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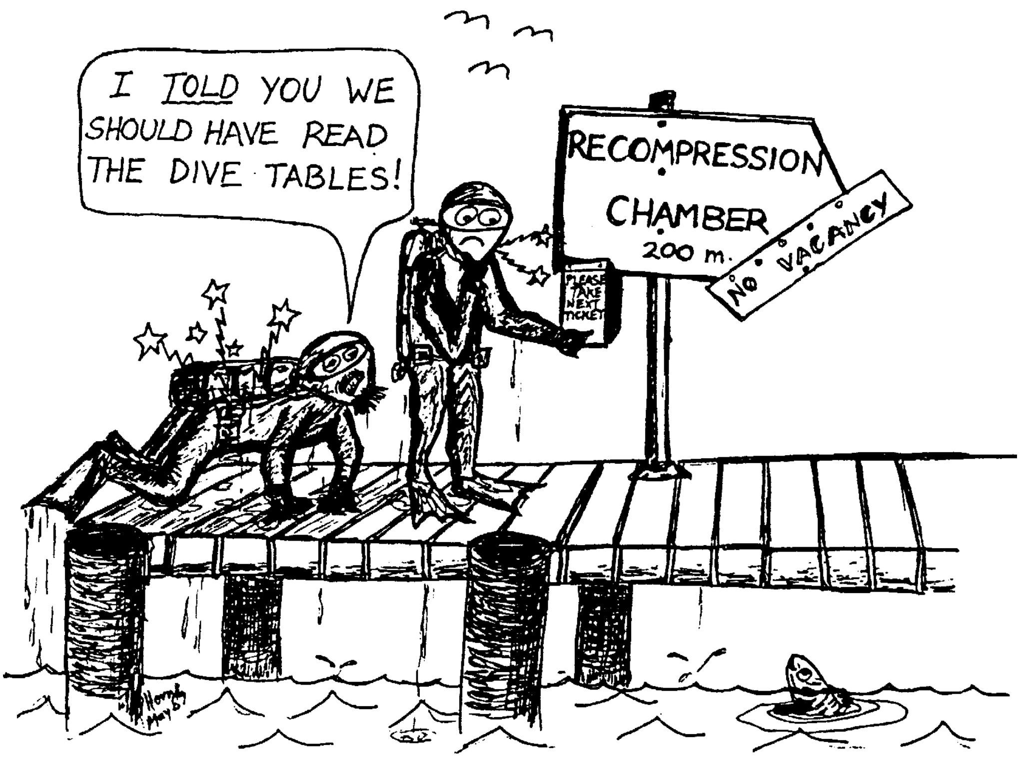

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REPRINTING OF ARTICLES

INSTRUCTIONS TO AUTHORS

Contributions should be typed in double spacing, with wide margins, on one side of the paper. Figures, graphs and photographs should be on separate sheets of paper, clearly marked with the appropriate figure numbers and captions. Figures and graphs should be in a form suitable for direct photographic reproduction. Photographs should be glossy black and white prints at least 150 mm by 200 mm. The author's name and address should accompany any contribution even if it is not for publication.

The preferred format for contributions is the Vancouver style (*Br Med J* 1982; 284: 1766-1770 [12th June]). In this Uniform Requirements for Manuscripts Submitted to Biomedical Journals references appear in the text as superscript numbers.[1-2] The references are numbered in order of quoting. The format of references at the end of the paper is that used by *The Lancet*, *The British Medical Journal* and *The Medical Journal of Australia*. Page numbers should be inclusive. Examples of the format for journals and books are given below.

1 Anderson T. RAN medical officers' training. *SPUMS J* 1985; 15(2): 19-22.

2 Lippmann J, Bugg S. The diving emergency handbook. Melbourne: JL Publications, 1985.

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, eg. decompression sickness (DCS) can thereafter be referred to as DCS.

Measurements should be in SI units. Non-SI measurements can follow in brackets if desired.

THE SAFETY SAUSAGE

As anyone who has looked for a diver at sea knows, a diver on the surface is difficult to spot. There is now a modestly priced aid to diver location.

The Safety Sausage *(SPUMS J* 1986; 16(2): 59), is a red plastic tube which can be inflated by the diver's regulator. It can either be held vertically in the water to indicate the diver's position to a boat or allowed to lie on the surface to aid recognition by aircraft. It is manufactured by TL Begg and Sons Ltd, PO Box 5216, Moray Place, Dunedin, New Zealand.

The Australian distributor of the Safety Sausage is RJ Knight Pty Ltd, 80 Wellington Parade, East Melbourne VIC 3002. They are available for members of SPUMS at $7.00 including postage. They will soon be available through dive shops.

EDITORIAL

There are two significant inter-related events now threatening the recreational scuba diving community. Divers who live in Western Australia will be well aware of the adverse publicity that has been generated by the reporting of the increasing number of divers requiring recompression treatment and that this has resulted in the setting up of an Underwater Diving Task Force to investigate why this increase has occurred and how it can be reversed. This news is not entirely bleak on two counts. First, the government response has been to ascertain the facts before introducing legislation, which might not have been the case. Second, it draws attention to a rise in numbers attending for treatment which has also been noticed in other states. For too long those involved in the management of such cases have behaved in the fashion of Sherlock Holmes' Curious Incident Of The Dog In The Night. They have done nothing to stir up a creative alarm in diving circles.

The report of cases treated at HMAS STIRLING last year shows that there can be no simple answer to this complex problem. A start would be made if divers ceased to place so much trust in tables based on theories, while omitting to be scrupulously careful in monitoring their dive depths and times. Undoubtedly some who develop decompression sickness have, in large measure, invited their affliction. Others, who have followed the accepted rules, appear to be the victims of capricious chance. Details are rarely sufficiently complete and accurate, however, for complete certainty that the "unwritten rules" have been followed. Nor that there has been no excess of effort nor any of the other factors, such as cold or changes of depth and using an inaccurate depth gauge, which influence susceptibility to decompression sickness.

One striking finding in this review is the revelation that there has been a resurgence in the pearl diving industry, if the evidence of the number of cases of decompression sickness is taken as an indicator. There is a long history of government limiting itself to licencing but not supervising this industry, both in Queensland and Western Australia. It is surely time for governments to a more responsible attitude to work safety. It is sobering to remember that it is now seventy (70) years since the Pearlers Association in Broome was presented with a oneman recompression chamber by CE Heinke & Co. This was a response to their pleas for assistance in reducing the then high death rate. The dangers of pearl diving now are far less. It is now morbidity rather than mortality. However now we are far less willing to accept needless work injuries.

By fortunate chance there is available in this issue (page 86) an account of Broome and a photo of this recompression chamber. When it was presented it was a state-of-the-art piece of equipment. Nowadays one and two man chambers are far more complex and costly but treatment is probably as unpleasant as ever. It remains, as always, a far, far better option to avoid decompression sickness than to suffer it and undergo treatment. And far better to be treated than accept the increased risk of residual damage which accompanies a decision to await nature's outcome.

The new Swiss Tables (page 88) come with a (relative) guarantee that they are effective. Readers are advised to evaluate them against the alleged dive profiles of the Western Australian cases before they accept that Australian diving patterns are the same as those used in Swiss lakes. The statement that the "Decobrain 2" uses the same calculations should therefore be read advisedly. It is wise to remember the caution once given by Dr Christian Lambertson that "when you know everything there is to know about diving you find out that you know hardly anything". It is Editorial policy to keep this fact ever fresh in our readers' minds.

We wish to apologise for the late publication of this issue. It is due to a combination of deputy editorial inertia and new technology. As readers will discern the typeface is different from previous issues. This issue has been produced on the newly purchased Apple Macintosh SE computer using the word processing programs Macwrite and Microsoft Word and the desk top publishing program PageMaker. In spite the of the deputy editor's inexperience with Page Maker the time eventually spent on producing this issue has been much reduced from the usual 20 to 30 hours spent with scissors and paste producing the A3 pages of typescript that were then reduced to A4 and printed.

We hope that the teething problems encountered will be overcome in time to produce the next issue on time.

PROPOSED LEGISLATION TO CONTROL DIVERS IN WESTERN AUSTRALIA

Verbal submissions from organisations and individuals to the Underwater Diving Task Force can be made, by appointment. Notice of intention to appear before the Task Force should be sent to

The Executive Director
Mr Simon Leunig
Underwater Diving Task Force
PO Box 66
Wembley WA 6014
Phone (09)-387-9706

SPUMS NOTICES

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.

MEMBERSHIP

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 $A35.00 and for Associate Members is $A25.00. New Zealand members' subscriptions ($NZ50.00 and $NZ35.00 inclusive of GST) should be sent to Dr P Chapman-Smith, Secretary/Treasurer of the New Zealand Chapter of SPUMS, 67 Maunu Road, Whangerei.

Membership entitles attendance at the Annual Scientific Conferences and receipt of the Journal.

Anyone interested in joining SPUMS should write to the Secretary of SPUMS,

Dr David Davies
Suite 6, Killowen House
St Anne's Hospital
Ellesmere Road
Mt LAWLEY WA 6050

AIRMAIL DELIVERY

The *SPUMS Journal* can be airmailed at the following annual extra costs:

Zone 1	eg. Papua New Guinea, Sth Pacific	$6.50
Zone 2	eg. Indonesia and Malaysia	$9.00
Zone 3	eg. India and Japan	$11.50
Zone 4	eg. USA and Israel	$14.50
Zone 5	eg. Europe, Africa & Sth America	$15.50

Those interested in having their copies of the *SPUMS Journal* airmailed should write to

SPUMS
80 Wellington Parade
EAST MELBOURNE VIC 3002
Australia

They will be advised which zone charges apply and of the appropriate amount in Australian dollars.

PROJECT STICKYBEAK

This project is an ongoing investigation seeking to document all types and severities of diving-related incidents. 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 organization to increase diving safety through better awareness of critical factors. Information may be sent (in confidence) to:

Dr D Walker
PO Box 120
NARRABEEN NSW 2101

SPUMS NOTICES

SPUMS JOURNAL BACK NUMBERS

Some copies of a few past issues are available at $2.00 each including postage.

The relevant issues are

1984 Vol 14, No 1 (10 copies)
This contains Professor Brian Hill's paper on "Decompression Physiology" presented at the 1983 Annual Scientific Meeting.

1984 Vol 14, No 2 (11 copies)
This contains papers presented at the SPUMS-RAN Meeting in August 1983 and at the ANZICS-SPUMS Meeting in Rockhampton in October 1983.

1984 Vol 14, No 3 (8 copies)
This contains further papers presented at the ANZICS-SPUMS Meeting in Rockhampton in October 1983.

1985 Vol 15, No 4 (15 copies)
This contains papers from the 1985 Annual Scientific Meeting in Bandos and from the New Zealand Chapter of SPUMS Meeting in November 1985, including an account of the formation of the New Zealand Chapter.

1986 Vol 16, No 4 (13 copies)
This contains papers from the 19865 Annual Scientific Meeting in Tahiti.

Orders, with payment, should be sent to

SPUMS
80 Wellington Parade
EAST MELBOURNE VIC 3002
Australia

NEW ZEALAND CHAPTER SUBSCRIPTIONS

The New Zealand Chapter has decided to have the New Zealand financial year, April 1 to March 31, as its subscription year.

Because subscriptions in the 1986-1987 year were paid for 12 months but now only apply to a nine month period, full members in 1986-7 will receive a NZ$9.00 credit and associate members a credit of NZ$6.00 when renewing their subscriptions. GST paid is NZ$2.25 for full members and NZ$1.50 for associate members.

The 1987-1988 subscriptions, due on 1 April 1987, have been fixed at NZ$50.00 for full members and $NZ35.00 for associate members, inclusive of GST. Current full members should deduct NZ$9.00 from this figure and current associate members should deduct NZ$6.00. New members will pay the full subscription.

DIVER EMERGENCY SERVICE

008-088-200

The duty supervisor of the Intensive Care Unit at the Royal Adelaide Hospital will answer the telephone and when told that it is a diving emergency will contact the on-call diving doctor. The call will be diverted to the diving doctor who will offer the caller expert advice. Civilian and naval doctors experienced in the treatment of diving accidents from all over Australia will be taking part in DES.

The diving casualty should contact DES on 008-088-200. In most cases he will be advised to attend the local hospital unless he has easy access to one with a hyperbaric unit. That hospital will be contacted by DES with advice. The hospital will notify the nearest hyperbaric unit and arrange a hospital to hospital transfer. It will also notify the local ambulance service. If necessary the hyperbaric unit will alert the retrieval agency, such as the National Safety Council of Australia (Victorian Division) who have portable recompression chambers and aircraft to carry them. If specialist transfer is necessary the local ambulance service will arrange it with the retrieval agency.

The DES number 008-088-200 can only be used in Australia. For access to the same service from outside Australia ring ISD 61-8-223-2855.

SPUMS NOTICES

MINUTES OF THE EXECUTIVE COMMITTEE MEETING HELD ON THURSDAY 5 JUNE 1986 AT THE HOTEL IBIS, MOOREA

CHAIRMAN

Dr C Lourey

PRESENT

Dr C Lourey, Dr D Davies, Dr G Barry, Dr J Knight, Dr A Sutherland

APOLOGIES

Dr C Acott, Dr J Williamson, Dr D Walker

1. MINUTES OF LAST MEETING

   Read and Confirmed.
   Moved by Dr Knight, Seconded Dr Sutherland

2. BUSINESS ARISING

2.1 The Secretary has yet to write to UMS.

2.2 The Committee noted that courses in diving medicine will be available for Doctors nursing staff and paramedics at the new Department of Diving and Hyperbaric Medicine at Royal Adelaide Hospital. Information will be published in the Journal.

2.3 Dr Acott has organised a Seminar in Rockhampton, to be called “Rockdive”, and to be held on 11-12 October 1986.

2.4 The New Zealand Chapter will be holding its AGM in Whangamata on 13-16 November 1986. The organiser is Dr M Fraundorfer. Diving will be available.

2.5 The Committee recommends a change in the Constitution to give a permanent ex-officio place on the Committee for the Chairman, or an alternate delegate, from the New Zealand Chapter.

2.6 No approaches to companies have yet been made in regard to advertising in the Journal but the costs have risen by about $1000.00 over the past year.

2.7 Diving for the Disabled. The Secretary has obtained a copy of the draft of this document. It has been examined by several members of SPUMS who agreed that it is well researched and presented and covers the essential points of a very difficult topic. The AUF are to be congratulated on their efforts.

3. NEW BUSINESS

3.1 In future the AGM would be held closer to the end of the Annual Scientific Meeting after delegates had a chance to discuss problems and topics. This would be at the discretion of the convenor.

3.2 In light of the Treasurer’s report the Committee agreed reluctantly to a rise in annual subscriptions. These will be:

Full Membership	A$ 35.00
	NZ$ 45.00
Associate Membership	A$ 25.00
	NZ$ 30.00

There will be no discounted rate for members from Third World countries.

Moved by Dr Barry and seconded by Dr Sutherland.

3.3 Venue for 1987. This has yet to be decided in view of recent climatic disasters. The Secretary will confer with Mr Newly.

3.4 Diving Safety. A new first aid container has been purchased by the Society as has a self contained oxygen generating apparatus.

It was suggested that a first aid kit be supplied to each dive boat for the conference and a Bendeez adaptor be supplied at each Conference, the cost to be added into the conference fee.

NEXT MEETING

To be held in Rockhampton in conjunction with Rockdive on 11 October 1986.

SPUMS NOTICES

MINUTES OF THE MEETING
HELD ON SATURDAY, 11 OCTOBER 1986
AT ROCKHAMPTON

PRESENT

Dr C Acott (President), Dr G Barry (Treasurer), Dr J Knight, Dr D Walker (Editor), Dr A Sutherland, Mr A Newly (Allways Travel)

APOLOGIES

Dr D Davies (Secretary), Dr C Lourey, Dr P McCartney, Dr J Williamson

1. MINUTES OF LAST MEETING

Not read nor confirmed.

2. BUSINESS

2.1 Mr Newly and Dr Barry reported on the site inspection in the Solomon Islands. The recommendation that the 1987 Annual Scientific Meeting be held in Honiara in June was accepted by the Committee. Mr Newly is to arrange final dates and organise a non-divers social program.

2.2 Dr Tom Shields has indicated to Dr Lourey that he is available to be guest speaker.

2.3 The Secretary will draft a letter to all members inviting attendance at the Meeting and calling for papers.

2.4 Dr Lourey will submit a written costing of arrangements for Dr Shields.

2.5 The Committee discussed the possibility of holding a meeting similar to "Rockdive". Both Adelaide and New Zealand were eliminated as being unsuitable at this time. Melbourne was acceptable to the Committee and a tentative date set for July 1987. Mr Newly agreed his organization was in a position to guarantee a good attendance of dive operators and medical personnel.

3. CORRESPONDENCE

Letters were read from:

Aquarius Travel
Index Medicus
Dr Batley
Dr Rubinstein
Paul Dicke
Dr C Downie

Drs Batley and Rubinstein complained their names were not included on the list of doctors trained in diving medicine. It was pointed out that inclusion on this list was dependent upon completion of the course at HMAS PENGUIN or its equivalent.

Dr Dicke, an oral surgeon, wished to design a mouth piece under the auspices of the Society.

Dr Downie complained about the conference in Moorea. It was noted that Dr Downie rarely, if ever, attended the actual Scientific Meetings. It was also noted that neither Dr Downie nor her husband are current financial members of the Society. The Committee recommended that an attendance register be kept at future meetings.

4. TREASURER'S REPORT

The Treasurer reported a good response to the membership renewal notices and was gratified by the number of new members.

The Committee gave him leave to seek an auditor for the Society's accounts.

Dr Carl Edmonds was appointed as SPUMS Representative to the 1987 UMS Meeting. The Secretary will compose a letter of accreditation for countersigning by the President.

The Committee will re-convene in conjunction with the Meeting of the IX International Congress of Hyperbaric Medicine in Sydney on 1-4 March 1-4 1987.

SPUMS NOTICES

MINUTES OF A BUSINESS MEETING OF THE NEW ZEALAND CHAPTER OF SPUMS

HELD 10 PM ON 5 APRIL 1987 AT THE PACIFIC RENDEZVOUS MOTEL, TUTUKAKA.

The meeting was opened by Alan Sutherland at 2200 hours.

Apologies: Nil

Minutes of the previous meeting:

These were accepted

Business arising from the minutes:

A letter to be written to Mike Davis regarding organising the 1988 AGM in the Marlborough Sounds. The general feeling of the meeting was that perhaps this should be at Easter. The role of SPUMS New Zealand was discussed and people felt that the current direction was quite acceptable.

President's Report:

Alan Sutherland presented his report (which is printed on page 60). Relevant points:

1. Change in NZUA stance to now a mandatory medical clearance for trainee divers as previously.
2. Establishment of a DES network.
3. General dissemination of information regarding HBO use

Stevens/Bennett
Passed

Treasurer's Report:

Dr Chapman-Smith provided an up to date financial statement of the SPUMS account and is awaiting clarification from SPUMS Executive regarding further remittance of fees across the Tasman. Concern was expressed regarding the likely funding of trans-Tasman travel for executive meetings in the coming year or two. (This cost is borne by the parent body of SPUMS not by the New Zealand Chapter).

General Business:

There was some discussion as to whether Carl Edmonds would be invited for the OCEANS conference to be held in Auckland in September, with a planned concurrent contribution from SPUMS perhaps. Perhaps some sharing of costs for this occasion.

The meeting concluded at 2235 hours.

CHAIRMAN'S REPORT

DELIVERED AT THE NEW ZEALAND CHAPTER OF SPUMS MEETING AT TUTUKAKA

Report on activities since the Whangamata AGM November 1986. This meeting was well organised and ably run by Mark Fraundorfer and his team.

Our guest speaker, Des Gorman from Adelaide, described the New Zealand Chapter of SPUMS as the group most suited to provide Diving Medical Audit.

Peter Robinson and Allan Sutherland arranged to meet with NZUA/PADI executive to discuss the subtle replacement of the Dive Medical with a Medical Disclaimer. Fortunately NZUA/PADI reviewed their stance and in a Standards Revision Document they stated that "from 1st March 1987 all candidates entering NZUA/PADI courses would be required to be examined by a Medical examiner and present a signed Medical Certificate."

The problem of inappropriate Diving Medical examinations was also addressed in this document with a mechanism for Dive Instructors to obtain a second opinion in appropriate cases.

A group of SPUMS, NZUA and Ambulance Medical Advisors visited Auckland's Westpac Helicopter on 12 February 1987.

Drs Fraundorfer, Robinson and Sutherland attended the IXth International Hyperbaric Conference in Sydney, 1-4 March.

Drs Robinson and Sutherland reviewed Diver Emergency Service Rescue and recompression facilities in Australia, see separate report.

Finally, the New Zealand Chapter of SPUMS has three major aims in 1987

1. Improve and formalise a Diver Emergency Service (DES).

2. Encourage the Navy Recompression Facility to be available for sport and Navy divers.

3. Inform medical colleagues of the advantages of hyperbaric oxygen (HBO) therapy for medical and surgical indications.

Allan FN Sutherland

SPUMS NOTICES

DIVER EMERGENCY SERVICES

A report by Drs P Robinson and A Sutherland.

Australian Diver rescue and recompression facilities were visited following the IXth International Conference on Hyperbaric Medicine in Sydney in March 1987.

The Sydney region has three Helicopter Rescue Services, the National Safety Council, Care Life and Surf Life Saving, and two recompression chambers at HMAS PENGUIN and Prince Henry Hospital. In other parts of Australia there is not such a diversity of retrieval and treatment facilities available. Most regions have a protocol of retrieval and treatment for dive accident victims. These protocols are centrally organised by the Diver Emergency Service network centred on the Royal Adelaide Hospital and Dr Des Gorman.

We were fortunate to stay with Dr Gorman and witness him handling four diving accidents, one from outside Australia, and discuss with him the past experiences and pitfalls to be avoided. We were also privileged to discuss diver rescue and treatment facilities with senior diving consultants from the United States of America (DAN) and England.

As a result of these discussions and experiences we recommend the following four principles be followed in setting up a Diver Emergency Service in New Zealand.

1. Utilize existing facilities.
2. Organization, centrally based at site of ultimate treatment.
3. Area protocols be simple to operate.
4. Encourage teamwork amongst DES Consultants.

Using the existing Auckland facility at the Philomel Naval Base as a model, 10 or 12 DES consultants could be appointed, covering the drainage area for accidents, including Tauranga, Whangarei, Whangamata, Great Barrier, etc. The DES operation would require a central co-ordinator or co-ordinators to fine tune and facilitate actual emergencies. The DES consultants should attend one refresher weekend per year to discuss the operation of the network.

The New Zealand Underwater Association (NZUA) accepts some responsibility for the welfare and safety of sport divers. We would recommend that the NZUA fund a re-direct toll-free telephone located at the Naval Hospital, and two locators for the use of medical personnel operating the chamber and co-ordinating diver accident advice. We would suggest that the NZUA publicise this system by the use of decals and in the press.

For a number of reasons, primarily that the Australian DES network may be required to give advice on New Zealand diving accidents, we feel that Diver Emergency Service is a more appropriate title than Diver Alert Network.

ROCKDIVE '86

This was the third Diving Medicine program run by SPUMS alone. The others were at Prince Henry's Hospital, Melbourne on 31 October 1975 and in Melbourne on 20 November 1982. Rockdive was designed for an audience of recreational divers and diving instructors as was the SPUMS-Oceans Society meeting held at Frankston, Victoria on 4 December 1976. The excellent planning and organisation of the meeting which contributed so greatly to its success, was by Dr Chris Acott, President of SPUMS. The program covered a wide range of matters and had as a backbone the entertaining informative, and occasionally deliberately provocative lectures of Dr Carl Edmonds. He performed the near marathon task set him of presenting five lectures. He demonstrated his mastery by maintaining the interest of the audience as he discussed matters ranging from decompression sickness to the development of Diving Tables, from the long term effects of diving (you cannot necessarily blame the diving if your friends think you are dull), to the use of the in water oxygen therapy, and let his views on some kinds of "Diving Medicals" be known.

The intervals between Dr Edmonds' lectures were filled by a supporting cast, Dr John Knight on first aid in diving accidents, and then on hypothermia. Dr Beinnsen appropriately later talked about the Antarctic. The marine stingers, for which Queensland has become famous, were discussed by Drs Fenner and Williamson, experts on this subject, then Dr Chris Acott talked about sea snakes, so a talk on diving fatalities by Dr Douglas Walker and on resuscitation may have seemed only natural to the audience. The latter, which was in part a demonstration, was presented by members of the Queensland Ambulance Service. An opportunity to practice the sometimes vital art of resuscitation may be considered a valuable component of any Diving Medicine Symposium for divers (and doctors?) as without correct initial care the victim may not survive to reach specialised medical attention.

SPUMS SCIENTIFIC MEETING 1986

CHAMBERS AND CHAMBER FIRES

Andrew Pilmanis

CHAMBERS

Hyperbaric therapy has a history of over 300 years. Hyperbaric oxygen (HBO) therapy in the United States is now respectable. This was not always so. It does have a very bad history of exploitation with no sound basis. Back before the turn of the century in Europe and later in the United States various chambers were operated for all sorts of indications. Dr Orval Cunningham[1] got into the business. He started treating anything, any disease that walked in off the street, and became a rather wealthy man with his 26.6 m (88 foot) long chamber. He decided to go on to bigger and better things and built the world's largest chamber. It was circular, seven stories high, with seventy two rooms. It was a rather posh hotel inside. Unfortunately for Orval the American Medical Association by that time had had enough of his practice and took his licence away and that ended his career in hyperbaric medicine and rightly so. The chamber after that became a Catholic Girl's School, and then at the start of the Second World War it was cut up for scrap.

In the 1950s and 1960s there were other questionable practices in hyperbaric medicine. All of this has left the medical community in general with a bad taste in its mouth when you mention hyperbaric oxygen therapy, even to this day. However in the last 10 years the hyperbaric medicine field has finally come on a solid footing. There is sound physiological data available for the diseases being treated. There are still a few individuals around treating executive high blood pressure during the lunch hour, baldness and a variety of other things for money. But in general the Undersea Medical Society can be commended for putting together a decent basis. The chambers used vary tremendously in size and shape.

Multiplace chambers

Large multiplace, multi lock chambers in hospitals are necessary for the fullest application of HBO to sick patients. There is a very large one in Baltimore, which measures about 15 m (50 feet) long, and 3 m (10 feet) in diameter. It is a very active unit and very good operation. It is an excellent example of the large hospital based facilities.

One of the newest ones is in Northbridge, just north of Los Angeles, it is a L-shaped chamber, with what they call the acute block then a sphere and then the long chronic unit. They are apparently treating an average of 14 patients a day. It is a very active unit treating primarily slow wound healing, from a variety of causes, gas gangrene carbon monoxide poisoning and the occasional diving accident. The Northbridge chamber is automated. One operator runs the whole thing. They have been in operation for a year and are doing very well financially. They operate with a staff of two physicians, five nurses and one technical person. What really increased their number of patients was an incident about a mile from the chamber at a Catholic Girls School. It had a dormitory where a heater malfunctioned during the night and the whole dormitory heating system was flooded with carbon monoxide. They treated 137 nuns and young students in one week in their chambers quite successfully.

Diving accidents are a losing proposition. Firstly, the diver seldom pays, that is well established. Secondly, treatment table takes up six hours or more whereas HBO therapy is an hour and a half. Thirdly, you can only put one diver in the chamber while in multiplace chambers you can put 10 people in at a time. Treating divers has PR value but on a financial basis it is not very good.

The typical field, military or commercial diving chamber is 1.3 m (54 inches) in diameter, with a double lock and manual control. It is the most common type of chamber around the world. It is quite adequate. One of the bad things about these chambers is the circular hatches. It is difficult to get patients in and out, but one can live with that. Some people have a steel chute down which the patient is slid.

One of the smallest double locked multi-placed chambers manufactured is 1.05 m (42 inches) in diameter. Again it is adequate and is quite affordable. It is used in the commercial diving industry fairly extensively. As an example of how successful it can be, Dr David Youngblood treated a commercial diver with cerebral arterial gas embolism (CAGE) in the Gulf of Mexico, in one. He, the tender and patient were inside for 7 days. It was an heroic effort but it can be done.

Over 200 chambers are listed as active in the United States. The vast majority sit in a back room and are not very active. However there are probably fewer than 10 active facilities with multiplace large hospital based chambers in the United States. It is not a large field. My criteria is that they are on a sound basis, that they are successful, and that they are doing good work.

Two person chambers

There is a push in various places for two-man chambers, the idea being for a tender to be with the patient during transfer. Carl Edmonds tell the story of using an old single man surface decompression chamber for "victim" and attendant which meant that neither could move or even be comfortable. I question the value of the tender chamber which was originally designed for a single fit diver to do surface decompression in and which is not fitted for transfer under pressure to a larger chamber. In a Drager Duocom the patient lies on a stretcher and the tender sits up with the patient's head between his legs. When pressurized it can be transported to a large chamber and mated onto it. I have not seen one used but I understand that they are used in Australia. And according to David Elliott the Swiss use it for retrieval of divers who have got bent in their lakes. I think it has the same problem that the tender really is very limited in what he can do.

The US Navy has its own version of a two-man chamber. It is a canvas chamber with the world's largest zipper and pressurized with scuba bottles. It delivers oxygen to the sufferer. The idea was to roll it up in a bag and store it on a ship until it was needed. Then one could pressurize the patient in it and transport him to a large chamber and take it in. Although it has a burst pressure of something like 257 metres of seawater (msw) (850 feet), unfortunately the US Navy regulations have sections on certifying aluminium chambers and steel chambers but had no section on canvas chambers. That of course ended the like of this chamber. If one cannot find it in the book, no one can certify it. I believe it still sits in Florida although I am not sure what has happened to it.

I have talked to Bob Sands about his design2 and it is interesting. It solves the problem of access to the patient in a two-man chamber.

I can see no role for two man chambers in treatment as assessment of the patient is virtually impossible. They may have a place in the transport of patients to a large chamber provided that the patient can be transferred into the large chamber while still pressurized.

Monoplace chambers

Monoplace acrylic chambers are very common in the United States. Just about every city hospital has one or more of these. They are pressurized not with air but with 100% oxygen. They are rated at the most to 18msw (60 feet). They are used for HBO therapy quite successfully and adequately.

I object to their use for diving accidents for a number of reasons, although there are a number of physicians in the United States who do use these for the treatment of diving accidents. One cannot run a commonly accepted treatment table in them because one cannot deliver air. So the most one can give is one and a half hours of 100% oxygen and then one has to take them out. Without air breaks, one would have to run a very short table. The adequacy of the one and a half hour table on air embolism and decompression sickness has never been proven. One cannot got to 6 ATA which is the standard of the worldwide treatment for air embolism. I know of two cases treated in monoplace chambers, one was a steel one and one was an acrylic one, where unknown to the persons outside, the patient developed an pneumo-thorax. When the pressure was reduced of course the pneumo-thorax expanded. In both cases the patient died by the time they were back to atmospheric pressure. There was nothing the operators could have done about it even if they knew what was happening. This applies if the patient has any problems. With carbon monoxide poisoning one simply depressurizes and brings the patient out and solves the problem. But with air embolism and decompression sickness if one does that the bubbles that have not yet dissolved re-expand and one creates a continuing problem popping them up and down. And finally one cannot do repeated neurological examination in them. Our whole management is based on frequent neurological examination to assess progress.

Comment

Dr FM Davis

At Christchurch we get quite a number of cases transferred down to us by chopper from the Wellington area which is at the bottom end of the North Island of New Zealand. Recently they have taken to putting one or two of the more severe ones into their monoplace chamber, and compressing them to three atmospheres on O_2 while they wait to arrange the chopper flight. In one particular instance I am certain that the exercise significantly worsened the lesions.

Do you have any comments on using hyperbaric oxygen followed by another decompression before transfer to a treatment facility?

Dr A Pilmanis

Did they bring him to the surface before transferring him to your chamber?

Dr FM Davis

Yes, he was decompressed and then flown to us.

Dr A Pilmanis

When did he worsen?

Dr FM Davis

It is not possible for me to be precise about that. All I know is that I could see from an administration note that at Wellington Hospital the patient was totally different then from the patient I received.

Dr A Pilmanis

I would first like to know whether that worsening occurred in that decompression from the HBO. Obviously if it did they had done an inadequate treatment. If one does not do the complete treatment procedure, our assumption is one has not eliminated the bubbles. If the patient is brought to the surface prematurely what is going to happen? Bubbles re-expand and if they are in the right (or wrong) place at the right (or wrong) time there is a worsening of his condition. That is another of my objections to monoplace chambers. Not just because of the transfer aspect but because if something happens, say the patient vomits and is aspirating, what are you going to do? You cannot practise hands on medicine through perspex. You have to decompress the chamber and when you do, if you have done an inadequate treatment the bubbles are going to re-expand and the patient's condition is going to worsen. That is the way I see it.

Dr Takashi Hattori, in the Monterey Peninsula area, has had a long, about 12 years, experience with a monoplace chamber when there was no double lock chamber in the San Francisco, Greater Bay area. With the serious cases he put them in the monoplace chamber. Then had them flown from the chamber to San Diego or Catalina. The monoplace chamber was taken into the bigger chamber which is a complicated exercise, and the patient was decanted under pressure. He practised this by necessity to avoid decompressing them before transport. Now he has a double lock chamber and he has thrown away his monoplace.

Dr FM Davis

I think this is a very important point because as you have pointed out there are a lot of monoplace chambers around. There are three to my knowledge in New Zealand. The tendency is that once there is an enthusiast or two in a particular area they start using the monoplace chamber. I am really quite concerned about that and I think this is a topic that should be aired.

Dr A Pilmanis

I have been accused of being somewhat, even almost, irrational about monoplace chambers so I am trying to stay calm here. I would say that, if one has to wait an hour and a half for a helicopter, it is better to give 100% oxygen by mask then recompress and decompress from a monoplace chamber. I am talking about true 100% oxygen because what one is trying to do is to exclude nitrogen, not give oxygen. I think that statement should be emphasized. If the mask does not fit properly one is not excluding nitrogen.

CHAMBER FIRES

Almost all chamber fires have been caused by extreme negligence. Recently, off Santa Barbara in Southern California, a diver on an oil rig was working on air at 85 msw (280 feet). He finished the job on a pipeline and came up covered in oil. They were using surface oxygen decompression, which is standard practice, that is they bring the diver to the surface and they have five minutes to get him into the chamber and pressurized to 12 msw (40 feet). They then decompress the diver on oxygen in the chamber. The diver had his helmet taken off and got into the chamber. A young student diver who was in his bathing suit spraying down equipment with WD40, which is a petroleum based product, and who was covered in the stuff, went in as tender. The diver was covered in oil. At 12 msw (40 feet) on oxygen the diver lit up a cigarette. In my definition that comes under extreme negligence. They both burned, they both lived. The young man in the bathing suit got the worst of it because he was exposed whereas the diver was still in his diving gear, except for his helmet. The diver had his ears burned off and his nose burned off and so on but he was back in diving in three months whereas the young man will never dive or do much else. When the supervisor of the operation was asked, "Why did you let him do something like that?" he said, "There is nothing wrong with that, we do it all the time." At that point the person who asked the question turned around and laughed. There was no sense continuing the conversation. That is the type of extreme that chamber fires come from. That includes the US Navy but most of the chamber fires occur in the commercial diving industry.

One is working in a very dangerous environment in a chamber and to me it is essential to avoid taking known risks.

References

1. Trimble V. Th*e Uncertain Miracle*. New York: Doubleday and Company Inc, 1974.

2. Sands Bob. The Divetech recompression chamber. *SPUMS J* 1986; 16(4): 151-152.

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DIVING ACCIDENT MANAGEMENT

THE CATALINA CHAMBER AND ITS CLIENTELE

Andrew Pilmanis

The Chamber

Our chamber at Catalina[1] is a 7.3 m (24 foot) long, 2.7 m (9 foot) diameter, rectangular door, double lock, 7.8 ATA (100 psi) chamber. It was donated by the Lockheed Corporation. It was brought over by a tug boat company free of charge which was very nice of them. They lifted it off and placed it on the railway and said goodbye. The thing weighs 22 tons and we had a great deal of fun in installing it. Getting it into the building was interesting. It is large. There are pros and cons to large chambers. My original reason for getting the chamber was research and size is a big plus. One can put a great deal of equipment and people and so forth inside a large chamber. We have had four simultaneous patients, 3 or 4 tenders inside in comfort. Whereas in a 1.3 m (54 inch) chamber one simply could not do that. We also do a tremendous amount of training. When one can put 10 or 11 people inside the chamber it saves a great deal of time.

We have a fire suppression system, which many chambers do not. I am a firm believer in such a system. Once a year we have what we laughingly call a chamber party. One of the exercises we do is we pressurize 4 or 5 people down to 50 msw (165 feet) and let them have a water fight and use the fire system. It does several things. It clears the pipes of any rust, or anything of that nature. It builds confidence in the crew because they have used the system. It proves the system works. And at 6 ATA, narcosis level, having some fire hoses going is a lot of fun.

The negative side of a large chamber is that it is in need of a great deal of machinery, machinery meaning large compressors, high pressure gas and so on. Compressor maintenance, size of compressors and so on, that is where the expense and time is. Our chamber interlock is approximately 28,000 lt (1,000 cubic feet) and to pressurize to 6 ATA takes a lot of gas. We put all the plumbing for the chamber together ourselves. We did not contract it out as we did not have the money. Being a physiologist I did not know the first thing about plumbing. However after a year of plumbing the chamber, I think I can plumb any chamber anywhere. It can be done, I cannot say inexpensively, but certainly for a lot less than what manufacturers quote.

The patient and staff

We are isolated. There is no hospital on the island. We treat all the local diving accidents. We do no hyperbaric oxygen therapy (HBO), although we have treated about 8 people with carbon monoxide poisoning off boats where the individuals were cold at night, left their gas stove alight and closed all the windows. In the morning they were found unconscious. They were right next to us and we did treat them but routinely we only treat diving accidents. In that sense we are somewhat unusual as far as large chambers go.

We have no physician in residence on the island. The medical support comes from the University County Hospital Emergency Room. They have a very active training programme in emergency medicine and as part of that twice a year we give a one week diving medicine course and then those residents are put on call. When we treat a case, a resident and a nurse (we give diving medical courses to nurses in the same department) are flown over by the Sheriff's

Department helicopter. We are lucky that we have access to an excellent helicopter organisation and because of that some twenty odd miles across the channel really does not impact on us very much. Some of the helicopters can be over in 15 minutes. It is not the helicopter flight that is usually the delay. The delay is finding the physician, beeper or no beeper. Our paramedic base station often has a very difficult time locating the resident who is often moonlighting in some other emergency room and we have to run all over Los Angeles trying to find him. On the average a physician arrives at the chamber between an hour and a half or two hours after the call.

We operate in a labour intensive way with a crew of five, three outside and two inside. It is a manually operated chamber and we need the extra help outside.

The majority of cases probably 60 plus per cent, come from Catalina Island. It is the most dived area on the West Coast and is probably one of the most often dived areas in the world. In one three day weekend we counted 2,500 dives just at Catalina. This goes on year round, not just in the summer. We also get patients from the mainland, shore diving and the various channel islands, but the majority come from Catalina itself.

In the twelve and a half years we have been in operation the patient load increased fairly linearly until 1985. In 1985 two things happened. Two other chambers opened up in the general area, therefore the patient load was diffused somewhat. And for whatever reason there was a very low incidence of diving accidents. That was reversed itself and this year (1986) by the end of May we had already done more treatments than we did the whole year last year (1985).

We treat almost entirely sport divers, both for air embolism and decompression sickness. With air embolism many were under training. That is now in the past. In the last two years we have rarely seen an embolism from training, whereas 10 years ago that was the number one source. I think that the training agencies are gradually increasing the level of instruction.

We have treated abalone and sea urchin divers. They are probably very similar to Australian abalone divers. They work a 6 to 8 hour day under water. They make just enough to buy some beer and then they are back underwater. The industry has decreased radically over the last few years because there simply are no abalone left, so they have switched to sea urchin diving. They take the sea urchin roes, freeze them and send them to Japan. It is quite lucrative. Sea urchin divers work very shallow whereas abalone divers were working very deep. We treated one individual who that day had made 13 dives to between 39 and 42 m (130 to 140 feet). He did not see anything wrong with that. He did it, he had the bends, but that population has decreased so now we only see about two or three in the course of the year.

Few scientific divers needed treatment. In the 12 years we have treated maybe five scientific divers.

We have treated a few wreck divers, who are very enthusiastic and to them decompression is a tremendous nuisance. For some years they were working a First World War destroyer at 140 feet, pulling bronze portholes off and working very hard, never leaving enough air, or having any spare tanks, to decompress with. One fellow was treated three times in the chamber. Towards the end of the last treatment we said “OK, Pat that is it, either you give us a bronze porthole or we are not going to let you out of the chamber”. We had to give in, he refused to give us the bronze porthole. We finally let him out.

We do treat some commercial divers from the Los Angeles Harbour, these are usually one or two men operations which cannot afford a chamber. They clean ship bottoms and that sort of thing. We have only treated two offshore oil industry divers in 12 years because most of the companies have their own chamber. They take care of their own as they do not want anybody to know what it is that they are doing anyway. The two that we did treat came from a 54 m (180 foot) air dive. They had a chamber on the oil rig, both divers were bent and both refused to go into the chamber. They considered it unsafe. The interesting thing is the Diving Supervisor agreed with them. So they were brought to our chamber and we treated them. We have done, up to last weekend, 555 treatments. Of those about 40% were air embolism and 60% decompression sickness.

Air embolism cases generally have come from either charter boats or the beach with some from private boats. Decompression sickness used to come from abalone divers or other similar individuals and a great deal from private boats. Since then things have changed. The private and charter boats would be a much larger proportion now.

Beach diving produces air embolism and near drowning but almost never decompression sickness because one cannot get deep enough diving from the beach in southern California. There has been one interesting case where going through very large surf, an individual had an air embolism. He was using his regulator and apparently held his breath as the swell came through.

The majority of divers at Catalina can see the chamber location at the Marine Science Center. I would say at least 60 if not more per cent of the patients we get were diving in sight of the chamber. The seven miles to the west end of the island, with its offshore rocks, is the lee side of the island. It has beautiful visibility and it is a most popular spot. So the location of the chamber is ideal from that stand point. There are a few cases that come from a wreck at the other end of the island and a few from the other side.

There was an incident a couple of years ago, where four divers died in one dive to 36 m (120 feet). They went down, they all ran out of air and they all drowned. No cause other than nitrogen narcosis or perhaps they simply did not know what to do. They simply were not used to that kind of depth and they were not used to their single tanks running out so fast and when the tank ran dry they simply drowned. Southern California divers are used to 9-12 m (30-40 feet) diving and the shallowest you can dive from a boat at Catalina is 18 m (60 feet), but that is unusual. Most people end up diving to 36-39 m (120-130 feet) just going down the anchor line, some get down to 60 m (200 feet).

Diving Accident Management

Communication is one of the most important aspects and we have gone to great lengths in Southern California to establish communication with the diving community and with the emergency services. We have a pretty good system, there is one phone number to call and the whole system is put into operation.

The US Military Services and the US Coast Guard jointly operate what we refer to as rescue co-ordination centres in a variety of places around the United States. There is one in Hawaii, two on the West Coast and one the East Coast down to the Caribbean. They have tremendous communication and transportation capabilities and even in the remotest site if they can be reached they can do a lot. They know nothing about diving accidents, one has to instruct them specifically what is wanted. Interestingly enough the US Coast Guard is not at all educated in what to do with diving accidents.

We constantly re-educate the helicopter pilots and crews in our area about oxygen and all kinds of other things. They simply do not train their people at all. But these Rescue Coordination Centres have tremendous capabilities.

Transportation and pre-chamber care

Our standard policy and party line to all the community, both medical and diving, is oxygen first. One hundred per cent oxygen for both air embolism and decompression sickness. We are not necessarily trying to give oxygen, we are trying to exclude nitrogen and in order to do that one has to have true 100% oxygen. A leaking mask allows dilution with air so that nitrogen is not being excluded, which is why the local rescue organisation uses a demand valve to give oxygen to conscious patients. And for embolism only we use the head down on the side position. I have some misgivings about the head down position. Certainly I would never suggest a person be sat up but when we receive some of these patients who have been head down for about 2-3 hours, they have a hell of a time clearing their ears and their lungs are congested. So we generally recommend one hour head down and then put them level but never head up. I would like to see some better basic research done on this whole aspect as we are functioning on very weak information. However the diving community as a whole, after 10 years of effort has finally been educated and head down is standard practice. I would be very hesitant of changing it now. I think we would create chaos.

The main reason that we do put a patient head down on his side is not for buoyancy or bubbles. It has to do with the much more practical matter of vomiting. Most of these patients will end up vomiting. If they do not have their head to one side or the other they are going to inhale vomit and have more problems and that is the main reason we utilise this position. It is very difficult to maintain incidentally and it is one of the problems in transport.

Rescue boats

The Baywatch is a rescue vessel that is based about a mile from the chamber. It is operated by the County of Los Angeles Life Guards. They operate very closely with the US Coast Guard. The Coast Guard generally operates more offshore and Baywatch takes care of the in-shore emergencies. They respond to all kinds of emergencies, including fires and boats sinking. They tow boats, they do the standard sort of thing that you would find in any boating community. They also recover people or bodies from aircraft.

Surprisingly there are a lot of aircraft going down in the waters around Catalina. It is a favourite place for weekend private pilots to fly about 3 feet off the water and sometimes they misjudge and take a tumble.

The Baywatch operates with a crew of two paramedics. They have all the standard paramedic gear on board. The individuals we have stationed at Catalina have had about 10 or 12 years experience with diving accidents. In some cases they have transferred patients to the chamber within about 5 minutes of them surfacing.

A recent paper on Baywatch statistics on pre-chamber care[2] is of interest. This was a series of 58 severe air embolism patients, all except one using scuba. Fifty five were sport divers and three were commercial abalone, sea urchin divers. Fifteen of the sport divers were in their training checkout dive, there was a wide range of symptoms from alert and oriented with neurological deficits to a few coma and full cardiac arrests. All symptoms occurred in these 58 cases upon surfacing or very shortly after surfacing. The mean arrival time of Baywatch to the dive site was 18 minutes (range 2-55 minutes), so they had very good care within that time frame. The mean transfer to the chamber was 31 minutes. They were all treated with oxygen and head down on the side. They used a demand valve for the conscious patient and a ventilation mask for the unconscious. Thirty-one patients were started on Ringers lactate. Thirty four of the 58 improved during transport, 20 patients remained the same and four deteriorated. Out of the 21 patients picked up unconscious, 12 regained consciousness before the arrival at the chamber. Thirteen patients were in full arrest and were given cardio pulmonary resuscitation, nine of the 13 regained vital signs before arrival at the chamber. Four remained in full arrest at the chamber.

Helicopters and aircraft

There are tremendous problems, especially with heavy weather conditions, in lifting patients having CPR up to the helicopter. They do accomplish this by using a basket with the person doing CPR straddling the patient and continuing it into the helicopter. It is a rather hairy situation, particularly when the basket starts spinning. Sometimes the person doing CPR wonders if he is going to make it, but they try very hard not to interrupt the CPR.

The Sheriff's Department has an airforce of its own and they often transport our physician and nurses and the patient. We also get the Marine Corps and the Navy involved at times.

They have search and rescue missions and they will go out to some of the other islands and even on occasions bring their own people in.

The Navy is not supposed to dive without a chamber on site. Yet about three times a year we get a call which goes something like this, "Are you on line?" ... "Yes, we are on line." "This is ... we are doing diving operations at such and such." "Did you say the US Navy?" "Yes, that is correct sir." "Well don't you have a chamber on board?" "No sir, can we use yours?" .... "Well yes of course!" I do not think regulations are always followed, in any event they do transport some of their own people.

In Los Angeles we have the Life Flight organizations, three companies competing for business. These have wonderful machines, they are quick with just about everything and they have emergency room personnel flying with them and they can do a tremendous amount. They have a 15 minute response time to the island from Long Beach, very nice. Somewhat expensive but in all our critical cases we transport in the Life Flight helicopters rather than the Coast Guard or Sheriff's Department. The Sheriff's Department would rather arrest the patient than treat him and that is not pleasant in some cases.

We work with the Coast Guard as closely as we can. It helps us, it helps them. They come out to all our courses and demonstrate their talents and we try to educate them on diving accidents in turn.

Air embolism

A few comments and a few statistics about our experience of air embolism.

Recently at a boy scout camp on the island, the instructors decided that it would be tremendous experience for the boy scouts to see marine life under water. They found an old diving helmet and placed it about 15 feet underwater and pumped air through it. They had the boy scouts swim down, put their head up inside the helmet and look around and have a good time and then take a breath and come back to the surface. Without getting unduly excited we convinced them to discontinue the practice, they were totally ignorant of what the consequences might be. That type of problem does occur. I will not say frequently but it does occur. One of the saddest cases was a 10 year old boy whose parents for his birthday put a scuba tank at the bottom of their swimming pool and had the kid swim down, breath from it and then surface. The birthday boy came up with a classical air embolism. They went to a succession of five emergency rooms and nowhere was it diagnosed or treated. To this day he is in a wheel chair with severe brain damage.

Currently the primary cause of air embolism in Southern California is running out of air. It used to be training, or lack of it. Now what is happening is people run out of air and then they have to do something. It is what they do that causes the air embolism, but the ultimate cause is running out of air. That is why I emphasise to all training agencies, over and over again, that these casualties can be avoided if they train their people to watch their pressure (contents) gauge. Some make ascents and do not make it, some try buddy breathing. Of course they have not done it since their training course. They do not know what to do. They hold their breath while the other person is breathing from the regulator, and both are ascending. This is the sort of air embolism that we see now. The other sort is inexplicable, that is everybody swears that the diver did everything right. One cannot find a cause, whether it is cysts in the lungs, whether it is something that he did that nobody saw. We had one of these last weekend in someone who obviously dives a tremendous amount, who had been looked over thoroughly medically yet during a very mild and simple dive suffered a severe air embolism.

In my mind the primary reason for buddy diving is if someone comes up with an air embolism and the buddy is not there they drown, that is the end of the story. This happens on a regular basis in Southern California because the death is not air embolism, it is drowning. The worse cases are the near drowning and air embolism combination. They are very difficult to manage. There are many reasons for buddy diving, I suppose, but there is nothing more important in my mind. We have had two cases where an individual came to the surface. Nobody was there. He became unconscious, sank down to about 9 m (30 feet). Somebody came along, saw him, and brought him to the surface. The underwater time was judged anywhere from 5 to 10 minutes. The rescuers did CPR, the patient had spontaneous respiration in about 2 or 3 breaths but were unresponsive. With aggressive treatment both individuals survived. That is a long time underwater. The San Diego chamber has three out of three such cases survive with no residual problems. The lesson there is not to give up.

Over approximately the last eight years we have had a series of assumed air embolism cases which by the time they arrived at the chamber have been having CPR anywhere from a half hour to two and a half hours, one might say, “Why bother to treat them?” We all know the medico-legal problems in the United States and there is the additional problem that the information one gets when one receives such patients is not always very reliable. Ask the helicopter pilot how long has this been going on and he says, “Hell, I don’t know. I just fly the aircraft.” One tries to contact the boat but they cannot be contacted. One cannot ask the patient, so one does not really know what has happened. As a result, with what we call “heroic efforts” we do pressurize to 50 msw (165 feet). If there is no response within a half hour then they are pronounced dead. Then we have to decompress our tenders. Out of about 30 such cases, not one has survived or even had any indication of life. I would like to terminate this procedure, however our medical supervisors are very reluctant to do so. The reason I would like to terminate it is that we are putting our tenders at risk and we go through some elaborate decompression for them afterwards.

Incidentally, I think the only autopsy done under pressure in a recompression chamber was done at Catalina. Los Angeles has a coroner who when informed that we had a dead diver in the chamber said, “Hold him there. I’m going to do a post mortem in the chamber under pressure.” He did not want the artificial bubbling that occurs on decompression. I said “We can’t very well hold it there. Our tenders are inside and I know you don’t care about them because they are living, but I do, one of them happens to be my wife. You can get out there as fast as you like and go in and do it, but I’m going to start recompression.” He flew out at night in the Sheriff’s helicopter and went inside, did a post mortem and that determined it was a heart attack, not an air embolism that killed the diver.

Most people with air embolism survive if you can get to them. There is a myth that goes around that if you get an air embolism you are dead. It is just not correct and I keep trying to emphasise that.

There is improvement during transport in a very high percentage. Often there is no deterioration with proper care, and many are asymptomatic when they arrive. There is a classic situation of a person unconscious from air embolism, who wakes up and on examination appears to be totally normal and is sent home. In our experience at that point the trouble starts. I cannot say how many relapses occur because we get a selected population, but we have seen quite a few. We try to educate people, especially those in emergency rooms and life guards and so on, that if someone is suspected of having air embolism they should not be sent home, they should still be sent to the chamber even though they appear to be perfectly normal. To get this message across is very difficult.

I am very happy to see research being done on air embolism. When I first got into this business I asked about air embolism and was told, “Well it’s due to holding your breath as you ascend and you rupture your lungs and you die and that’s it.” Des Gorman’s lecture last night was the first time, other than Hallenbeck’s articles in the last few years, that somebody is doing something about finding out exactly what is going on. It is necessary because patients do not fit the picture that is in the text books or in the training manual. For example, I have never seen frothy breath, or bleeding at the mouth and nose in air embolism, yet every text book has that and it is said to be the primary thing to look for. We have been on the radio and the boat skipper argues with us and says, “Yeah, but he does not have frothy red bleeding at the mouth and nose therefore he cannot be an air embolism.” That is a very unfortunate situation. I do not know the source of this misinformation, possibly it was the US Navy, but I have never seen it with a patient.

Again I would agree that it is very strange that one does not get pneumothorax and mediastinal or subcutaneous emphysema with air embolism or even two of the three together. It doesn’t make sense, there is something more to it than the standard explanation. I do not know what is happening. We have had only three or four embolisms who also had a pneumo-thorax and we have had maybe two air embolisms that also had subcutaneous or mediastinal emphysema, that is all.

It has been suggested that perhaps the explanation is the effect of a small volume of air in the cerebral circulation is much more noticeable than the same 5 ml of air in the mediastinum or in the pleural cavity. That could be true, but we do actively look and try to find air in the mediastinum and pleura and yet do not demonstrate it.

Very often by the time they arrive at the chamber they only have headache and chest pains. We go by their history extensively and diagnose air embolism that is asymptomatic if the history is strong enough in an air embolism direction. But very often headache and chest pain are the only things present and I would suggest that that is something to look for. Nausea and dizziness are also quite often present, and many more types of things occur. We have had a number of seizures and the immediate reaction in the chamber during treatment is to blame oxygen toxicity. We have had three patients fit in the chamber during treatment. All three occurred at 9 msw (30 feet) not 18 msw (60 feet) and I believe all three were due to air embolism not oxygen.

Decompression sickness

What causes can I point to in Southern California in cases of decompression sickness? One of the causes is very simple, tables are not used. Not which tables or any of that, they simply are not used in the majority of our patients. They simply ignore decompression procedures. There is no magic special reason. It is a very straight forward reason. Why are they not used? The majority do not know how to use them. Those that do will give you answers like, “Well it is just too much trouble”, or “I don’t think it’s important.” And that is the cause in the majority of our cases. Twenty eight per cent of our cases are directly due to exclusive reliance on the SOS decompression meter. In the last two years we have not had a single case because of these, I think they are on the way out and I am not very happy about that. They are very dangerous gadgets as far as I am concerned. In many cases the watch and depth gauge are not used. Many divers wear them but do not use them. We have a very difficult time extracting dive profile information from the patients.

Delay in seeking treatment is a disturbing feature of sports diving cases. Our average delay on bends cases is over 24 hours and yet they do well. We have had a three week old case that we treated successfully.

Question

Unknown speaker

Where I come from the sports divers use tables and the abalone divers do not, yet they do not seem to get bent. What is your experience and what is your explanation.

Dr A Pilmanis

We have had many, many hours of discussion along these lines. I think first of all you have to question what a particular diver means when he says he does not get bent. How do you know he does not? Have you done a neurological examination on him? I have sat for hours with abalone divers and have been told, “I’m fine, I’m fine,” and suddenly three minutes later he says, “Hey, that pain just cleared up.” My response is, “What pain, you said you were fine.” We put people in a chamber who say they are asymptomatic and they tell us, “Oh boy does that feel better.” The pain has gone, this is resolved and that is dissolved. Human nature dictates that in certain situations people deny. That is number one comment.

I am sorry, I will not accept that statement without further elaboration. I do not believe that abalone divers' physiology is different from sports diving physiology, nor from Navy divers' physiology nor from commercial divers' physiology. The laws of physics apply to all. I question the basic premise. I certainly accept there are certain individuals that are "more susceptible to the bends", or less susceptible. There is a distribution curve people are on, certainly. But one cannot define that curve individually. One cannot pick out one individual and say you are here on the curve. It is almost an impossible thing to do. I am not answering your question basically because I cannot accept the question or the premise.

Financial problems

We make no money from the use of the chamber. The patients usually do not pay. The collection rate is almost non-existent and as a result it is a publicly supported facility. Most other chambers that depend on diving accidents are either closing or are somehow supported publicly. They cannot exist on the income from divers. Divers will not pay their bills in the United States. Most of them have insurance and still will not pay.

However our chamber operation has never been successfully sued. I said successfully, that is nobody has collected a thing. There have been six law suits during our 12 years that the patient or relatives initiated. In all six cases they named everybody in the world except our chamber. We feel grateful, we thank them profusely, but I do not know how much they collected. This is a constant threat, the number one reason why our chamber will probably, or could possibly, close is because of insurance rates. The University insurance went up from $200,000 last to $2.5 million this year. Rates like that mean you can't operate.

SUMMARY

I feel in diving accident management the easiest part is after you get to the chamber, the hardest part is getting patients to a chamber adequately and I think communications and transportation are the key. I would put a patient on true 100% oxygen, in order to exclude nitrogen, and transport him on his side, also head down for suspected air embolism cases, as soon as possible as close to sea level pressure as possible.

REFERENCES

1. Pilmanis A. University of Southern California Marine Science Center. SPUMS J 1986; 16(4): 134-140.

2. Stonier JC. A study of pre-chamber treatment of cerebral air embolism patients by a first provider at Santa Catalina Island. *Undersea Biomed Res* 1985; 12 (Supplement to No. 1): 58.

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DECOMPRESSION TABLES AND DIVE COMPUTERS

Andrew Pilmanis

Decompression Tables

I firmly believe that the Standard US Navy Tables when used to the limit cause bubbling in the body in 100% of the population. This has been shown by Doppler studies, years of them. So what do you do? What we have done in our own facility and are encouraging around Southern California and Canada is to switch to other tables.

A few years ago we did a Doppler study of USN no-stop dives. With a dive to 30 m (100 feet) for 25 minutes (USN maximum no-stop time) the numbers of bubbles decreased over a period of three hours. A similar curve can be generated by just about any of the tables. In four years we ran hundreds of dives and many divers. These are typical graphs. So that is one of the reasons I make that statement.

You may ask the question, "How far off are these tables?" If one takes a dive to 100 feet for 25 minutes, which is right on the limit and use a 60 ft a minute rate of ascent, using exact depths, exact times and exact ascent rate one hears bubbles in all the divers. The divers are normally symptom free but bubbling. If one takes the same individuals, does the same dive and except for adding two minutes of decompression at 3 m (10 feet) in the hyperbaric chamber the bubble count drops dramatically. One can add one minute at 6 m (20 feet) and four at 3 m (10 feet), in other words arbitrary hanging off, and eliminate bubbles. This tells you that the US Navy when they wrote the tables on an end point of symptoms were not far off. They did not have a Doppler. One does not have to back up too far and the diver is out of the bubble zone. That is why I say that the US Navy Tables should not be used to the limit.

I have been asked how long ago did we, in the United States, begin questioning the US Navy Standard Air Decompression Tables and following other procedures. At present probably the majority of the diving population in the United States still follow them. I happen to be more in the scientific diving arena which tends to be a little bit ahead of the recreational community and we have questioned and used alternative methods for at least 10 years. There are several other institutions who have done likewise. In the beginning all we did was use the 5 minute rule, subtract 5 minutes from all no-stop times. That is a rather arbitrary, simplistic approach but it is a warning to the divers. One can increase surface intervals. One can use the next greater depth in the table. One can do a variety of things. We have required for at least 10 years, if not longer than that, that one of those procedures be done. In other words in our programme one cannot dive to the limit of the US Navy Tables.

Last year we switched to the University of Michigan decompression tables developed by Carl Huggins. They provide no-decompression limits and repetitive capability. They do not provide stage decompression tables. The reason is that they are directed at sports diving and decompression diving is not supposed to be part of sports diving. The reason I like these tables is they are based on an end point of no bubbles rather than no symptoms. They are not just more conservative, but they are based on a somewhat different model from the US Navy tables. Our Diving Control Board now makes it mandatory that all divers in our programme use those tables. It is absolutely forbidden to use USN tables. I know of three University programmes that have this rule.

The Edge dive computer

Then we have the Edge. It gives nodecompression limits at various depths. As one goes down the pressure transducer is activated and the clock is activated and it provides all the information you need on the dive. It is a real decompression computer. I do not own part of the company and I am not advertising for them, I like the Edge because I know the model is programmed into it is based on an endpoint of no bubbles rather than no symptoms, it has 12 half time tissues rather than six, therefore shallow, long dives are covered better. It is a good model. The instrument itself is like all gadgets, it can fail if you do not take care of it. On this trip I did not put a new battery into it. It told me I was negligent in taking care of it and refused to provide me with any information! You must put batteries in it and you must turn it on. But it is relatively idiot proof in that there is only one control. It recalculates the dive profile every two seconds, so multi-level diving is covered. The National Park Service in California has used it for three years exclusively for a tremendous number of dives. They have had no bends and they have increased their average daily bottom time by an hour and a half because it follows the diver wherever he goes. One does not have to take the deepest depth as one does with tables. It calculates the diver's decompression. I think this is the way to go in the future. I think tables are archaic and eventually will be used for a back-up only. The US Navy has decided to build its own dive computer because obviously they can do it better than civilians. They have made the decision that within 5 to 10 years every diver will be wearing a dive computer rather than using tables. Frankly, I am happy to see it go that way. Depth gauges are incredibly inaccurate and the divers do not always look at their watches. The Edge does it all for them.

Dr AA Pilmanis' address is University of Southern California, Catalina Marine Science Centre, PO Box 398, Avalon, California, 90704, USA.

LETTERS TO EDITOR

LETTERS TO THE EDITOR

Hyperbaric Medicine Unit
Dept. Anaesthesia and Intensive Care Royal
Adelaide Hospital
North Terrace
ADELAIDE SA 5000

5th May 1987

Sir

I would be grateful if you would bring to the attention of your members the availability of positions on the Underwater and Hyperbaric Medicine Courses that will be conducted by this Hospital in September 1987.

Royal Adelaide Hospital offers these courses because these subjects are not included in most undergraduate medical curricula. Also, there has been a dramatic increase in Australians and New Zealanders taking up recreational diving, and consequently an increase in diving accidents of all types. Similarly, the frequency of those life threatening medical conditions for which hyperbaric therapy is the definitive treatment such as carbon monoxide intoxication, have increased significantly.

The course details are:

1. **Basic Course in Underwater Medicine: 14-18 September 1987**

   Aim:

   To enable medical practitioners to determine the fitness of candidates for diving.

   To introduce medical practitioners to the types of diving accidents.

   Duration: 5 days

   Course:

   Lectures, evolving clinical problems practical work.

   Location: Hyperbaric Medicine Unit, Royal Adelaide Hospital.

   Cost: $250

2. **Advanced Course in Underwater and Hyperbaric Medicine: 21-25 September 1987**

   Aim:

   To enable medical practitioners to recognise and initiate treatment for diving accidents, and those medical conditions for which hyperbaric therapy is life-saving.

   Duration: 5 days

   Course:

   Lectures, evolving medical problems practical work.

   Location: Hyperbaric Medicine Unit, Royal Adelaide Hospital.

   Cost: $250.

   The courses are conducted six-monthly.

Anyone interested in these courses should write to me directly, and I will forward further information.

Yours sincerely
DF Gorman BSc MB CHB FACOM
Director, Hyperbaric Medicine Unit

Phone (08) 224-5116

School of Applied Science
Gippsland Institute of Advanced Education
Switchback Road
CHURCHILL VIC

6 May 1987

Sir

The Provisional Report on Australian Diving Related Fatalities *(SPUMS Journal* Vol 17, 1987) again makes fascinating if somewhat depressing reading for a long-time diving instructor and hopefully newer instructors alike. I feel compelled to comment on one aspect in particular.

The buddy system appears to have been reduced to a status of little importance in both Dr Walker's discussion of the fatalities and in the behaviour of divers and dive-leader/instructor referred to in these analysis. While not claiming that adherence to a rigid buddy system would have saved the lives involved, I feel certain that it would have significantly reduced the overall probability of the fatal outcome. Lip-service to the buddy system or the often joked about "two divers in the same ocean" is not enough. The buddy system consists of two divers, and only two divers, allocated before the dive and remaining together for the duration of the dive. It does not cover three divers, or, of more concern in these analyses of 1985 fatalities, the loose allocation of buddies with the understanding that, "... as soon as anyone's gauge showed 50 mPa they and whoever had next lowest remaining air would be ordered to ascent, the buddy groups being reallocated" (SC 85/6). It does not including sending divers back to the surface alone or the descent of one buddy alone whilst the other buddy "had no reason to watch his descent as he was then completing his own preparations to follow" (SC 85/9).

These situations all mean that there is no true dedication to a single buddy since pairing may vary during the dive or indeed that there maybe periods of diving without a buddy at all. The price is obvious.

The dependence no a divemaster/instructor only exacerbates the situation since the dependent divers rely on the divemaster/instructor's decisions underwater and less on their own judgement and their own buddy system. This is necessary during training but requires rapid weaning toward the end of the course. If the students are not fully competent they should not be certified. Competency includes training in the buddy system; not as a member of a loose group with ill defined responsibilities. Although open to interpretation the buddy system involves at least the following components:

* A joint decision as to the suitability of diving in the prevailing conditions (includes mental and physical status of the divers).

* A joint decision on dive plan.

* Assistance in gearing up.

* Complete buddy check of all items of equipment
  - Tank fully on
  - Tank full
  - Regulator function
  - Belts, amount of weight, quick releases
  - Mask
  - BC function and use (including check for leaks)

* Joint descent

* Constant monitoring of buddy during the dive (air consumption behaviour)

* Actively avoiding separation.

A further factor relevant to the fatalities in question is the need to plan a sensible air cut off point; making due allowance for depth, 'the red zone' is not always sufficient air in reserve. There is no excuse for running out of air underwater.

I have not gone into individual analyses of the fatalities but an interested reader by referring to the provisional Report on Fatalities will see the relevance of these comments to the individual cases.

Yours sincerely
Peter RL Mosse
FAUI Instructor 347

EDITOR

In fairness to the author of the Provisional Report it should be noted that as the Case Resumes, the Significant Factors, and the Table all noted the occurrence of SEPARATION in the eleven cases in which it occurred, it was assumed that readers would identify this factor for themselves. For this reason the Discussion listed the somewhat less obvious factors "whose significance deserves fresh consideration". It was indeed remiss to make such an assumption and the author apologises.

RADIAL KERATOTOMY THE DIVER'S DILEMMA

PO Box 6052
St Kilda Road Central VIC 3004

Dear Sir

I would like to relate my experience concerning radial keratotomy in the hope that one or more members of SPUMS may be able to cast some light upon the subject and its ramifications for divers.

I recently had an appointment with Dr X a specialist in radial keratotomy. He advised that I should abstain from diving for six months after the procedure. As diving is my principal sport and recreation I suggested that this period of "drying out" could be a problem. Dr X then suggested "you could probably squeeze it down to four months".

At this stage I began to worry about the arbitrary nature of these time frames and the basis from which they had been deduced.

I sought advice from Dr Y a diving medical expert of very high repute. Dr Y suggested that any diving activity should be prohibited for at least 12 months after radial keratotomy. He drew the analogy of a window pane with cuts 75% through its thickness trying to withstand hurricane force winds.

I got back to Dr Y and explained Dr Y's opinion. Dr X , who does not specialist in diving medicine assures me that six months would be more than adequate.

Now I am confused. Is it four or twelve months and who actually knows ? Why not 2 years or even 5 years ?

I am in a dilemma. The reason I want my eyes "fixed" is for diving but to get them "fixed" I must give up diving albeit for four to twelve months.

My question is simply this. Has any research been done on the effects of radial keratotomy on divers and if so, what are the results ?

Yours faithfully

L Griffiths
Associate Member

This letter has been shown to Dr Y whose comments appear below.

As yet I have not read any published work dealing with the effects of radial keratotomy on divers. So my advice was based on the knowledge that radial keratotomy is normally restricted to those with mild myopia and that there have been corneal complications in patients in the USA. Under these circumstances I would not have the operation. Lenses in one's mask are much cheaper than the operation of radial keratotomy and are not associated with any ocular complications. Of course when someone has dropped a weight belt or a tank on your mask you can not see clearly using a borrowed mask. But care will prevent such accidents.

REPORT/DISCUSSION PAPER 1987-1

COMMENTS ON DECOMPRESSION SICKNESS IN WESTERN AUSTRALIA IN 1986

Douglas Walker

SUMMARY

There was a significant increase in the number of divers who attended at HMAS Stirling for recompression treatment during 1986 (20) and this increase has accelerated during 1987 (33 cases in the first 5 months). The information available concerning the divers treated during 1986 is reviewed to discover whether there are any identifiable reasons for this increase or identifiable remediable factors. It is suggested that the increase may be more apparent than real and represent a greater awareness among the at-risk diving community of the availability of the upgraded RCC facilities now available at HMAS STIRLING, this making visible a previously hidden frequency of decompression sickness. The length of delay before seeking medical assistance makes this probable.

CASE 1

This trained and very experienced diver had made a series of six dives to 30 metres for 20 minutes between 27th December and 6th January including a stop at 3m for 5 minutes in each ascent. He presented on 8th January. This knee had been injured in 1975. The knee was noted to have restricted movement. He had also made a dive to 6m for 50 minutes on 19th January but it was not stated whether this had effected his symptoms. He was treated on RN Table 62 plus IV fluids and dexamethasone and complete resolution of his symptoms was achieved. No additional details of these diver is known.

CASE 2

This trained and apparently experienced diver had made repeat dives on three consecutive days, an intermittent "pins and needles" sensation over his back, chest, and arms commencing after his last dive on 11th January. This became more severe and regular as the days passed until it was occurring ever 15-20 minutes. There were no other pains. He had some time in the past suffered an injury of his left shoulder and periodically experienced pain in this shoulder after repetitive and deep dives. There were no significant clinical finding. A diagnosis of neurological DCS was made and he was treated with IV fluids, dexamethasone (16 mgm then 8 mg tids),

DIVERS RECOMPRESSED AT HMAS STIRLING IN 1986

CASE	MONTH	AGE	TRAINED	EXPERIENCE	DIVE PURPOSE	DIVE TABLE	MAX DEPTH	DIVE PROFILE (that day)
1	January	39	Yes	30 years	Recreation	Royal Navy	30 m	30m x 20 min. stop 3m, 5 min.
2	February	26	Yes	20 years	Not stated	DCM	17 m	14m x 40 min. stop 10m, 10 min 1 hr then 17m x 35 min stop 7m, 5 min
3	November December	26	No "on job" learning	1 year	Pearl diving Hookah	Not stated	40 m	x 5 - x 6 daily last dive to 30-40m, 35 min.
4	February	33	Yes	13 years	Recreation	BSAC	20 m	20m x 35 min. Surface 2 hr 18m x 29 min. DC 10m, 5m, 5 min.
5	March	33	Yes 3-4 years	Experienced	Recreation	Not stated	14 m	12-14m x 4 min. Ascent normal.
6	March	33	No	Not stated	Crayfish Hookah	Nil	21 m	approximately 6m x 20 min x 1; 21m x 60 min x 2.
7	April	46	No	Experienced	Recreation	Nil	21 m	21 m x 50 min. 1 hour later 21 m x 55 min no decomp. stops.
8	April	31	Yes	15 years	Recreation	PADI	43 m	40m x 20 min. Stop 3m, 7 min
9	July	43	No	Not stated	Spearfishing: Hookah	Nil	15 m	15 m x 30 min. 15 min surface 15m x 45 min time estimate use of petrol by compressor!

(Based on available information)

PREVIOUS DIVING	SYMPTOMS ONSET DELAY	TREATMENT DAILY	DCS TYPE	TREATMENT/RESULT PREVIOUS HISTORY
5 days similar dives	Right knee pains 11 days	Further 2 weeks	1	Table 62 + IV etc. Symptom free. Right knee injury, 1975.
Day 1 3 x 14m 40 min Day 2 5 x 35-40m 14 min.	Paraesthesia trunk, arms increasing severity 3 weeks	3 weeks	2	Table 62 + IV and dexamethasone symptoms cleared. Right shoulder injured in past: painful after deep dives.
2 month x 6/day diving	Right knee pain paraes-thesia weak right leg 2 months	2 months	2	Table 62 + IV and dexamethasone + Table 61 x 3 + Oxygen soaks x 2 PH in-water treatment.
—	Right shoulder, neck pain, paraesthesia lower limb 36 hours later	5 days	2	Table 62 extended. IV, dexamethasone. Previous DCS had left paraesthesia left thigh
—	Sudden weakness, disorientated 2 min after surfaced	1 hour	AE	Oxygen at 18 metres. Table 62 extended. Minor residual impaired balance.
—	Sight blurred end last dive. Right shoulder pain; weak, numb left arm	few hours	2	Oxygen in plane. Table 62 in Recompression Chamber. Symptom free.
—	Right shoulder pain 1 hour post dive. Later impaired cerebration.	2 days	1	Table 62 + IV etc. “Usually fatigue, thirst and poor concentration post dive”.
	Right shoulder pain 10 min post dive, worse. Upper arm neck paraesthesia.	8 hours	1	Table 62 extended. IV, dexamethasone then Table 61. Also strain arm.
	Chest tight, both arms numb 5 min. after surfaced, then legs weak and numb and urine retention.	7 hours	2	Flown: Oxygen, IV, head down. Table 62 extended then oxygen soaks. Nil response: history laminectomy 6 years previously.

CASE	MONTH	AGE	TRAINED	EXPERIENCE	DIVE PURPOSES	DIVE TABLE	MAX DEPTH	DIVE PROFILE (that day)
10	July	41	Yes	10 years	Recreation	PADI	15 m	15m x 45 min; 55 min surface; 19m x 45 min.
11	August	37	Yes	2 years	Recreation	Not stated	30 m	24m x 20 min; 30m x 15 min; stop 5m x 5 min; 21 m x 30 min; stop 5m x 4 min.
12	September	22	Yes	6 months	Pearl diving Hookah	Not stated	36 m	4 dives today. 30m x 30 min x 2; 36m x 30 min x 2. Oxygen stops.
13	September	31	No	Not stated	Pearl diving Hookah	Not stated	41 m	5 x 38-41m but made x 2 further dive trips.
14	November	-	Not stated	Not stated	Seashell collect. Hookah	Not stated	40 m	40m x 35 min stops 10m, 5 min; 6m 5 min; and 3m for 20 min.
15	November	26	No	Not stated	Pearl diving Hookah	Not stated	14 m	8m x 60 min; 9m x 180 min; 14m x 75 min; 14m x 45 min.
16	November	21	Not stated	Not stated	Pearl diving Hookah	Not stated	14 m	9-14m,5 dives in 6 hours; dive times not reported.
17	December	17	Yes	Inexperienced 6 months	Recreation	Not stated	15 m	15m x 30 min; 2 hours surface; 12m x 50 m in.

PREVIOUS DIVING	SYMPTOMS ONSET DELAY	TREATMENT DAILY	DCS TYPE	TREATMENT/RESULT PREVIOUS HISTORY
-	That night "full" head, later ache. Flew home: continued malaise, headache.	17 hours	2	Table 62 reduced headache. Oxygen soak next day. "Much improved".
10 day many repeat dives	Left elbow pain in evening; balance disturbed; flew back home 3 days later, developed paraesthesia left hand.	ENT 4 days	2	Table 62. Oxygen soak next day. Residual balance impairment. Cause uncertain.
7 day series 10/day	Right shoulder pain 1 hour post 4th dive: worse when drove over hills and other symptoms.	9 day	1	Table 62. Oxygen soak 3 days later as 2? recurrence. History in-water 02 x 4 past 6 months.
x 10/day 15-23m; 40-70 minutes	Left shoulder pain persisted, much less when dived.	> 1 month 10 days after last dive.	1	Table 62. Stated had total cure.
Not stated	Hanging by left arm decompression stops, then mowed lawn. Pain left biceps 11 hours post dive which increased.	1 day	1	able 62 extended + IV, Decadron Clinical cure.
Not stated	Right knee pain 1 hour after last dive; worsened. 3 days later dizziness, general weakness, collapsed. Relief knee pain with 0_2.	3 days	1	Table 62 extended + IV, Decadron + Oxygen soak. Claimed injured right knee day prior to symptoms.
Not stated	Not stated. symptoms/onset in-water treatment 3 days later: day 4 after table tennis swollen elbow so x 2 in-water: 20m, 35m.	9 days	1	Table 62. No relief, to hospital.
Not stated	5 mins after end 2nd dive left elbow pain, fatigue, thirst, light headed.	a few hours	1	Table 62 + IV etc. Good relief but chest discomfort 1 day further.

CASE	MONTH	AGE	TRAINED	EXPERIENCE	DIVE PURPOSES	DIVE TABLE	MAX DEPTH	DIVE PROFILE (that day)
18	December	25	Yes	Not stated	Recreation	Not stated	18 m	18m x 30 min; 5 min surface; 18m x 20 min.
19	December	40	No	Not stated	Recreation	Not stated	14 m	14m x 45 min; 90 sec surface; 14m x 80 min stop 3m, 10+ min.
20	December	24	Yes Inexperienced	11 months	Recreation	Not stated	25 m	25m x 30 min stops 6m, 2 min and 3m, 5 min

and the RN Table 62 protocol. There was a complete resolution of symptoms but the "pins and needles" recurred three times that evening so RN Table 61 was given the next day, and this producing a permanent clearing of symptoms. His dive profile was

Day 1 3 dives - 40 min at 14m 1 hr between dives

Day 2 5 dives-14 min at 35-40m 1 hr between dives

Day 3 2 dives - 14 min at 14m with DC stop 10 min at 10m, 1 hour surface interval before 2nd dive, 35 min at 17m with DC stop 5 min at 7m

CASE 3

This man presented with a two month history of a painful right knee, weakness, and "pins and needles". His dive pattern was of making 5-6 dives to 30-40 metres daily in late November and early December. During the November dives he suffered bilateral knee pains and these responded to recompression in the sea. His last deep dive was 8th December and since that time he had developed increasing pain in his right knee, a sensation of "pins and needles" over this knee, and a marked weakness of both extensors and flexors of knee and ankle. These symptoms were reduced after treatment by Table 61 and oxygen soaks but there was residual knee pain about 50 per cent of the presenting severity and both the flexors and extensors of his knee remained weak. It is probable he had suffered a spinal bend affecting both motor and sensory pathways and he was advised to attend for follow-up. He had been pearl diving for a year, his diving instruction being "on the job" and informal. His symptoms appeared after his last deep dive on 8th December but he did not attend for treatment until 7th February. His activities in the intervening period are not known.

CASE 4

This diver experienced a 36 hour delay before the onset of pain in his right shoulder, neck pain, and prickling in his left foot, calf, and right pectoral region. There was also paraesthesia of his left thigh, the result of a previous DCS incident. He had made two dives, the first to 20m for 35 minutes with a no-stop ascent, followed after a 2 hour break by a second dive, this to 18m for 29 minutes. He made 5 minute stops at 10m and 5m after this dive. An extended RN Table 62, Hartmanns solution IV, and dexamethasone 16 mg followed by 8 mg tid, was successful in clearing all symptoms, some intermittent stabbing back pains resolving spontaneously.

CASE 5

This experienced diver made an apparently normal ascent but suddenly developed a generalised weakness, disorientation, and decreased consciousness with numbness of his arms and legs

PREVIOUS DIVING	SYMPTOMS ONSET DELAY	TREATMENT DAILY	DCS TYPE	TREATMENT/RESULT PREVIOUS HISTORY
Not stated	2 hours post dive left shoulder pain which worsened.	a few hours	2	Table 62 extended and IV, Decadron complete relief.
Not stated	Abdominal pains and bad chest pains when surfaced, then lost power in both legs so in-water oxygen.	1 day	2	IV, Decadron, 0_2 during transfer Table 62 extended, later 0_2 soaks slight residual.
Not stated	Next morning right shoulder pain. Flew home - got right elbow, shoulder pains, headache.	3 days	1	Table 62, IV and Decadron: relief but recurrences so 0_2 soaks x 2.

2 minutes after surfacing. By the time he reached HMAS STIRLING, about one hour later, he was semiconscious, with weakness and paraesthesia of all limbs, responding partially to commands and questions, speech slurred, and complaining of the numbness of his limbs. He was taken directly to the recompression chamber in a head-down position and compressed to 18m on oxygen. There was marked improvement during the "descent". Treatment was by extended RN Table 62, which left him well except for a slight tingling in his arms and legs. This resolved overnight but a mild impairment of balance persisted. He was checked later by a neurologist and advised not to dive again.

CASE 6

This man was a self taught diver crayfishing using a hookah supply system. Neither dive depth nor duration was measured but he estimated that his three dives were to 20 fsw for 20 minutes, 70 fsw for 60 minutes, then 70 fsw for 60 minutes with surface interval of 40 minutes and 20 minutes respectively. He noticed blurred vision during the last dive and felt unwell soon after surfacing. One hour post dive he developed a sharp pain between his shoulder blades, this quickly moving to his right shoulder. It became worse when travelling over a 600 foot hill. He subsequently noticed that there was weakness and numbness of his right arm and bruise-like blotches developed over his torso that evening, so he presented at the local hospital the next day. He was flown at sea level, on oxygen, to HMAS STIRLING. Full power and function returned to his right upper limb after treatment with an extended RN Table 62. Follow-up was arranged and he was given advice about safer diving methods.

CASE 7

This untrained diver of unknown experience made two dives to 70 fsw (as measured by depth sounder), for each 50-55 minutes approximately, there being a little over one hour between the dive dives. No decompression stops were made. One hour after he surfaced from the second dive he developed a pain in his right shoulder which gradually increased in severity. The next day the pain was a little less but he noticed excessive thirst, decreased concentration, and difficulty in writing or holding objects. This led to him presenting for treatment the following day, two days following the index dive. He showed no apparent distress and was described as being neurologically normal. There was history of diving most summer weekends from the age of 12 (now 46), often to 120 fsw, following a similar dive profile to that stated. He apparently frequently experienced lethargy, thirst and decreased concentration following diving. He was treated by oxygen at 18 metres, IV fluids, and dexamethasone. The shoulder pain cleared after 70 minutes at 18 metres. The next day he was feeling well, more alert, and pain free. He was strongly advised about correct diving practices.

CASE 8

This man, who was trained and experienced, developed a pain in his right shoulder 10 minutes after surfacing from a dive for 20 minutes at 130 fsw, having made a 7 minute stop at 10 feet depth. The dive had not been strenuous but he thought he might have "pulled" his shoulder getting out of the boat. This pain steadily worsened and he also noted a slight discomfort in his upper arm and neck, and "pins and needles" in his right hand, but no weakness was apparent. He attended for treatment 8 hours later. There was some reduction of abductor power of his right upper limb but no other evidence of neurologic deficit was noted. He was treated by IV Hartmanns, Dexamethasone 16 mg stat, and an extended RN Table 62. His shoulder pain became less and the "pins and needles" was eased, but he developed a pain in his right bicepts at 18 feet "depth" and this persisted even after a Table 61 treatment the next day which cleared the remaining shoulder pain. This continued despite a further Table 61 treatment the following day, indeed recompression appeared to exacerbate the biceps pain, which continued despite the continued use of Decadron 8 mg tid and Indocid. He failed to return for checkup. The biceps pain may have represented actual strain injury rather than being decompression sickness related.

CASE 9

This man was spearfishing using hookah supply and had made two dives to 15 metres, the first for 30 minutes and the second for 45 minutes, with a surface interval of 15 minutes. These times were estimates based on the amount of petrol the compressor used as neither the diver nor his companion had a watch, and depth was estimated by using notches on the anchor line. After a reportedly slow and normal ascent he climbed back into the boat without any difficulty but 5 minutes later he noticed some chest tightness and numbness and weakness in both arms. These symptoms quickly resolved but were replaced by numbness and weakness of both legs: by the time the boat reached the shore he was unable to stand and when he reached the local hospital he was unable to lift his legs off the bed and pain sensation was grossly diminished in both his legs. In view of the dive profile and the rapidity of onset of the symptoms it was initially thought that he must have suffered a cerebral arterial gas embolism (CAGE), so oxygen and a lignocaine infusion were commenced and he was transported to the nearest RCC facility in a head-down position in a Royal Flying Doctor plane pressurised to 1 Bar. There was reportedly some clinical improvement during this journey. When he reached the RCC, 7 hours after the onset of his symptoms, there was gross weakness noted in both legs and inability to discriminate pin-prick sensation up to the level of the umbilicus but he was reasonably well and orientated. He was compressed to 18 metres on oxygen but this produced no relief so he was laid flat and catheterised. As there was still no real improvement after 120 minutes and the clinical picture pointed to a spinal cord lesion, a non-diving cause was thought possible and a neurological review arranged to follow the completion of an extended RN Table 62.

It was known that he had a long history of lower back pain and of left leg numbness, a problem treated by a laminectomy and spinal fusion in 1980. This had been only partially successful, leaving him at the time of this dive with an ability to walk only 300 metres before having to rest. However investigations, including both CAT scan and myelogram, were negative apart from showing evidence of the L 3-4-5 surgery. It was decided to treat him as a case of spinal decompression sickness and a series of daily 10 metre oxygen soaks commenced. A progressive improvement in power of his lower limbs was noted, the right more than the left, and the level of sensation moved down, but there remained significant impairment of both bowel and bladder control. During the evening following the sixth oxygen treatment he developed dyspnoea, retrosternal discomfort, and haemoptysis. A cautious further treatment the next day was aborted after 30 minutes and a provisional diagnosis was made of pulmonary embolism. This was confirmed by lung scan and a chest x-ray and he was commenced on heparin. The combination of pulmonary embolism and a developing pulmonary oxygen toxicity now precluded further hyperbaric oxygen therapy and he was returned to purely medical management. The outcome is not known.

CASE 10

While on an interstate diving holiday this trained, fit, and experienced diver spent a week diving at one resort. On the evening of the seventh day he developed a headache and feeling of fullness in his head. He had made two dives that day, 50 fsw for 45 minutes and 30 fsw for 45 minutes with a 55 minutes surface interval. The next day and twice subsequently he travelled using commercial aircraft, returning home 9 days after this index dive. He attended for advice 8 days later, presenting a 17 day history of persistent dull headache and malaise. After a treatment with RN Table 62 the headache was improved and only occasional so he received a further oxygen treatment, 10 metres for 2-1/2 hours, 5 metres for 1/2 hour. This further reduced but did not totally eliminate his lethargy and vague residual headache. The final clinical result is not known.

CASE 11

This diver, well trained, was on a 10 day diving holiday during which many repetitive dives were made. On the index day there were three dives, 24 metres for 20 minutes, a surface interval of just over 5 hours then a dive to 30 metres for 15 minutes with a decompression stop at 5 metres for 5 minutes. The third dive, 3 3/4 hours later, was 21 metres for 30 minutes with a decompression stop at 5 metres for 5 minutes. That evening the left elbow developed pain, a dull ache extending to the upper arm. Some imbalance had been noticed when leaving the boat and there was an increased thirst the next few days. After flying home three days later "pins and needles" and numbness occurred in the left hand. Because the balance remained impaired medical advice was obtained but the other symptoms were not reported to the doctor. However the persistence of a dull ache in the right elbow and tingling in the left palm and fingers caused the diver to attend HMAS STIRLING two days later, six days after the apparently critical dives. After treatment with RN Table 62 the symptoms resolved, but they returned slightly and an oxygen soak (2 hours at 10 metres, 30 minutes at 5 metres) was given the next day. The persistence of a mild imbalance despite this therapy was taken to indicate that this symptom was not due to Decompression Sickness and the case was defined as being one of musculo-skeletal DCS.

CASE 12

This diver had obtained scuba certification at some time but had been working as a pearl diver using hookah for the past six months. This involved making repeated dives to 21 to 24 metres depth, about 60 dives during a 10 days work schedule, although during the first 7 days of this trip he had usually made 10 dives daily to approximately 13 metres. The dive depths and times were not accurately measured. On the eighth day he made four dives, pain developing in his right shoulder one hour after the fourth dive, followed by pain in his left elbow and right knee.

Dive 1 30 m x 30 min: stops 12m, 3 min and 9m, 2 min.

Dive 2 30m x 30 min: oxygen stops 12m x 5 min; 9m x 2 min; 6m x 2 min.

Dive 3 36m x 30 min: oxygen stops 12m x 10 min; 9m x 5 min; 6m x 5 min.

Dive 4 36m x 30 min: oxygen stops 12m x 15 min; 9m x 5 min; 6m x 5 min.

This was not the first time he had experienced Bends symptoms - in fact he had been treated four times in the six months of his employment by in-water oxygen. No details are known concerning the treatment schedule used, his symptoms, the effectiveness of the treatment, or even whether any of the other divers required, or received, similar treatments. This was the last dive of this trip and some unstated time later he noticed that when driving back to Perth across 300 metre high hills these pains were exacerbated. He had continued to have variable but fleeting pains in his shoulders, elbows, and knees and also experienced some visual distortion, lethargy, and difficulty in concentrating. This led him to seek medical advice 9 days after his last dive. He was treated on RN Table 62, which resulted in the complete resolution of all his symptoms, though some pain returned in his right shoulder, right knee, and left elbow 3 days later and required an oxygen "soak" (10 metres for 2 hours). He was advised to abandon his pearl diving career.

CASE 13

Untrained and of unstated experience, this pearl diver had developed a pain in his left shoulder after a dive mid-September and this had persisted. Despite this he made two further trips, on the last one making 9-10 dives to 15-23 metres, each of 40-70 minutes duration. During these dives the shoulder pain did not trouble him. He presented for treatment 10 days after his last dive, with pain but full function of his left shoulder. Treatment using RN Table 62 produced full resolution of the symptoms. He failed to attend for follow-up check.

CASE 14

The training, experience, and age of this diver is unknown but it is probable that he was experienced as he was diving for sea shells using a hookah. The dive was to 130 few for 35 minutes with decompression stops for 5 minutes at 30 fsw, 5 minutes at 20 fsw, and 20 minutes at 10 fsw depth, hanging on by his left arm. At home later he mowed and raked his lawn. That evening he developed a pain in his left biceps, this increasing overnight despite taking analgesics, so he drove to HMAS STIRLING the next day. There were no objective signs of damage so he was commenced on IV fluids and given Decadron (16 mg stat, 8 mg tid), and treated with an (extended) RN Table 62. Complete resolution of symptoms resulted.

CASE 15

This was the second time this pearl diver had attended at HMAS STIRLING in 1986 with DCS. He reported that he had injured his right knee the day prior to making five no-stops work dives:

Dive 1 8 metres x 60 minutes

Dive 2 9 metres x 180 minutes

Dive 3 9 metres x 45 minutes

Dive 4 14 metres x 75 minutes

Dive 5 14 metres x 45 minutes

He developed a painful right knee one hour after the last of these dives and this gradually became worse, then a general weakness and dizziness developed and he collapsed. He was taken to the local hospital, where he was commenced on oxygen and transportation was arranged to HMAS STIRLING using the Flying Doctor Service. On his arrival there he had been on oxygen for 13 hours and the pain in his right knee was much improved but he had developed pain in his right elbow and ankle and there was a generalised weakness, worse on the right side. He could stand and walk but his alertness was reduced. Treatment with IV fluids, Decadron and RN Table 62, which was extended at 18 metres, was effective. As there was slight stiffness of his right knee the next day he was treated by oxygen 10 metres for 2 hours and this was clinically effective.

CASE 16

This pearl diver made 5 dives to 9-14 metres in 6 hours, receiving in-water treatment (no details of symptoms or treatment are available) 3 days later. The next day he developed swelling, pain and stiffness of his right elbow after playing table tennis, this being treated by two in-water treatments, first at 20 metres on air and then to 35 metres on air with oxygen at 15 metres: no relief was obtained. He was admitted to the local hospital on day 8 and transferred to HMAS STIRLING the next day. By this time there was no pain though there was some swelling and a 15° reduction in extension of the right elbow. He was treated with RN Table 62 but the elbow became more painful the next day, indicating a non-decompression cause.

CASE 17

The first dive was to 15 metres for 30 minutes, then after a 2 hour break there was a second dive, 12 metres for 50 minutes. Five minutes after surfacing from this dive he noticed an ache in his left elbow which fluctuated in intensity and radiated into his left thumb. He also felt tired, thirsty, and light-headed. He gave a history of having a similar pain after a Treasure Hunt dive two weeks previously, this resolving spontaneously over 3 to 4 days. When he attended for treatment he showed signs of dehydration, the left elbow was tender on movement, the wrist had decreased power, and there was slight abdominal tenderness. He was commenced on IV fluids and Decadron and treated with RN Table 62. This resolved all symptoms save for a slight chest discomfort, this clearing by the next day, so the IV fluids and Decadron were then discontinued.

CASE 18

An overseas visitor, trained but of unknown experience, made a dive 18 metres for 30 minutes and then another 18 metre dive for 20 minutes after a five minutes surface interval. Two hours after the second dive he developed a slight pain in his left shoulder which became gradually worse. There was no loss of power or shoulder movement. He was treated by IV Hartmanns, Decadron (16 mg stat, then 8 mg tid), and an extended RN Table 62. This produced a complete resolution of all symptoms. The Decadron and IV fluids were ceased the next day as he remained symptom free.

CASE 19

Self taught and of unstated experience, this man initially made a dive to 14 metres for 45 minutes, then surfaced for 90 seconds before returning to 14 metres for a further 80 minutes. No details are available concerning the dive group dive purpose, or the equipment used. He made a decompression stop (3 metres, 10 to 15 minutes) as he ascended from the second dive. On surfacing he reported severe chest pains and some abdominal pain, and 10 to 15 minutes later developed "dull, solid pain" in the lower back and pins-and-needles down both legs, then a loss of power in both legs. He took the boat to 7 metre

TABLE 2

BREATHING APPARATUS, TRAINING, EXPERIENCE AND NUMBER OF DIVES

	Trained			Experienced			No of dives	
	Yes	No	Not stated	Yes	<1 year	Not stated	Single	Repeat
SCUBA	9	2	-	7	2	2	2* (*+1 Air Embolism)	8
HOSE SUPPLY	2	5	2	1	2	6	1	8

deep water and hung off the side breathing 100% oxygen at 4 metres for 15 minutes, which was associated with a return of sensation. He surfaced at a rate of 2 minutes per foot. However after a further 15 minutes he noticed more tingling so treated himself for a further 22 minutes at 3 metres, then had to surface and return home as the weather worsened. He noticed slight tingling in his legs but this later disappeared.

Next morning he awoke with numbness and weakness of both legs and attended the local hospital. He was found to have weakness of both lower limbs, altered sensation L2 down, and loss of pin prick and light touch sensation in both feet. He was commenced on IV fluids, Decadron (16 mg stat, 8 mg tid), and oxygen and transferred to HMAS STIRLING. He was described as obese. Diagnosis: Spinal DCS. He was treated by RN Table 62, extended for 25 minutes at 18 metres: this produced great improvement but there remained some back pain and slight numbness over the right toes. It was suggested that this numbness antedated the incident but the records do not enlarge on this statement. As he complained of migratory numbness over his left hip and the soles of both feet, with decreased sensation in these areas, he was treated with a 2 hour 10 metre oxygen soak 2 days later, and again the following day. Residual impaired sensation of the sole and toes on the right foot was regarded as irreversible, however his other symptoms were now resolved and power appeared to have fully returned to his lower limbs. He was "given advice about diet, diving, and flying" and discharged as fit for work.

CASE 20

While on an overseas holiday this man dived to 25 metres for 30 minutes, making decompression stops at 6 metres for 2 minutes and 3 metres for 5 minutes. The next morning he noticed some malaise, lethargy, and an ache in his right shoulder. During the flight home later that day the shoulder pain was exacerbated and he also developed pains in both elbows and a headache. He apparently recognised the cause of his symptoms so presented for treatment on reaching Perth. This was the third post-dive day. He was commenced on IV fluids, Decadron, and RN Table 62. There was an initial resolution of the symptoms but some pain recurred in his right shoulder the next day and this was treated by an oxygen soak, 10 metres for 2 hours, a treatment repeated the following day as the pain again returned. This was successful and no further treatments were necessary.

DISCUSSION

The information contained in these brief cases notes indicates some of the matters requiring further examination when considering both the factors significantly effecting the recent increase in numbers of decompression sickness cases receiving treatment and the best ways to reduce this incidence of DCS. First it is necessary to note that discussion is being directed at cases attending at HMAS STIRLING for treatment and the true incidence of cases is unknown as many divers are probably allowing their symptoms to resolve and failing to attend for treatment. This is suggested by the delay in attending for treatment noted in many of these cases. It is to be noted that the pearl divers are proportionally over represented in this survey despite the evidence that they are frequently treated by ad hoc in-water decompression. There appears to be need for better diving procedures in this industry. It is very likely that the divers employed in pearl diving would show a high incidence of aseptic bone necrosis changes if surveyed.

It is noticeable that a large proportion of divers were experienced and it is reasonable to suppose that the index dives were similar to their usual diving procedures. Whether it was the availability of improved recompression facilities or the occurrence of symptoms more severe than they usually experienced

TABLE 3
BREATHING APPARATUS AND MAXIMUM DEPTH OF DIVE

MAX DIVE DEPTH	<=10m	<=15m	<=20m	<=30m	<=40m	>40m
SCUBA	-	4	2	3	-	1
HOSE SUPPLY	-	3	1	1	3	1

and tolerated which was the factor which decided several of these divers to seek treatment is unknown but it cannot be assumed without further investigation that the true incidence of decompression sickness has changed. It can be assumed, however, that the incidence is greater than present figures indicate. If the improved facilities for treatment have in any way increased the willingness of divers to attend for treatment of decompression sickness it would be unwise to discourage their attendance by interposing a fee for treatment. While this would effectively reduce the number attending for treatment it would in no way effect the incidence of decompression sickness. Prevention depends on the identification of a problem and then applying the appropriate management of such factors. The failure of Government agencies to regulate Pearl Diving activities in either Queensland or Western Australia is reprehensible. Had the diving community in Western Australia supported the collection of reports of diving incidents, the Stickybeak Project, the severity of the Decompression Sickness problem would have been identified far earlier and there would have been no need for a Task Force to be set up by the WA Government to collect information and threaten legislation.

Another point of interest is the fact that several cases appear to have occurred following “safe dives”. Readers may like to check the dive profiles declared in cases 1, 2, 4, 9, 17, 18, and 20 against the Swiss Tables or any other tables. It is a matter for investigation as to whether the problem lies in the inaccuracy of the divers in measuring dive depths and duration, their previous diving history, their physiological oddity compared with the Tables, or the Tables themselves. Diver error appears the most likely factor, and it is noteworthy that the majority of cases followed repeat dives. It is possible to calculate the residual gas BUT it is often forgotten that the diver’s physiology has been altered by the first dive so presents a different substrate for the second and subsequent dive changes. In several cases the presence of previous pathology may have been significant.

It is regrettable that divers have not accepted the knowledge that in-water air recompression is a poor option although it may appear to produce cure, and the misuse of oxygen treatment in case 19 must be deplored. There appears to be a belief that recompression CURES decompression sickness. This is not necessarily so. Such treatment seeks to halt and reverse the sequence of damaging changes which have caused the presenting symptoms, but such symptoms indicate that damage has already occurred. In particular it is now believed that resolution of symptoms of Spinal Cord Bends does not indicate the complete resolution of the damage to the spinal tracts. Such damage is permanent.

The single case of CAGE in this series is another warning that the ascent phase of the dive is critically important. There is now an increasing awareness that this tragic misadventure DOES occur with apparently normal ascents.

The answer to this “Bends” problem will only be found by examination of case histories which are as full and accurate as possible. This requires the co-operation of the divers as well as of those whose task it is to treat them. Better understanding by divers of the factors influencing the development of decompression sickness, the limitations of The Tables, the importance of early treatment, and the limitations of treatment are all factors requiring attention.

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THE DIVING CHAMBER AT BROOME AUSTRALIA’S FIRST AND AUSTRALIA’S OLDEST ?

John Hayman

Diving for pearls and pearl oyster shell off Australia’s north-west coast has a long history, which stretches back to the time of first European settlement of Western Australia’s inland regions. Dampier visited the coast in September 1700 and recorded the

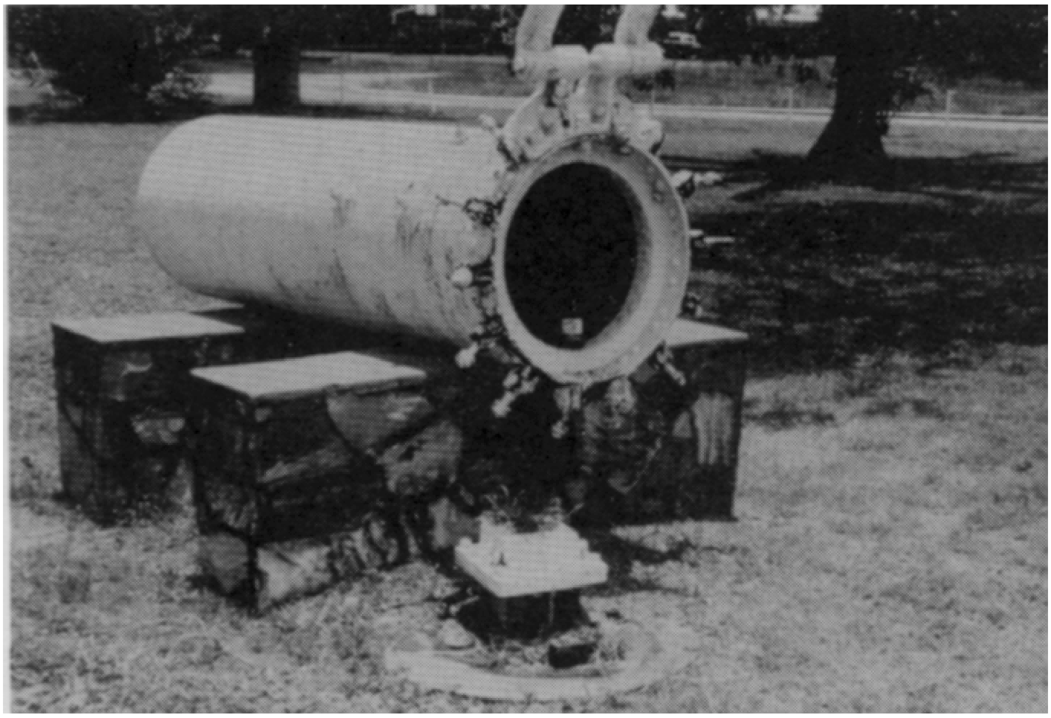

FIGURE 1. The Decompression Chamber as it now stands in Bedford Park, Broome. The chamber door has been broken off, and lies on the ground, innerface down.

presence of pearl shell. In 1854 Lieutenant Helpman, commander of the colonial schooner *Champion* found and surveyed commercial pearl beds near Shark Bay. From 1860 to the 1880s pearl shell was gathered by skin divers, usually Aboriginal or Malays recruited or coerced by Europeans. Hundreds of these divers died: attacked by shark or crocodile, drowned while diving or being lost together with their lugger, the master, and their collected shell when the vessel was struck by cyclone.

Diving helmets were introduced about 1835 and thereafter divers were able to reach much greater depths and the mortality rose proportionally. Aborigines were unable to use this equipment and they disappeared from the pearling industry. The Japanese became very proficient with the new equipment, and hundreds of these divers entered the trade. Decompression illness was not understood before the work of Haldane and Hill, and staging an ascent was never practised. Diving all day and every day to depths of more than 30 m, these divers suffered nightly from "divers rheumatism" and paralysis, and few divers were not crippled or dead after four or five seasons. Between 1910 and 1917, 145 divers in the Broome fleet died; in 1914 alone there were 33 deaths. The Japanese cemetery in Broome contains more than 600 bodies, mostly young men and mostly divers and it has also a memorial to pearling fleet crew members who were lost in cyclones.

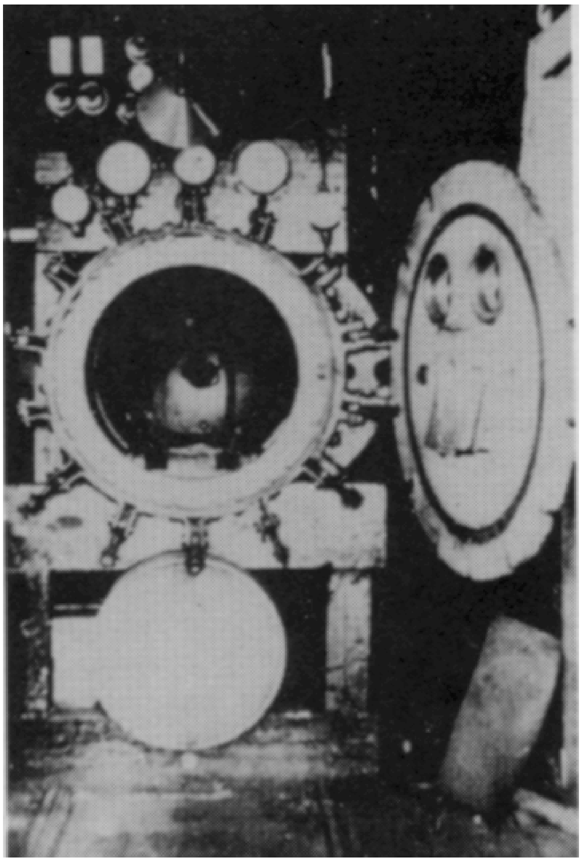

FIGURE 2. Photograph of the chamber in its operational state, installed in the old hospital.

In 1913 the London diving firm, CE Heinke & Co commissioned construction of a diving chamber for the town of Broome. This was installed in the old hospital, situated on a hill beside the now demolished pearling wharf. Installation of this chamber, together with better understanding of diving physiology and the need for "staging' led to a substantial reduction of deaths for decompression illness. In 1918 there was only one death, and although there were more deaths in later years the mortality remained relatively low. The practices then, however, still seem appalling by today's treatment protocols. The 1918 report of the Master Pearlers Association read as follows: *"this* (one death) *is the lowest on record and it must be ascribed solely to the education of divers by means of the decompressor the generous gift of Messrs CE Heinke and Co with the present day engine boats we are working deeper than ever before* (as deep as 80 m) *and partial paralysis is fairly common, but immediate decompression by returning the diver to the water has almost solved the question. In the majority of cases a few hours "staging" effects a complete cure and the diver is able to carry on his work the next day "*.

Between the wars there was a progressive decline in pearling and the chamber was no longer used. After the second World War the chamber was rescued from the local rubbish tip by Mr Alec Reid, who ran a service station and car sales business in the town. The chamber, together with its motorised compressor now stand in Bedford Park opposite the rebuilt Continental Hotel. Compared with modern chambers, it is primitive in the extreme, barely large enough to accommodate a small Japanese. A normal sized European would have been a very tight fit; there appears to have been no means of communication, no oxygen, and certainly no room for an attendant. The internal diameter is 80 cm, the internal length approximately 6.3 m. It may well have been the fear of being shut in this chamber which persuaded divers to adopt some, be it imperfect, staging procedures!

The chamber now stands in the open, partly filled with rubbish, with the cast iron door unhinged and lying on the ground beside it. Commissioned in 1913, it would seem very likely that this is the first chamber ever operated in Australia. Its present situation is very much better than the town tip, but such a relic, now 74 years old, is probably deserving of even better treatment. The town of Broome has many diving relics; anchors form garden ornaments and the wheels from hand compressors are used as garden edging. The museum, situated in the old Customs House near the now demolished wharf and hospital has a photograph of the chamber as it was in use, as well as many items belonging to divers.

SPUMS has had meetings in many different parts of the Pacific and Indian Oceans. Perhaps we would celebrate the 75th anniversary of the inauguration of Australia's first diving chamber by holding a meeting in Broome.

REFERENCES AND FURTHER READING

Edwards H. Port of pearls. A history of Broome. Perth, Adelaide: Rigby, 1983.

Photograph inscriptions and newspaper cuttings. Museum, Broome.

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SWISS DECOMPRESSION TABLES

John Lippmann

HISTORICAL BACKGROUND

The laboratory of Hyperbaric Physiology of the Medical Clinic of the University of Zurich was established in 1960. The theme of the research being carried out was that of assessing the well-being and functional ability of the human being in atmospheres of abnormal pressure and composition. The Swiss, lacking a history of decompression research, were free from the shackles of traditional approaches and could begin to introduce new ideas in this area.

The effects of both nitrogen and helium have been considered throughout their decompression research, and the tolerance to nitrogen in decreased ambient pressure has also been investigated, due to the local interest in diving in mountain lakes.

The "Swiss Decompression Theory" is only a method of calculating saturation and desaturation in a way which permits safe decompression. All of the empirical factors that are important for this method were determined experimentally in Zurich.

For decades 240 minutes was considered to be the longest half-time for nitrogen in man, but in the mid-1960s it was shown that complete saturation with nitrogen takes 3-4 days, and hence the longest half-time for nitrogen was calculated to be 8-10 hours. Eventually, after various trials and experiments, sixteen tissue compartments with half-times for nitrogen of 4 to 635 minutes (and for helium of 1 to 240 minutes) were considered for calculating the equalization of the pressure of the inert gas. The sixteen nitrogen (N_2) half-times selected are shown in Table 1 (right). The half times associated with various body organs were identified and some are shown in Table 2.

THE ZH-L_{12} SYSTEM

The Swiss observed that the difference between the pressure of the inert gas in the tissue and the tolerated (ie. asymptomatic) ambient pressure, the "over-pressure" of nitrogen or helium, increases approximately linearly with increasing ambient pressure. Put simply, at depth our tissues can tolerate more excess gas than in the shallows.

It is commonly accepted that tissues with longer half-times (slow tissues) tolerate less excess inert gas than do shorter half-time tissues (fast tissues) at a given ambient pressure. The ambient pressure that can be tolerated (P amb.tol.) when a particular half-time tissue with a calculated inert gas pressure (P i.g.t.) is decompressed is given by:

TABLE 2

N_2 1/2-times associated with various body organs

Organ	**N_2 1/2-time in minutes**
CNS	4.0-27.0
Skin and muscles	38.3-77.0
Inner ear	146.0-239.0
Joints and bones	305.0-635.0

$$\textbf{P amb.tol.} = \textbf{(P i.g.t. - a)b}$$

where a and b are coefficients determined experimentally for various tissue types. Twelve pairs of coefficients were determined in order to represent the sixteen tissue half-times. This became known as the ZH-L_{12} system.

Using the ZH-L_{12} system both staged and continuous decompression can be calculated quite easily and a computer can be programmed to carry out the decompression calculations. In fact the "Deco-Brain 2" decompression calculator utilizes this system.

TABLE 1

Sixteen half-time values for N_2 corresponding to various tissue compartments for the ZH-L_{12} system.

Compartment	N_2 1/2 Time
I	4.0
2	8.0
3	12.5
4	18.5
5	27.0
6	38.3
7	54.3
8	77.0
9	109.0
10	146.0
11	187.0
12	239.0
13	305.0
14	390.0
15	498.0
16	635.0

FEATURES OF THE ZH-L12 SYSTEM

The difference between the maximum depth of the dive and the depth of the first decompression stop increases as dive depth increases, and the rate of ascent to the first stop is governed by both the maximum depth and the controlling half-time tissue. *In practice, for SCUBA divers, the maximum ascent rate recommended is 10 metres per minute*, as Swiss experience shows that this is a safe continuous decompression for saturated tissues in order to prevent bubble formation. This ascent rate enhances gas elimination for dives to depths to about 30 metres. However for deep to very deep dives (ie. greater than 30 metres) it is recommended to use ascent rates of 15 to 20 meters per minute below 30 metres and thereafter ascend at 10 metres a minute. This is suggested in order to avoid allowing the "slower tissues" to absorb extra gas during the ascent. Decompression stops are calculated at 0.3 bar (3 msw) intervals.

For short air dives the ZH-L_{12} system gives decompression times comparable to the US Navy and Royal Navy tables, utilising slightly longer stays at the deeper stops and giving an overall decompression time often between those of the US Navy and Royal Navy systems.

DIVING AT ALTITUDE

As previously mentioned, many Swiss have an avid interest in diving in mountain lakes and consequently,

NO-DECOMPRESSION LIMITS AIR DECOMPRESSION TABLE

Depth m	BT min	Stops 6	3	RG
12	125		1	G
15	75		1	G
	90		7	G
18	51		1	F
	70		11	G
21	35		1	E
	50		8	F
	60		16	G
24	25		1	E
	35		4	F
	40		8	F
	50		17	G
	60	4	24	G
27	20		1	E
	30		5	F
	35		10	F
	40	2	13	G
	45	3	18	G
	50	6	22	G
30	17		1	D
	25		5	E
	30	2	7	F
	35	3	14	G
	40	5	17	G
	45	9	23	G

m	min	9	6	3	RG
33	14			1	D
	20			4	E
	25		2	7	F
	30		4	11	G
	35		6	17	G
	40	2	8	23	G
36	12			1	D
	20		2	5	E
	25		4	9	F
	30	2	5	15	G
	35	2	8	23	G
39	10			1	D
	15			4	E
	20		3	7	F
	25	2	4	12	G
	30	3	7	18	G
	35	5	9	28	G
42	9			1	D
	12			4	D
	15		1	5	E
	18		4	6	F
	21	2	4	10	F
	24	3	6	16	G
	27	4	7	19	G

m	min	12	9	6	3	RG
45	12				5	E
	15			3	5	E
	18		2	4	9	F
	21		3	5	13	G
	24		4	6	18	G
48	9				3	E
	12			2	5	E
	15			4	6	F
	18		3	4	10	F
	21		4	6	16	G
51	9				4	E
	12			3	6	E
	15		2	4	8	F
	18		4	5	13	F
	21	3	4	7	18	G
54	9			1	5	E
	12		1	4	6	E
	15		3	4	10	F
	18	1	3	6	17	G
57	9			2	5	E
	12		2	4	8	E
	15	1	4	5	11	F
	18	3	4	7	18	G

Altitude **0–700 m** above sea level

Ascent rate: 10 m/min → Safety stop: 1 min at 3 m

FIGURE 1. Buehlmann no-decompression limits air decompression table for altitudes from 0 to 700 m above sea level.

in 1973, decompression tables for diving at sub-atmospheric pressure were developed. They enabled the calculation of decompression after dives of between the altitudes of 0-3,200 metres above sea-level. These tables were then thoroughly tested by Swiss Army divers and published in 1976. Between 1973 and 1983 no cases of decompression sickness were reported although well over 1,000 real dives were performed, many of these being repetitive dives.

The ZH-L_{12} system suggests somewhat different decompressions to those described in the earlier tables, but provides almost the same nitrogen excess on surfacing. They have been tested by supplementary experiments and found to be acceptable.

For dives above sea-level it is important to consider whether the divers reach the mountain lake quickly and then dive immediately, or whether they have been at altitude for some time prior to the dive, thus commencing diving with a subnormal nitrogen pressure (PN_2) in their tissues. In order to allow greater safety these tables assume that the diver had travelled to altitude very quickly and consequently has not yet adapted to the decreased atmospheric pressure. Adapting to altitude decreases the PN_2 in the tissues and thus provides additional safety. Furthermore the supersaturation factor on surfacing was chosen to allow for a further reduction in pressure, which may occur as a result of travelling by plane or car to a higher place after the dive.

FLYING AFTER DIVING

Experiments were conducted in order to determine the surface intervals required before a diver may be subjected to further decreases in atmospheric pressure. When this reduction of ambient pressure occurred in accordance with the ZH-L12 system, no symptoms of inadequate decompression occurred on testing.

REPETITIVE DIVING

Joints and bones have the least tolerance to an excess of inert gas and release any excess gas only very slowly. The 240 minute tissue half-time, which is the longest utilised in the US Navy tables, has often been found to be inadequate in situations when repetitive dives are undertaken for a number of days in succession (eg. on diving holidays). In these situations, the longer half-times of nitrogen with the lower tolerance towards nitrogen shown by the slower tissues, must be taken into consideration.

NO-DECOMPRESSION LIMITS
AIR DECOMPRESSION TABLE

Depth m	BT min	Stops 6	4	2	RG
9	238			1	G
12	99			1	G
	110			4	G
15	62			1	F
	70			4	G
18	44			1	F
	50			4	F
	60			11	G
21	30			1	E
	35			2	F
	40			5	F
	45			9	G
	50		1	13	G
	55		3	17	G
24	22			1	F
	30			3	F
	35			7	F
	40		2	11	G
	45		4	16	G
27	18			1	D
	20			2	E
	25			4	F
	30		2	7	F
	35		4	11	G
	40	1	6	16	G

m	min	9	6	4	2	RG
30	15				1	D
	20				3	E
	25			2	6	F
	30		1	4	11	G
	35		2	7	15	G
	40	1	5	10	20	G
33	12				1	D
	15				2	E
	20			2	4	F
	25		2	3	9	G
	30	1	3	6	14	G
	35	2	4	9	20	G
36	10				1	D
	15			1	3	E
	20		1	3	6	F
	25	1	3	5	12	G
	30	3	3	8	19	G
39	9				1	D
	12				3	E
	15			2	4	E
	18		2	3	7	F
	21		3	4	10	G
	24	2	3	6	15	G
	27	4	4	8	18	G

m	min	9	6	4	2	RG
42	8				1	D
	12			1	4	E
	15		1	3	5	F
	18		3	4	8	F
	21	3	3	5	13	G
	24	4	4	7	18	G
45	9				3	D
	12			3	3	E
	15		3	3	6	F
	18	2	3	4	11	F
	21	4	4	7	16	G
48	9			1	4	E
	12		1	3	4	F
	15	2	2	4	9	G
	18	4	5	5	14	G
51	6				2	E
	9		1	1	3	F
	12	1	2	3	5	F
	15	3	3	4	11	G
54	6				2	D
	9		1	3	3	F
	12	2	3	3	7	F
	15	4	4	6	13	G

Altitude **701–2500 m** above sea level

Ascent rate: 10 m/min ——→ Safety stop: 1 min at 2 m

FIGURE 2. Buehlmann no-decompression limits air decompression table for altitudes from 701 to 2,500 m above sea level.

In the Swiss system the inert gas pressure in the tissues with nitrogen half times between 305635 minutes play a leading role during a surface interval and consequently with repetitive dives. This, however, does not mean that the Swiss tables are necessarily more conservative than the US Navy tables when used for repetitive dives. In fact, quite often the converse is true.

THE BUEHLMANN TABLE

The Buehlmann Table, derived using the ZH-L_{12} system, was published in order to provide sports divers with no-decompression limits and decompression stops for both single and repetitive dives.

The following definitions and rules apply to this table:

DEFINITIONS

Depths listed are the maximum depths reached during a dive.

Bottom Time (BT) is the time from leaving the surface until commencing the final ascent to the surface or to any decompression stop/s

Decompression Stop Time (Stops) is the time actually spent at that stop. It does not include the time taken to ascend to it.

Repetitive Group (RG) is a measure of excess nitrogen remaining in the body after a dive.

Surface Interval is the time from surfacing from a dive to commencing the next descent.

Residual Nitrogen Time (RNT) is a measure of the amount of excess nitrogen still in the body at the end of the surface interval. It is the time that the diver must consider that he or she has already spent at the planned depth of the repetitive dive when commencing a repetitive dive.

BUEHLMANN TABLE

REPETITIVE DIVE TIMETABLES 0–2500 m above sea level

Surface Interval Times

RG at start of surface interval

RG							"0"	✈
A							2	2
B						20	2	2
C					10	25	3	3
D				10	15	30	3	3
E			10	15	25	45	4	3
F		20	30	45	75	90	8	4
G	25	45	60	75	100	130	12	5
G	F	E	D	C	B	A	hrs	hrs

RG at end of surface interval

Example:
Previous dive 24 m, 35 min = Repetitive Group (RG) = F
- after 45 min at surface: RG = C
- after 90 min at surface: RG = A
  (intermediate time: use next shorter interval time)
- after 4 hrs: flying is permitted
- after 8 hrs: RG "0", no more Residual Nitrogen Time (RNT)

RG for No-Decompression Dives and RNT for Repetitive Dives

Repetitive dive depth m (intermediate depths: use next shallower depth)

RG	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57
A	25	19	16	14	12	11	10	9	8	7	7	6	6	6	5	5	5
B	37	25	20	17	15	13	12	11	10	9	8	7	7	6	5	5	5
C	55	37	29	25	22	20	18	16	14	12	11	10	9	8	7	7	6
D	81	57	41	33	28	24	21	19	17	15	14	13	11	10	9	9	8
E	105	82	59	44	37	30	26	23	21	19	17	16	14	13	12	11	10
F	130	111	88	68	53	42	35	30	27	24	21	19	17	16	15	14	13

Example: RG = C at end of surface interval.
Planned depth of repetitive dive = 27 m. RNT = 18 min. *

* **to be added to the bottom time (BT) of the repetitive dive.**
Note the handwritten correction in line 2 of the RG table.

FIGURE 3. Buehlmann repetitive dive timetables for 0 to 2,500 m altitude above sea level.

RULES

The ascent rate must not exceed 10 metres per minute.

For interim depths use the next greater depth on the table.

For interim times use the next longer time on the table, eg. for a dive to 17 m for 73 minutes look up the decompression for 18 m for 80 min.

For "strenuous" dives use the decompression prescribed for the next longest time increment, eg. for a strenuous dive to 17 m for 73 minutes look up the decompression for 18 m for 90 min.

Repetitive dives require additional time to be added. This time is determined by using the repetitive dive table and is called the residual nitrogen time. The residual nitrogen time is a measure of any excess nitrogen already in a diver's body before a repetitive dive.

If the depth of the repetitive dive is in between two depths then take the shallower figure when calculating the residual nitrogen time. This gives a greater residual nitrogen time and is thus safer.

A safety stop of at least 1 minute at 3 m is required after every no-decompression dive at altitudes up to 700 m and a stop of 1 minute at 2 m is required after dives at higher altitudes.

The following additional rule precedes Professor Dr Buehlmann's publication of his full ZH-L_{12} tables. It reads: "Because of the risk of nitrogen narcosis, diving to more than 40 m may not be undertaken without some security being given from the surface. For diving instructors the limit is increased to 50 m." The Swiss Federal Assurance Court considers that dives deeper than these depths carry "above normal risk" and diving to greater depths may affect a Swiss diver's insurance benefits.

USING THE BUEHLMANN TABLE

A. PLANNING SINGLE DIVES

Enter Table 1 at the exact, or next greater depth box. The lower (and less bold) figure in the first column is the no-decompression limit (NDL) for that depth. If the planned dive exceeds this time, go to the “Bottom Time” (BT) column (column 2), to the exact, or next longer time, then move right to read off the stops and, if required, the repetitive group at the end of the dive.

Example 1

You are planning a single, no-decompression dive to 22 m and wish to know the NDL.

Enter the 24 m box. The NDL is written in bold at the top of the BT column (column 2). It is 25 minutes. Remember that a safety stop of at least 1 minute at 3 m is suggested.

Example 2

What decompression is required for a dive to 36 m for 18 minutes?

Enter the 36 m box and read down the second column until the exact, or next longer time is found, in this case 20 minutes. Moving right, the decompression is found to be 2 minutes at 6 m followed by 5 minutes at 3 m. Remember that the maximum ascent rate must be 10 m/min. The repetitive group after the dive, given in the last column, is E.

Note 1. The time taken ascend from 36 m to the 6 m stop is not included in the 6 m stop time of 2 minutes. It should take 3 minutes to ascend to this first stop.

Note 2. The time taken to ascend from 6 m to 3 m (ie. 20 sec.) and from 3 m to the surface is not included in the 3 m stop time. The diver must spend the entire 5 minutes at 3 m.

Example 3

Calculate the decompression required for a dive to 31 m for 36 minutes.

Enter the 33 m box and move down column 2 until 40 minutes is found. Moving right, the decompression is found to be 2 minutes at 9 m, 8 minutes at 6 m and 23 minutes at 3 m. The repetitive group after the dive is G.

Note: It should take at least 2.2 minutes to ascend from 31 m to the 9 m stop. This is calculated as follows:

Distance to first stop = 31 - 9 = 22 m.

Time taken (at 10 m/min.) =22/10 = 2.2 min.

It is permissible to slow the ascent rate so as to take 3 minutes.

B. PLANNING REPETITIVE DIVES

Example 4.

Calculate any decompression required for the following pair of dives:

25 m for 20 minutes followed 2-1/2 hours later by a dive to 10 m for 50 minutes.

Upon entering the 27 m box the NDL for 25 m is found to be 20 minutes. Hence no decompression is required for the first dive. The repetitive group immediately after the dive is E.

Enter Table 2 from the left at E (the repetitive group) and move right until the 2 1/2 hour surface interval is found. It is between 45 minutes and 4 hours so moving down the repetitive group at the end of the interval is found to be A. Enter Table 3 from the left at A and move right until intersecting the column corresponding to the depth of the repetitive dive, in this case 18 m. The figure 14 which appears, represents the time to be considered already spent at 18 m before the repetitive dive. This 14 minutes must be added to the proposed bottom time in order to compute the correct decompression. Therefore this repetitive dive has an equivalent bottom time of 50 + 14 = 64 min. From Table 1 the decompression required is found to be 11 minutes at 3 m. After the dive the repetitive group is G.

Example 5

You wish to carry out two no-decompression dives, the first to 20 m followed 3 hours later by a dive to 32 m. Calculate the maximum allowable bottom time for each dive.

Enter the 21 m box. The NDL for 21 m is 35 minutes which is the maximum allowable time for the first dive. After this 20 m for 40 minutes dive the repetitive group is E (remember the safety stop time of one minute at 3 m). Entering Table 2 at E, move across to find the surface interval of 3 hours. It lies between 45 minutes and 4 hours so the repetitive group after the surface interval is A. Enter Table 3 from the left at A and move right until the 30 m row (ie. shallower in this case) is intersected. The residual nitrogen time is 9 minutes. Thus your body still has as much extra nitrogen as if you had already spent 9 minutes at 32 m before the dive. Returning to Table 1 and entering the 33 m box, the NDL is found to be 14 minutes You have already used 9 minutes of this (ie. your residual nitrogen time) so you may only dive for 5 minutes for a no-decompression dive. Hence the maximum allowable bottom time for the second dive is 5 minutes. Again do not forget to do the safety stop en route to the surface.

Example 6

You are planning to do two dives. The first is to 34 m for 18 minutes and the second, five hours later, is to be a no-decompression dive to 27 m. Calculate the decompression required for the first dive and the maximum allowable bottom time for the second.

Enter the 36 m box and move down column 2 to 20 minutes. Moving across, the required decompression is 2 minute sat 6 m and 5 minutes at 3 m. The repetitive group is E. Entering Table 2 at E, move across to find the surface interval of 5 hours. This row ends at 4.00 hours which means that, for group E, after 4.00 hours no residual nitrogen needs to be added. In other words, the previous dive can be ignored.

This situation occurs after a surface interval of 2.00 hours for group B, 3.00 hours for group C and up to 12.00 hours for group G. Therefore to find the allowable bottom time for the second dive, return to Table 1, enter the 27 m box and the maximum bottom time is found to be 21 minutes.

Determining the repetitive group after dives with bottom times less than the no-decompression limit is done by referring to the bottom part of Table 2, the repetitive group for no-decompression dives.

Example 7

Find the repetitive group after a dive to 9 m for 30 minutes.

Enter the bottom half of Table 2 at the 9 m column and move downwards to find the 30 minute (or next greater) bottom time. In this case we get 37 minutes and by moving across to the left the repetitive group is found to be group B.

Similarly after a dive to 30 m for 7 minutes (the no-decompression limit is 9 minutes) we are in group A and after a dive to 18 m for 38 minutes (the no-decompression limit is 44 minutes) we are in Group E.

<u>If the bottom time is exactly (or more than) the no-decompression limit the repetitive group must be taken from Table 1</u>. The repetitive groups in Table 1 do not always coincide with those in Table 2.

C. FLYING AFTER DIVING

The surface interval required before flying (or otherwise ascending) to normal commercial cabin altitude (2,400 m) is found in the following manner:

Use the repetitive group after the last dive to enter Table 2. Move across until entering the rightmost column with the picture of the aeroplane. This gives the time required before flying. After this interval it should be safe to fly.

Example 8

After a dive to 27 m for 20 minutes you are in repetitive group E. Entering Table 2 at E and moving across, you will find that after 3 hours it should be safe to fly. If after the dive you were in group F, you would have to wait at least 4 hours before flying.

D. DIVING AT ALTITUDE

Table 1 can be used for diving at altitudes between 0-700 metres. Table 3 is for use for dives at altitudes 701-2,500 m above sea level. This table is governed by the same rules as the 0-700 m tables and utilize the same repetitive dive timetable (Table 2).

***NOTE:** This article is taken from the draft of a book relating to decompression and practical diving which is currently being prepared by John Knight and John Lippmann. The author wishes to thank Professor Dr Buehlmann and Beat Mueller for their assistance in the preparation and checking of this draft.*

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PULMONARY OEDEMA FOLLOWING AN IRUKANDJI STING

Ivan Herceg

It appears that stings by the small jellyfish "Irukandji" (Carukia barnesei) are relatively common in northern Queensland, some 61 cases being reported in the 1985-1986 summer season.[1] Although the Irukandji syndrome, as described by Barnes,[2] is extremely unpleasant, no life threatening complications have been described. It is generally believed that with correct supervision Irukandji sting carries no threat to life.[3]

A case of life threatening pulmonary oedema, severe enough to require mechanical ventilation, is described following an Irukandji sting.

CASE HISTORY

While snorkelling near Seaforth Island on the Great Barrier Reef, a previously fit 28 year old man was stung on the face and neck by an unseen marine stinger. He swam to the boat without difficulty and immediately applied household vinegar to the affected area.

Within five minutes, he had developed abdominal cramps, sweating and heaviness of the legs. The symptoms worsened over the next thirty minutes with the development of severe low back pain, generalised myalgia, profuse sweating, chest tightness and marked apprehension. he thought he was going to die.

On arrival at hospital an hour after the original sting, he was very agitated and his main complaint was back pain. The face and neck were swollen and erythematous, but there was no blistering or skin damage. His blood pressure was 210/150 and a third heart sound was noted. There was no respiratory difficulty, his chest was clinically clear and a chest x-ray was normal. Aside from a tachycardia of 130/ minute, the ECG was normal. Later a brief run of bigemini was recorded.

The patient was a non-smoker, had no history of heart or lung disease other than childhood asthma. He had no previous exposure to marine stingers.

Pain relief in casualty was provided with intravenous pethidine to a total of 250mg. Hydralazine, 20mg intravenously was used to control the blood pressure, which fell to 170/100. He was given diazepam (Valium) 10 mg, promethazine (Phenergan) 50 mg, and hydrocortisone 100mg, all intravenously.

An Irukandji sting was assumed responsible, and a pethidine infusion was started at, initially, 30mg/hour. Intravenous fluids were commenced, 0/9% saline with 40 meq KCl over 12 hours, as the serum potassium was 3.0 mmol/l (normal 3.5-5.5 mmol/l).

Nine hours after the initial sting, the pain and the facial oedema were settling, but he developed acute shortness of breath, profuse pink frothy sputum, cyanosis and widespread crepitations in both lung fields.

Chest x-ray showed the changes of pulmonary oedema. He was treated with oxygen with a face mask and intravenous frusemide 80mg. Deterioration continued, and by thirteen hours after the sting, he was no longer coping. His arterial PO_2 on 50% inspired oxygen was 45 mmHg (normal 75-100 mmHg). PCO_2 was normal. At this stage, he was intubated and ventilated.

A total of fifty hours of ventilation was necessary, with oxygen concentrations as high as 55% and a positive and expiratory pressure (PEEP) of 7.5cm H_2O. Three days after admission, his PO_2 on 28% oxygen via mask, was 83 mmHg, and his blood pressure had settled to 130/80. He was discharged the following day.

Muscle enzyme studies showed a markedly increased creatine kinase, to a maximum of 1266U/l (normal 20-200U/l). However, as has previously been reported,[1] the myocardial isoenzyme portion was normal.

DISCUSSION

The composition and action of C. barnesei venom is unknown.[4] Many of the symptoms and signs of envenomation are those of excess catecholamine release. Hypertension is described,[1,5] but it is difficult to attribute this patient's pulmonary oedema to hypertension alone as the blood pressure was controlled promptly and remained below 170/115 after admission. Fenner et al1 suggest the use of phentolamine for an alpha-blocking agent, for the control of the blood pressure. However in this case it seems the Hydralazine worked well. A direct toxic effect on the myocardium or the pulmonary vasculature can be postulated.

Barnes believed that several jellyfish in Australian waters were capable of producing the "Irukandji syndrome". Possibly this specimen was of a more toxic variety than those commonly encountered, or the patient hypersensitive. Nevertheless, it seems that the Irukandji is a jellyfish potentially lethal to man.

REFERENCES

1. Fenner PJ, Williamson J, Callanan VL and Audley L. Further understanding of, and new treatment of "Irukandji" (Carukia barnesei) sting. Med J Aust 1986; 145: 569-574.

2. Barnes JH. Cause and effect in Irukandji sting. *Med J Aust* 1964; 1:897-904.

3. Williamson JAH. *The Marine Stinger Book*. 3rd edn. Brisbane: Queensland State Centre, Surf Lifesaving Association of Australia, 1985: 18.

4. Sutherland SK. *Australian Animal Toxins: the creatures, their toxins, and care of the poisoned*

patient. Melbourne: Oxford University Press, 1983: 381.

5. Fenner P, Rodgers D, Williamson J. Box-jellyfish antivenom and Irukandji stings. *Med J Aust* 1986; 144: 665-666.

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ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE UNIT COURSE FOR NURSES - RCC ATTENDANTS

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or ring him on (08) 224-5116

The Royal Adelaide Hospital Hyperbaric Medicine Unit also runs courses for divers and nurses. Details are available from Dr Gorman.

BOOK REVIEWS

Medical Examination of Sport Scuba Divers, Edited by Jefferson C Davis MD. Best Publishing Co., PO Box 1978, San Pedro, California 90732, USA. 60 pages

Price - US$13.50 plus postage and handling: $3.25 (surface), $12.00 (air).

This is an excellent booklet which provides the reader with a comprehensive and reasoned review of the medical factors which deserve consideration when deciding on the medical fitness to dive of some applicant. As the title indicates consideration is limited to the recreational diver, and by inference one with some common sense, it being assumed that such persons will not attempt to dive in obviously adverse sea conditions. There is recognition of the possibility that after their training they may choose to go diving at locations far from readily available emergency aid and have become less fit than when they were initially examined, and are likely to be far less well supervised than professional divers would be in such locations. The role of the instructor in providing a thorough and appropriate training and in persuading some pupils that diving is not an appropriate activity for them is implicit in this text because it is admitted that not only is a medical examination not always required before obtaining scuba instruction but there is no present requirement that the doctor examining the applicant should have knowledge of Diving Medicine. Most instructors would welcome the closing of this loophole, one which sometimes makes a mockery of a Diving Medical Certificate.

The text deals briefly but comprehensively with matters ranging from cleft palate (can the ears be "equalized"?) to psychiatric and neurological problems, from septal defects to asthma, diabetes, and the Gas Bloat Syndrome. There is a listing of the conditions in order of their discussion and a subject index which makes it a simple matter to locate any of the conditions discussed.

This booklet should be useful to instructors and to doctors who are faced with a need to undertake Diving Medicals but are not interested in studying the matter deeply. Even those who have a copy of Diving and Subaquatic Medicine and read this Journal can find items of interest in this booklet.