36 msw (120 ft) for 15 minutes carries a 1.8% risk of DCI. The same dive, but with a bottom time of 30 minutes and a 14 minute stop at 3 to 5 msw as required by the table, carries a risk of 0.9%, half that of the shorter dive! There would indeed seem to be some advantage accrued in the staged decompression process! Looking more closely, we see that, by putting this data into the computer and analysing it with a 3rd generation Haldanian algorithm, the effect of the staged stop has been to reduce the inert gas loadings in the fast tissue compartments, the brain and cardiovascular system. Both dives are allowed in the US Navy tables.

The safety stop as currently practised may go some way in reducing the risk of DCI to the diver, but the practice of spending 5 minutes at 3 m was introduced to slow the ascent, thereby decreasing the risk of DCI secondary to pulmonary barotrauma. Using the same algorithm but this time looking at the safety stop, we see a similar beneficial effect in terms of fast tissue inert gas loadings. There is the belief that time spent off gassing in the shallows before surfacing will decrease bubbling and hence the risk of DCI. Intuitively this would follow from analysis of the p(DCI) as predicted by likelihood analysis, which indicates that, up to a point, staged decompression diving is inherently safer than no-stop diving. But can formal decompression after every dive, even when not required by whatever algorithm is used to control the dive, reduce the risk of DCI for the recreational diver? The evidence for a benefit to the recreational diver is less clear than is the evidence for a benefit in staged decompression diving.

Pilmanis in 1975 looked at bubble counts following a 30 m (100 ft) dive for 25 minutes. His small study clearly showed a reduction in bubble count if time was spent off-gassing at depth.

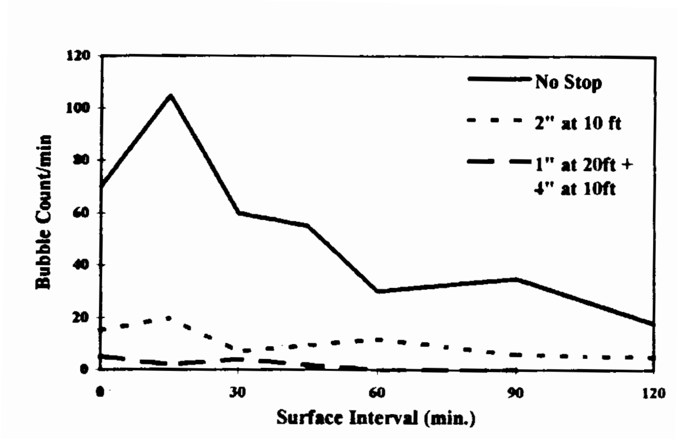

Figure 2. Bubble counts after no-stop dives and those with stops.

What we may conclude is that time spent performing a safety stop does reduce bubble counts after the dive. What we do not know is if this reduction in bubble count equates with a reduced risk of DCI. It is likely that a reduced doppler bubble count will have little effect on the incidence of DCI. This apparent dichotomy between bubbles being clearly the cause of DCI and not premonitory is due to the nature of doppler detection. The bubbles that are detected have left the body tissues and are in the venous system on their way to the lungs to be filtered and removed. It is the evolution of bubbles in the tissues, particularly the nerve tissue, that causes DCI. The relationship between venous bubbles and tissue bubbles, if any, is waiting for some eager beaver to determine.

Kindwall has shown that N_2 elimination between the depths of 5 and 15 m, exceeds that at the surface for some time following a dive to 30 msw (100 ft) for 40 minutes. Rates of off-gassing were measured at 30, 15, 5 and 0 msw. Combining the data from this study and that by Pilmanis, the only reasonable conclusion is that off gassing is more effective in the absence of bubbling.

Thalmann reported similar results at 9 msw in 1983. A more recent trial, this time from the UK, demonstrated a reduction in the incidence of DCI by 40% when the safety stop was transferred from 3 msw to 6 msw. Perhaps what we can conclude is that a safety stop will not be effective in reducing the risk of DCI if substantial bubbling has occurred before reaching the stop. Deeper stops may thus be beneficial, and shallow stops may well do nothing more than slow the ascent as originally intended.

It has long been recognised that frequent exposure to pressure reduces the risk of DCI, thus suggesting that some type of acclimatisation does occur that is in some way partially protective.

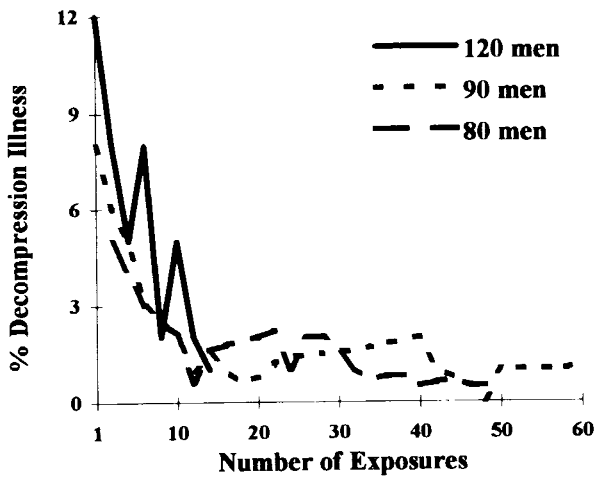

Figure 3. Adaptation in caisson workers.

Figure 3 shows the reduction in DCI, “adaptation”, in caisson workers with increasing exposure to pressure. During the first 10 exposures the incidence of DCI in these caisson workers is seen to fall dramatically, an effect that is maintained as pressure exposure continues. After 10 days without pressure exposure the incidence returned to the initial level so adaptation, if it does truly exist, is short lived. Similar effects were seen during the construction of the Hong Kong tunnel project. Data from recreational diving however shows an increase in cases of DCI rather than a decrease with repetitive multi-day diving.

I have hypothesised that for tables to become safer, more decompression time at depth is required than provided in existing tables. A comparison of DCI incidence for the 1974 and 1986 French Tables provides some insights into this hypothesis. With 57,000 recorded dive profiles for the 1974 table, an overall incidence of DCI of 0.22% was seen. This database was used to empirically develop the 1986 tables. These tables effectively increased the decompression time by some 30-40% and, on reviewing the data from 32,000 dives, an overall incidence of DCI of 0.1% was seen. The effects of this empirical increase in decompression time are demonstrated, but there is a point at which increases in decompression time render recreational diving a pointless activity. Perhaps though, this data further supports my original hypothesis that staged decompression after every dive, even if no decompression debt is owed, will reduce our risk of DCI.

The new US Navy tables due to be released soon have incorporated a lot of this theory into their construction. They are based on a mathematical model which used statistical techniques to optimise its fit to a database of some 2,300 plus dives This new model computes the actual expected risk of DCI and has a p(DCI) of 2.3% for no-decompression dives within the range 18-

33 m (60-110 fsw). This risk has been applied to the new no-decompression limits, and the same level of risk has been used for decompression dives up to a total decompression time of 20 minutes. Longer dives have been allowed to ramp up to 5% when the total decompression time reaches 60 minutes. The old 12 hour clean rule has gone, and on some dives it will take up to 33 hours to be clean.

These new tables are no longer considered to be safe or unsafe by the US Navy, rather, they simply have a greater or lesser chance of causing DCI. Additionally, they give information about the level of risk at various times during a dive. This is an exciting approach to the way we conduct our diving, and reinforces the point that diving is merely a risk acceptance activity.

In conclusion, I believe that our thinking regarding how we dive needs to change if we are to reduce further the incidence of DCI in recreational diving. The holy grail of no-stop diving may not be such a laudable goal after all, and the data suggests that staged decompression after every dive will substantially reduce a divers risk of DCI. Further, studies suggest that these stops need to be made before significant bubbling has occurred if a benefit is to be realised. Spending, say, 1 minute at 18 msw, 2 to 3 minutes at 10 msw and 5 to 10 minutes at 5 msw after each dive should significantly reduce risk. An increase in risk is seen as dives get deeper, but this effect is not nearly as great as with time. DCI can be expected to occur occasionally, even in relatively unprovocative exposures. Thus it should not be regarded as an accident. It is expected to happen occasionally, and it does not always represent a loss of control as is implied by the use of the term “accident”.

But can we trust recreational divers to discipline their diving to this extent so that we will see a decrease in those presenting for treatment of DCI? Realistically I think not, as current studies show an alarming number of divers who are unable to manage even their air supply, with those that make the statistics probably representing only the tip of the iceberg. However, I do hold out hope for those who have a genuine interest in reducing the risk of DCI in their dive practice, mainly us older, once bolder types.

I believe that the evidence is overwhelming for staged decompression even following a dive profile that, according to some algorithm, incurs no decompression debt. The objective of our procedures after all is to REDUCE the probability of DCI to an ACCEPTABLE minimum, and I believe we have the tools at our disposal to enable us to do this within a predicted probability of risk.

Key Words

DCI, risk, tables.

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A list of references consulted is available from Dr Gordon.

POST DIVING ALTITUDE EXPOSURE

Ian Millar

The Alfred Hospital experience

During the 68 month period 1 November 1987 to 30 June 1993, the Alfred Hospital, Melbourne, Hyperbaric Unit treated a total of 401 cases diagnosed as suffering decompression illness (DCI). Of these, 44 had involved post diving altitude exposure. Only one of these was associated with medical retrieval; cases where air ambulance transport occurred but did not aggravate DCI were not included in the 44. This series provides illustrations for many of the dilemmas associated with determining safe limits for altitude exposure after diving and after treatment for DCI.

Review of available case records revealed the following:

All but 5 were recreational divers.

Note that several patients appear twice. DCI was initially provoked by altitude exposure after diving and subsequently relapsed with further altitude exposure post treatment

ASYMPTOMATIC BEFORE EXPOSURE

Twenty one cases were asymptomatic prior to their altitude exposure ranging from 300 to 800 m above sea level (ASL).

Twelve of these developed symptoms during surface based travel. In this group 8 involved altitude ascent several hours after dives which had been preceded by multiday repetitive diving. Five also involved post dive exercise and alcohol as risk factors.

3 late onset cases involved altitude ascent one to three days after dives involving risk factors of multiple ascents or vigorous underwater exercise.

1 case involved returning to place of residence at 800 m altitude on the Sunday evening of a routine entry level training weekend.

Nine developed symptoms after flying. Six of these involved flying at between 12 and 24 hours after multi-day, repetitive, deep diving. One involved flying at 24 hours after extreme multi-day diving. One involved flying 2 days after a single extreme air dive in emergency circumstances.

One involved multi-day diving with detail regarding the interval not recorded.

SYMPTOMS BEFORE EXPOSURE TO ALTITUDE

16 cases had some abnormal symptoms present prior to altitude exposure.

In 3 of these, symptoms had resolved without treatment prior to altitude, but returned and increased with an altitude exposure some days after the symptoms.

In several of the remainder, who flew with symptoms, these symptoms were initially mild and had not been recognised as DCI prior to altitude exposure.

One patient suffered deterioration during a 300 m altitude exposure whilst driving home several hours after symptom onset

The remainder were associated with flying after delays ranging from 17 hours to several days and in one case, two and a half weeks after the diving which caused symptoms to arise.

Four cases were notable for minimal exacerbation resulting from altitude despite moderate symptoms and preceding deep repetitive multi-day diving

POST-TREATMENT RELAPSES

Nine cases involved post treatment relapse associated with altitude exposure (Table 1)

DETERIORATION DURING RETRIEVAL

One case involved neurological deterioration during a 90 minute helicopter retrieval at 900 metres above sea level (ASL).

Sources of altitude exposure

Cabins of commercial aircraft are usually pressurised to an altitude equivalent not exceeding 2,500 m above sea level (ASL) or 0.75 atmospheres absolute (ATA) approximately. Cabin altitudes in the order of 1,500- 2,000 metres ASL are more common during domestic flight sectors.[1] Depressurisation to cruising cabin altitude usually occurs over 15 to 20 minutes. In Australia, unpressurised flight is limited to 3,000 m ASL (10,000 feet or 0.68 ATA approximately).[2] Light aircraft flight commonly involves climb rates of 300 to 600 m per minute. Many diving venues allow the possibility of significant altitude exposure after diving as a result of travel over hills or mountains. Of the Alfred Hospital cases, 24 involved flying after diving while 21 cases involved car, bus, train or horse travel to altitudes. The lowest altitudes associated with initial onset of DCI were approximately 300 m ASL although these cases involved other risk factors including alcohol, exercise and prior multi-day deep diving.

TABLE 1

RELAPSES WITH ALTITUDE AFTER SUCCESSFUL TREATMENT

Travel method	Effective altitude experienced	Time after treatment
Car	100 m	Several hours
Car	300 m	1 day
Car	700 m	2 days
Car	800 m	5 days
Commercial Aircraft	? 2,000 m	5 days (Against advice)
Light Aircraft	100 m	7 days
Train	400 m	10 days
Walk	1,500 m	10 days
Car	1,000 m	3 weeks

After treatment for decompression illness, most relapses were associated with surface based rather than air travel. The case involving apparent exacerbations of symptoms with altitudes of approximately 100 m only involved travel between the patient's home and the Alfred Hospital each day for hyperbaric treatment. In addition to the relapses listed above, several patients who did not present for retreatment reported temporary return of symptoms during altitude excursions by road and air and, in one case, following travel by elevator to the top of a 200 m building.

Although this series includes many cases associated with altitudes and intervals usually considered safe, several cases are notable for an apparent lack of significant altitude related deterioration when obvious symptoms were present before a flight back to Australia after intensive diving activity during Pacific island holidays.

Theoretical Considerations

Many flying after diving tables and theoretical models have been based upon prediction of nitrogen wash out using tissue half time models. Most models do not take into account the effect of established bubbles which have been demonstrated following most diving activity.[3,4] Further, it has been demonstrated that extrapolation of diving decompression models into the hypobaric realm would result in an excessive risk of altitude DCI.[5] Nitrogen diffuses out of established bubbles at a far slower rate than it does from solution in tissues and the “oxygen window” effect that is largely responsible is much reduced at altitude.[6] In the past, it was generally accepted that the threshold for safe decompression from a saturated state to a lesser pressure was a relative pressure reduction of approximately 50%. Hence dives to 10 msw could be of unlimited duration and the threshold for altitude decompression sickness was generally accepted to be 5,500-6,000 m. Venous gas bubbles have been detected, however, in 50% of subjects following decompression from saturation at only 3.5 msw.[7] In the case of decompression from surface to altitude with no prior diving, NASA research has estimated a threshold for DCI at 3,400 m in the case of 6 hour altitude exposures.[8]

Flying usually occurs at least some hours after diving and it is likely that most blood borne bubbles will have cleared before flight. The pathology of DCI associated with altitude is therefore likely to result from tissue bubbles which were present before the altitude exposure and from newly generated blood born bubbles. These presumably arise as a result of a lowered threshold for altitude DCI resulting from persisting supersaturation of nitrogen in “slow” tissues after extensive diving. Exercise has been shown to produce a surge of bubbles from moving limbs and this is likely to be a significant factor during walking or horse riding to altitude. Dehydration is common during flying and is a further risk factor for DCI.

Twenty six of the Alfred cases had symptoms of incipient or actual DCI or had recently been treated for DCI prior to altitude exposure. Many of the remainder had undertaken diving likely to be associated with persistent “silent bubbles”. The presence or absence of such asymptomatic but potentially critical bubbles before altitude exposure may help explain the extreme variability of experience with regard to the consequences of travel to altitude following diving.

It is clear therefore that the pathophysiological consequences of post diving altitude exposure cannot readily be predicted by extrapolation from normal decompression theory. Even if individual factors are considered for any one situation, predictability will remain low and conservatism will be necessary to minimise risk.

Bubble expansion with altitude

When bubbles are present before an ascent, they will expand during time at altitude and may remain enlarged after return to ground level. Boyle’s law related bubble diameter increase can be calculated and is often used to illustrate altitude effects. This, however, significantly under estimates the in vivo effects of altitude. The pressure reduction to an average commercial aircraft cruising altitude of 2,000 m is approximately 20%, from 1 ATA to 0.8 ATA. This correlates to a bubble volume increase of 25%. The actual volume of bubbles in the body will, however, increase somewhat more than this as a result of the effect of gases other than nitrogen. Although a decompression generated bubble will initially principally consist of nitrogen, subsequent equilibration with surrounding tissues result in water vapour, carbon dioxide and oxygen entering the bubble. As the total pressure drops with altitude, additional quantities of these gases will diffuse into the bubble, enlarging it further until these gases are again equilibrated. As a result of this, the predicted volume increase from a 20% decrease in pressure is approximately 30% rather than the 25% that would apply if the bubble were in an inert environment. Further nitrogen may also diffuse from tissues into the bubble, resulting in further bubble growth.

A 30% increase in volume results in a diameter increase of only approximately 9% (for a spherical bubble). At lower altitudes, altitude related pressure change can be approximated as 1,000 m ASL =1 msw ascent and an ascent of 300 m represents a pressure decrease of only 3% approximately. The diameter increase of a spherical bubble would thus be a mere 1% in the case of DCI exacerbated at an altitude of 300 m.

Bubble diameter is, however, unlikely to be the critical determinant of DCI severity in the case of altitude exposure many hours after diving when the bulk of venous gas bubbles will have dissipated. Bubbles in brain surface arteries have been shown to become trapped at pre-capillary bifurcations where they form round ended cylinders which fill the vessel. Trapped bubbles will thus expand in length in almost direct proportion to their volume increase, increasing friction and increasing the likelihood of the bubble remaining fixed in its position.[9]

Bubbles which have remained stable for some time will have a “shell” of haematologically and immunologically active substances surrounding the gas bubble and triggering inflammation and oedema in adjacent tissues. This shell is likely to be semi-rigid and may provide a gas diffusion barrier which is partly responsible for the long term persistence of bubbles despite the forces of partial pressure gradient and surface tension that normally work to decrease bubble size with time. The components of this shell are thought to be activated by the physical and chemical forces acting at the blood-bubble or tissue-bubble interface.[10] It follows, therefore, that further activation could result from changes in molecular shape forced by changes in bubble wall tension, size and curvature as a result of depressurisation with altitude. This mechanism could underlie exacerbation of pre-existing DCI as a result of an increased inflammation and oedema rather than merely in response to local pressure effects or increased blood vessel obstruction by the offending bubbles.

Hypoxia

Altitude exposure also results in significant hypoxia which may aggravate DCI pathology by several mechanisms. Commercial aircraft flight may involve a decrease in arterial oxygen partial pressure in the order of 30%. While the functions of haemoglobin and of the respiratory system in normal persons serves to maintain oxygen delivery at sufficient levels for normal, healthy tissues, this reduction in oxygenation may be critical for tissues which have marginal blood supply as a result of bubbles and adjacent inflammation associated with incipient or actual DCI.

New venous gas bubbles may be a factor in some cases, especially when a rapid ascent, higher altitude flight closely follows deeper multi-day repetitive diving activity. Excess venous bubbles are presumed to be the cause of pulmonary DCI ("the chokes") as a result of pulmonary vascular overload. They also can result in "paradoxical embolisation" of the arterial system if bubbles pass through the pulmonary capillaries or via right to left shunting through a patent foramen ovale when this abnormality is present and when pulmonary obstruction by bubbles is sufficient to result in right heart pressures exceeding those on the left.[11] Hypoxia is known to trigger pulmonary vascular hypertension to a variable degree.[12] This mechanism may be partly responsible for the comparatively high incidence of "chokes" which is seen with non-diving related altitude DCI as well as causing an increased risk of bubble arterialisation during flying after diving.

Altitude Exposure After Treatment For DCI

After treatment for DCI, there should not be any significantly increased levels of dissolved nitrogen left in any body tissues. The frequency of post treatment relapse would seem to indicate, however, that persistent bubbles, residual tissue inflammation and a sensitivity to re-activation of inflammation and oedema can remain for many days or even weeks even when complete resolution initially seems, clinically, to have been obtained.

Most Australian hyperbaric units currently seem to use one month post treatment as a guideline with regard to the appropriate post treatment interval before flying. The Alfred Hospital utilises this guideline although the author's clinical practice has involved proposing variations to this advice in certain circumstances. Factors in favour of early altitude exposure being considered acceptable include:

Mild DCI

Early Treatment

Rapid response to treatment

Early and complete resolution

Apparently "single site" DCI with a low likelihood of significant disability if recurrence occurs

Single ascent, low altitude, short duration of proposed altitude exposure

Treatment facilities available at destination if required

Patient with good understanding of problems, acceptance of risk and willingness to seek help if necessary

Intervals longer than one month seem appropriate in those patients who do not achieve clinical resolution and who experience symptom exacerbation with or after non-specific stimuli such as physical exertion, viral disease or lack of sleep. Local circumstances may allow such patients to undertake a voluntary trial of altitude exposure in the form of trips to hill locations of increasing altitude and duration. It seems preferable for such "at risk" patients who believe that they must fly for business or personal reasons to experience short haul domestic flight before embarking upon a long duration overseas trip to a destination without hyperbaric treatment facilities.

Current Recommendations

The range of recommendations with regard to flying after diving have received several reviews in recent years. A gulf appears to exist between decompression theory based tables and dive computer function on the one hand and individual or consensus based blanket guidelines on the other.[13,14]

The recommendations in published guidelines for flying after non-saturation diving range from a delay of a few hours only to 24 hours or more. Decompression diving is often treated differently from no-decompression diving and a few publications provide for reduced intervals in the case of lower altitudes or emergency circumstances. After reviewing many of these, the 1979 Undersea and Hyperbaric Medical Society workshop on Flying After Diving issued consensus guidelines (Table 2).[14]

It is noteworthy that the late Dr A. Bühlmann indicated that he saw a necessity for guidelines for road travel. For dives involving less than 60 minutes dive time in the previous 12 hours he proposed a delay of 4 hours only before travel to altitudes up to 3,000 m ASL. This was apparently based upon his decompression research and experience gained by Swiss divers who have followed tables allowing altitude exposure only a few hours after diving. Such divers usually gain their altitude exposure during road or rail travel rather than flight, however, and a comparison of typical ascent rates is of interest (Table 3).

TABLE 2

FLYING AFTER DIVING RECOMMENDATIONS

No-decompression diving

a Less than 2 hrs total dive time in previous 48 hrs
12 hrs delay

b Multi-day, unlimited air diving
24 hrs delay

Decompression diving

24 hrs minimum, preferably 48 hrs delay

TABLE 3

ASCENT RATES OF VARIOUS ACTIVITIES

Ascent type	Rate of Ascent	Pressure change per min
Recreational diving	9-18 m per minute	30-65%
Air travel	1,000 m altitude in 2-10 minutes	1-5%
Driving over mountains	1,000 m altitude in 15-60 minutes	0.15-0.6%

Recommendations

With the number of Alfred Hospital cases requiring treatment following surface based travel nearly equalling those following flying, there is clearly a need for guidelines to cover more than simply commercial airline flight. Flying after diving guidelines sometimes do assume minimum altitudes. If air transport is necessary for DCI, retrieval is usually arranged at 300 m ASL or less. This seems a reasonable limit for immediate land based travel and helicopter transport also. The practice of some emergency retrieval aircraft flying at less than 30 m ASL seems unnecessarily and dangerously low.

It is apparent that a significant number of divers fly with symptoms of DCI or having suffered symptoms of DCI in the period preceding flying. It is unknown, of course, as to how many divers do this without suffering sufficient adverse consequences to result in them seeking help. Nevertheless, there is clearly a need for more awareness of the risks associated with DCI prodromal symptoms such as lethargy, malaise, and transient “pins and needles” or “niggles”. Caution also is required if dive limits have been exceeded in any way or if adverse factors such as rapid ascent, undue exertion or thermal stress have occurred. If obvious symptoms are apparent, consultation with an experienced diving and hyperbaric medicine physician is, of course, appropriate.

All divers planning flying after diving should make their bookings with contingency plans in place to allow for rescheduling of flights if required. Where hyperbaric facilities are not present, post diving oxygen breathing is likely to greatly reduce risk if flying cannot be delayed and an “at risk” situation has occurred or potential DCI prodrome symptoms have been noted.

It is inevitable that some cases of altitude related DCI will continue to occur, given the unpredictable nature of the condition. It would appear that the physics and pathophysiology of altitude exposure may create a far greater unpredictablity in DCI risk than is the case following diving activity alone. Divers should make their travel plans with an awareness of this. Although even a 12 hour delay prior to flight is probably unnecessarily cautious following most diving involving one dive per day well within conservative no-decompression limits, the current common practice of waiting 24 hours seems more appropriate as a general standard. Multi-day, deep repetitive dives should be followed by at least 36 hours or more before flying (two night’s rest). Divers should remember that travel to hill locations during a diving holiday increases risk and any abnormal symptoms, injuries or intercurrent illnesses suffered during a trip should be an indication to cancel or at least severely restrict remaining diving activity or alternatively, to delay flying. The scheduling of shallower dives towards the end of a diving holiday seems desirable.

If DCI symptoms do arise during commercial air travel, 100% inspired oxygen will not be available. Nevertheless, use of low concentration therapy oxygen which is carried by some operators may be of value given that the effect of additional oxygen at altitude is far higher than at the surface or in hyperbaric situations.[6]

Following DCI treatment, hyperbaric physicians should assess the clinical progress of the patient before allowing even minor altitude exposure in the first few days post treatment. The current one month guideline appears generally reasonable provided that patients who have responded poorly are individually assessed if flying is planned.

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Key Words

Altitude, decompression illness, flying, treatment sequelae.

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