with two treatments, the Suva chamber is not the place to have them. But sometimes expectations are quite high.

Non-emergency calls

General medical enquiries using the free phone number make up a significant proportion of DES calls. Ninety one (18%) calls were general medical enquiries and this group seems to be increasing. DES was set up to provide advice for divers involved in diving accidents. The medical service is provided free by five unpaid consultants who do this service in addition to their normal duties. DES was not set up to provide a toll free number for doctors to get advice during diving medicals. There is a phone number (08-8222-5116) available for such advice in the Hyperbaric Medical Unit at the Royal Adelaide Hospital.

Commonwealth Government funding for DES was discontinued during the past two years. Now after a period of difficulty in funding the DES phone is being funded by DAN Australia South East Pacific.

In conclusion, looking at the 1996 statistics, DES still provides a valuable service to divers in Australia and for Australian divers who are travelling overseas. We can understand why doctors find it useful for medical advice. In this user-pays worlds it would reduce our operating costs if doctors used the Hyperbaric Unit line for advice.

I would like to thank Steve Goble, the Senior Hyperbaric Technician at the Royal Adelaide Hospital, for his assistance in preparing the data.

Dr Michal Kluger, FFARCS, Dip DHM, was on the staff of the Hyperbaric Medicine Unit, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital, for some years. His address is now Department of Anaesthesia, Auckland Hospital, Park Road (Private Bag 92024), Auckland 1, New Zealand.

DIVING MEDICINE COURSE

The School of Public Health and Tropical Medicine, James Cook University, Townsville, will be conducting a course in Diving Medicine from Monday 6th to Saturday 10th of October 1998.

For further details contact

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DECOMPRESSION ILLNESS IN NEW ZEALAND DIVERS: THE 1996 EXPERIENCE

Karen Richardson, Simon Mitchell, Michael Davis and Marie Richards

Key Words

Decompression illness, diver emergency services, recreational diving, sequelae, transport, treatment.

Introduction

Two hyperbaric units, one located at Auckland in the Royal New Zealand Navy (RNZN) Base, and one at Christchurch, previously located at Princess Margaret Hospital and now at Christchurch Hospital, provide treatment for injured divers in New Zealand. From 1967 to 1983 the average number of patients seen at the RNZN unit was less than 2 annually, but from 1984 to 1990 this rose to a mean of 15 per year.[1] There were 24 cases in 1990, 31 in 1991, 55 in 1992, 68 in 1993, 48 in 1994 and a record 100 cases in 1995.[2] The Christchurch Hyperbaric Unit (CHU), treated an average of 6 divers per year from 1979 until its temporary closure in May 1994. The unit reopened in February 1996 and its 1996 caseload is included in this review.

During the 1996 calendar year 76 cases of decompression illness (DCI) following diving were treated in New Zealand: 57 at the RNZNH Slark Hyperbaric Unit (SHU); and 19 at the CHU. Demographic data describing this patient population is presented in this review.

Methods

Relevant data describing patients diagnosed as having DCI and treated by recompression at both units during 1996 were entered on a Microsoft Access 2 database. One case of DCI induced by extreme altitude exposure in an unpressurised aircraft was excluded from this review. Most data was gathered prospectively by patient interview and examination, but some was obtained retrospectively from clinical records. The collection of data at the SHU was aided by use of a baseline clinical data form designed for use in a randomised prospective double blinded trial of lignocaine in the treatment of DCI which is currently underway. The relationship between incomplete recovery at discharge and a variety of putative prognostic factors was assessed using a Chi square test.

Results

SEASONAL INCIDENCE

The peak incidence of DCI was in the warmer months October to April, while there were very few cases in July.

The number of cases by month is plotted in Figure 1.

AGE AND GENDER OF DIVERS

The age of divers ranged from 14 to 51 years, with a mean of 31.5 (8.6 SD). Fourteen divers (18%) were female (21 to 37 years, mean 27.6) and 62 (82%) were male (14 to 51, mean 32.6)

PAST DIVING HISTORY

Seven divers had received no formal diving training. Three divers suffered DCI during training for their initial diving qualification. The training history was not recorded for five divers. All others held recognised qualifications. Table 1 records the number of divers trained to each qualification level and the number of divers awarded their highest qualification by each major training agency.

In the 57 patients treated at the SHU, diving experience before suffering DCI was variable with the number of dives ranging from 0 to 8,000 with a mean of 614 (SD 1,420). The deepest previous dive ranged from 9 m to 72 m (mean 37 with SD 14). Twenty two divers admitted to diving deeper than 40 m on at least one occasion, including 7 of those trained to instructor level and 2 of the untrained divers. The percentage of divers treated at the SHU with fewer than 20 and with 100 dives before their episode of DCI was 21% and 44% respectively.

NATURE AND LOCATION OF DIVING

All cases of DCI developed after air scuba diving except for one using surface supplied air , two which occurred in chamber attendants and one which occurred in a snorkel diver (see Discussion). Seventy cases (92%) were diving for sport or pleasure, while 6 were engaged in occupational activities. Forty nine divers were diving in waters around New Zealand's North Island, 19 in South Island waters, 2 in Australia and 4 off various South Pacific Islands. Two DCI patients were diving in recompression chambers as attendants.

REFERRAL AND TRANSPORT

The majority of patients were referred for assessment either by their local doctor or by themselves. Most referrals were made via the dedicated Diver Emergency Service (DES) telephone line funded by New Zealand Underwater and maintained at the SHU. Common forms of transportation to the treating unit included fixed wing, one bar pressurised air ambulance, helicopter ambulance and private vehicle. Further details of referral and transport modalities are given in Table 2. The time from surfacing after the last dive to arrival at the treatment facility ranged from 30 minutes to 24 days, mean 67 hours (SD 113).

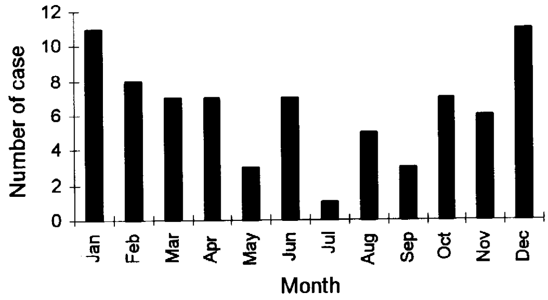

Figure 1. Numbers of DCI patients treated in New Zealand by month during 1996.

TABLE 1

HIGHEST DIVING QUALIFICATION AND THE ISSUING AGENCY FOR THE HIGHEST QUALIFICATION

Highest qualifications	**Number**	**%**
Open water diver	30	39
Advanced open water diver	6	8
Rescue diver	5	6
Divemaster	5	6
Instructor	10	13
Under training	3	4
Commercial	3	4
Diving Medical technician	2	3
No training	7	9
Not recorded	5	6
Issuing agencies	**n**	**%**
PADI	36	47
SSI	11	14
NZUA / CMAS	10	13
NAUI	2	3
Royal Adelaide Hospital	2	3
No qualifications	7	9
Unknown	8	11

DEPTH, TIME AND OTHER RISK FACTORS

Thirty two divers used standard tables to assess their decompression status, 23 used dive computers while 3 used a combination. Eighteen divers used no form of assessment and for 3 divers the means of decompression status control was not recorded. Thirty eight divers (50%) reported dive profiles within the limits set by their table or computer, while 35 (46%) either did not use a means of decompression status control or dived outside the no decompression limits. Compliance with their own table could not be assessed for the 3 patients whose means of decompression status control was not recorded. Only 19 divers (25%) reported profiles within the limits specified

TABLE 2

THE SOURCE OF DCI REFERRALS TO THE SHU AND MEANS OF EVACUATION FOR ALL CASES

Source of referral to SHU (57)	**Number**	**%**
Local doctor	27	47
Self	17	30
Hospital	6	11
Coast guard	1	2
Dive instructor	1	2
Charter boat crew	1	2
Ambulance	1	2
Other	3	5
Means of transport (76)	**Number**	**%**
Private vehicle	24	31
Fixed wing ambulance	18	24
Helicopter ambulance	16	21
Road ambulance	12	16
Helicopter and fixed wing ambulance	2	3
Other	4	5

TABLE 3

THE MEANS OF DECOMPRESSION STATUS CONTROL EMPLOYED

Means of decompression control	**Number**	**%**
Computer	23	30
PADI Recreational Dive Planner	19	25
US Navy Air Diving Table (including recreational agency derivatives)	7	9
DCIEM Sport Diving Table	6	8
No decompression status control	18	24
RNZN 63 treatment table	1	1
18:60:30 treatment table	1	1
Control unknown	3	4

Note. 3 divers reported a combination of computer and table control of decompression status, the snorkeller is not included, therefore n = 78.

TABLE 4

RISK FACTORS FOR DCI IDENTIFIED IN THE HISTORY

Risk factor	**Number**	**%**
Previous DCI - known	5	7
- suspected	9	12
Repetitive diving	52	78
Second dive deeper than first	28	37
Consecutive days diving	27	35
Strenuous diving	14	18
Equipment failure	3	4
Out of air	11	14
Multiple Ascents	18	24
Rapid ascent	27	36
Flying within 24 hours of diving	9	12
Ascent to >300m after diving (other than flying)	10	13

TABLE 5

FREQUENCY OF PRESENTING SYMPTOMS AND SIGNS

Symptom or sign	**Number**	**%**
Pain	52	67
Fatigue	41	54
Tingling	35	46
Headache	35	46
Numbness	26	35
Weakness	20	26
Cognitive difficulty	19	25
Dizziness	15	20
Ataxia	13	17
SOB	9	13
Itch	7	10
Visual disturbance Rash	6	8
Loss of consciousness	4	5
Cough	2	3
Urinary dysfunction Other	1	1
Other	9	13

by the Canadian Defence and Civil Institute of Environmental Medicine (DCIEM) table. Divers are grouped according to the method/s of decompression status control used in Table 3.

A thorough analysis of other risk factors for DCI has not been performed here since the DIMS database compiled at Adelaide includes these patients and will be reported by Dr Chris Acott in due course. However, a retrospective notes review was conducted to determine the incidence of known risk factors for DCI (other than provocative depth/time profiles). These data are presented in Table 4.

PRESENTATION OF DCI

First symptom latency varied from zero (present on surfacing) to 54 hours after diving, mean 7.3 (SD 21 hours). Musculoskeletal pain was the most frequently reported symptom with headache, fatigue and tingling also common. The percentage incidence of presenting symptoms is recorded in Table 5. Objective signs were found in 43 patients (57%).

TREATMENT

Fifty nine patients were compressed to a maximum pressure of 2.8 bar (18 m) during the initial treatment. With the exception of 8 patients (see discussion), all of these completed US Navy (USN) treatment table 6[3] with or without extensions. Seventeen patients were treated according to deeper treatment tables after initial compression to 2.8 bar failed to achieve adequate resolution of symptoms and signs. At the SHU where the lignocaine trial protocol[4] is followed, this is defined as less than 80% recovery in subjective symptoms or less than full resolution of objective signs. It should be noted that not all symptoms and signs are "followed" for the purposes of decision making during treatments.[4] The frequencies of use of the various initial treatment tables are given in Table 6.

Daily retreatments with an 18:60:30 table[5] were given until the patient either made a full recovery or experienced no sustained improvement over two consecutive days. Thirty two patients required retreatments. The number of retreatments ranged from 1 to 12 with a mean of 2.6.

One patient suffered central nervous system oxygen toxicity, manifested as a convulsion. The episode occurred 23 minutes into the first oxygen breathing period of a third and final 18:60:30 retreatment. The convulsion resolved spontaneously after which the chamber pressure was reduced to 2.4 bar and the treatment completed on 0_2.

OUTCOME

Fifty seven (75%) of the 76 patients treated for DCI in 1996 were discharged with no sequelae. Omitting 6 cases from the SHU and 2 cases from the CHU in which the diagnosis of DCI was considered highly equivocal, the proportion fully recovered at discharge increased to 81% overall (84% for the SHU; 71% for the CHU). The groups achieving full and incomplete recovery (exclusive of equivocal cases) are compared with respect to a variety of factors postulated to be predictive of outcome in Table 7.

TABLE 6.

THE RECOMPRESSION PROTOCOLS EMPLOYED IN 1996

Treatment table	Maximum depth	Treatment gas	n=
18:60:30	18 msw	O_2	7
USN 5	18 msw	O_2	1
USN 6	18 msw	O_2	51
RNZN 1	30 msw	Nitrox / O_2	2
RNZN 1A	30 msw	Heliox / O_2	7
RN 63	50 msw	Air / O_2	1
RNZN 63	50 msw	Heliox / O_2	4
RNZN 63 Modified	50 msw	Heliox / O_2	3

Discussion

The total of 76 DCI patients represented a decline in annual cases compared with the 100 patients in 1995. The SHU caseload was particularly affected since this unit treated all 100 divers in 1995, whereas 19 of the reduced 1996 total of 76 divers were treated by the CHU. There is no clear explanation for the decline in total cases.

As in 1995, a large proportion of the 1996 patients were trained to Professional Association of Diving Instructors (PADI) Open Water level,[6] and used the PADI Recreational Dive Planner (RDP)[7] to control decompression status. These data reflect the PADI market share in diver training and cannot in any way be interpreted as an indication of a poor standard of training.

An impressive proportion (50%) of divers with DCI reported profiles within the limits of the dive table they were using. Moreover, retrospective calculations revealed that 25% of the reported profiles were within the limits of the DCIEM table. While it is acknowledged that reported profiles are unreliable, these data illustrate that DCI does occur despite adherence to dive tables, a fact that is still poorly appreciated among recreational divers.

The presenting symptoms and signs in the 1996 patients were quantitatively and qualitatively similar to those reported in 1995[2] and in other series.[8] There was a 60 hour discrepancy between the symptom latency (mean 7.3 hours) and delay to presentation (mean 67 hours), although there was a large standard deviation for both parameters. Nevertheless, even if an average evacuation time of 6 hours is allowed, these data indicate that many divers tolerate symptoms for a significant period before seeking help.

Selection of treatment tables at the SHU during 1996 was dictated by the protocol for the lignocaine trial.[4] Initially, this protocol included randomisation to treatment on a heliox or nitrox/air table in the event of the treatment being deepened beyond 2.8 bar, hence 30 and 50 msw nitrox/air tables appear in Table 6. This attempt to retain elements of our earlier "heliox trial" was abandoned because of statistical concerns after only a short period and now all patients requiring deep treatment are treated according to a 30 or 50 msw heliox table. Seven patients were initially treated according to an 18:60:30 table, which is an unconventional approach. In one case, the symptoms of

TABLE 7

NUMBERS OF PATIENTS MAKING COMPLETE AND INCOMPLETE RECOVERY BY DISCHARGE FACTORED AGAINST VARIABLES OF PUTATIVE PROGNOSTIC IMPORTANCE

Variable	Complete Recovery		Incomplete recovery		p
All cases	**n = 55**		**n = 13**		
Age					
≤ 40	45	(80%)	11	(20%)	n.s.
> 40	10	(83%)	2	(17%)	
Gender					
Male	43	(81%)	10	(19%)	n.s.
Female	12	(80%)	3	(20%)	
Delay to onset of symptoms					
≤ 1 hour	29	(81%)	7	(19%)	n.s.
> 1 hour	26	(81%)	6	(19%)	
Delay to presentation					
≤ 24 hours	28	(82%)	6	(18%)	n.s
> 24 hours	27	(79%)	7	(21%)	
Compliance DCIEM tables (n = 65)*					
Yes	15	(88%)	2	(12%)	n.s.
No	37	(77%)	11	(23%)	
SHU Data Only	**n = 43**		**n = 8**		
Objective signs at admission					
Present	21	(75%)	7	(25%)	<0.05
Absent	22	(96%)	1	(4%)	
Previous DCI					
Known or suspected	7	(70%)	3	(30%)	n.s.
None	36	(88%)	5	(12%)	

Note. Eight cases (6 from the SHU and 2 from the CHU) where the diagnosis of DCI was highly equivocal were excluded leaving 68 cases for analysis.

* The two recompression chamber attendants and the snorkeler are excluded from analysis of compliance with the DCIEM table.

decompression illness were minor and of secondary importance to a salt water aspiration syndrome. The treatment was truncated after resolution of symptoms to minimise both patient stress and any pulmonary oxygen toxicity. The others were cases of equivocal DCI where the compression was conducted as a diagnostic manoeuvre.

Nineteen patients (25%) were recorded as having made an incomplete recovery despite recompression therapy. This number fell to 13 (19%) with exclusion of 8 patients for whom the diagnosis of DCI was equivocal. The true treatment failure rate in this series therefore lies somewhere between 19 and 25%. This is similar to failure rates previously reported by the Royal Australian Navy facility at HMAS Stirling during the period 1984-88 (20%)[8] and the SHU in 1995 (30%).[2] It is significantly lower than failure rates in the range 40-60% previously reported by other Australasian units.[1,9-10] Of the factors tested for association with incomplete recovery at discharge, only the presence of objective signs at admission was shown to be significant, although non-compliance with the DCIEM tables and a history of previous DCI generated strong numerical trends. It is notable that these two factors were shown to be significantly related to poor outcome in a previous series of similar size.[11] As in 1995,[2] we have again failed to demonstrate any prognostic significance for delay to presentation. However, this may simply be a reflection of the tendency for the more severe cases to present early.

Three specific cases are worthy of mention.

Case 1

A male of 24 years developed chest pain, dizziness, nausea, and upper motor neurone weakness on the left side including the face while snorkelling. An ECG revealed no evidence of myocardial ischaemia, and a chest X-ray was normal. The weakness almost completely resolved with recompression therapy (table RNZN 63 plus three 18:60:30 retreatments). Unfortunately, the patient discharged himself before treatment was complete and before further investigations could be carried out.

Two cases of DCI arose in nurse chamber attendants after treatment tables.

Case 2

The first followed an uneventful RNZN 63 treatment table. Symptoms, including rash, itch, nausea and multifocal limb pain, arose approximately 30 minutes after completion of the table and were rapidly progressive. Complete recovery was obtained after an extended USN Table 6 and four 18:60:30 retreatments. There was no known predisposition to DCI and a bubble contrast echocardiogram did not detect an inter-atrial shunt. The RNZN 63 table was subsequently modified to include stops between the 50 and 18 msw depths and an extended period of oxygen breathing for the attendant at 9 msw.

Case 3

The second followed an uncomplicated 18:60:30 table, despite the nurse breathing oxygen for the entire ascent. Moderate right elbow pain was noted 5 minutes after completion of the treatment and the nurse was recompressed some 15 minutes later according to USN Table 6. The elbow pain was slow to resolve and the table was extended, resulting in symptomatic pulmonary oxygen toxicity. All pain had resolved by the end of this treatment and there were no sequelae. It was suspected that holding the arm in a tightly flexed position throughout the ascent (to hold the oxygen mask on), with consequent reduction of circulation, may have contributed to this event.

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