SPUMS JOURNAL
South Pacific Underwater Medicine Society
APRIL TO JUNE 1982

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OFFICE BEARERS

EDITORIAL

Diving is full of examples of the propensity of problem-solutions to father more complicated problems. Starting from the time men discovered how to extend underwater endurance by first hyperventilating, and thereby "invented" anoxic blackout deaths, diving progress has marched from problem to new problem. At the present time there is a possibly over-simplistic belief that safety will be significantly increased if only those without the slightest blotch on their health record are allowed to dive. Wing Commander Wilkin's paper illustrates what can happen when such an apparently rational approach is introduced while there exists an unsuspected but important inadequacy of understanding of the true weightings of different factors. Man, in the species sense, is imperfect. He is also a mass of checks and balances which tend to provide protection against many problems. It has yet to be decided how strictly the Medical Fitness Standards should be applied, borderline cases being decided on whether one can morally say "You should not dive, but can do so at your own risk".

In this issue we print the final selection of the papers given by Dr David Elliott at the SPUMS Scientific Meeting in the Philippines. To read his papers is to gain new perspectives and acquire new facts concerning the great range of matters included in the title "Diving Medicine". Each reader will mine his own personal nuggets of information. Some will be awed by the knife-edge accuracy of gas mix required for really deep dives, while others will seize on the new "acceptability" of shaft dysbaric osteonecrosis. Those with a teleological approach may wonder that Man is said to function better at a higher PO_2 than that common at sea level, while others will be struck by his views on the priorities of Medical Support. It is obvious that his views are based on a great mass of experience of practical diving problems.

There are many points of intervention in planning to improve safety, in diving as in other activities. Papers in previous issues have noted the limitations in practice of the use of helicopters and planes in diving problems, other than long range transport of victims. Dr Wishaw writes about the Helicopter Rescue Service in the Sydney area, his paper based on his active participation in this service. The service has been involved in a number of diver rescues but has, naturally, not had to face the problems of airlifting portable chambers. Sydney divers, at least, seem to prefer to drive themselves to the SUM. Hopefully, good diving procedures will maintain this low need for emergency RCC facilities.

The problem of flying after diving may increase in significance with the growth of "package holidays" for divers. Although few cases of DCS have been published as resulting from a dive-fly sequence, they certainly occur on occasion. A recent true Aviation Bends case, where a non-diver required RCC therapy after a plane with a broken window was forced to fly high to conserve fuel, illustrates the reality of danger from reduced ambient pressure in planes.

The sad tale told by "Old Master" is a reminder of the danger of non-recognition of location specific potential problems. The worth of specialist groups in countering such dangers through the training and grading of divers and assessment of dive site skill requirements, as is so well exemplified by the Cave Diving Association, deserves greater recognition. This is a type of self-help no regulations could achieve and reflects the present day realisation by most divers that appropriate training is a prime factor in safety underwater, particularly in dangerous situations.

There are many further matters of interest for readers to discover in this issue: Dr John Knight's paper on Marine Mammals (their diving safety record shows that, given time, Nature can perform "the impossible"), a warning on the intrusion of The Law as a stimulus to careful diving procedures, notice that UMS will now have the benefit of a closer relationship with SPUMS, and up to date information on the search for the Holy Grail of a University cachet for the Diving Medicine Diploma. But none of this will be of value unless you, the reader, feel involved and stimulated by the extending of understanding of the complexities of safe involvement in the underwater world.

MINUTES OF THE EXECUTIVE MEETING
Held at
HMAS PENGUIN on March 20th 1982 at 1700

Present: John Knight, Chris Lourey, Douglas Walker
Apologies: Bill Hurst, Victor Brand, John Doncaster, John McKee

Minutes of Previous Meeting
Read and accepted as correct. (Published in the October-December 1981 Journal).

Business Arising

1. SPUMS has been officially welcomed as a member of the Australian Resuscitation Council. The annual subscription is $50.00
2. SPUMS has been enthusiastically welcomed as an affiliate of UMS. With this affiliation we are entitled to send a *voting* member to the Executive Committee Meetings of UMS and receive free of charge workshop publications and associated scientific data.

Correspondence

1. Letter from Eric P Kindwall MD, President, Undersea Medical Society, welcoming SPUMS affiliation. Action: Affiliation.
2. Letter from Surgeon Rear Admiral BT Treloar, Director General of Naval Health Services, "A Policy Statement by the RAN in respect of a Post Graduate Qualification in underwater medicine".
Action: Published in October - December 1981 Journal.
3. Letter from Dr Brian McLaughlin seeking the Newcastle Underwater Medicine and Barotrauma Society (NUMBS) as a regional sub-group of SPUMS.
Action: Agreed that NUMBS be a regional sub-section of SPUMS.
4. Letters from Sir Phillip Lynch, Minister for Industry and Commerce and Mr Michael McKellar, Minister for Health, stating that due to government policy on health, the establishment of a national unit for decompression sickness, as recommended by the National Health and Medical Research Council is unlikely to be developed in the foreseeable future.
Action: SPUMS to liaise with the Professional Divers Association of Australia to promote a "public awareness" of the need for such a unit.
5. Letter from the Department of Occupational and Environmental Health, Commonwealth Institute of Health to the President of SPUMS seeking SPUMS views and involvement in a new College of Occupational and Environmental Health.
Action: The President has replied conveying the views of SPUMS. Both letters published in this issue.
6. Copy of letter from AUF(Q) to the President on Diving Medical Examinations and Standards. Action: The President has replied. Letter published in this issue.

Treasurer's Report
The investment accounts are as detailed in auditors report, 30th April 1981. The cost of the Journal Supplement (proceedings of the Singapore Meeting) was $2,000. 1982 audit will be conducted on 30th April 1982.

President's Report

The arrangements for the 1982 AGM/Scientific Meeting at Madang, PNG are progressing well. Considerable overseas interest has been expressed in the meeting.

Secretary's Report

The Secretary reported the developments, or lack of, with regard to the establishment of the Central Medical Registry. The next step to be taken is aimed at public awareness through media support.

The Secretary sought leave to explore the possibility of a Joint meeting with UMS, either prior to, or after the International Underwater Physiological Society meeting in Australia in 1983. The venue is to be discussed with UMS at the Executive Meeting in June, 1982. A report on these discussions will be made by the Secretary at the AGM in Madang, 1982.

Journal

The next issue of the Journal will feature the Scientific Agenda of the 1981 AGM.

The December 1981 Supplement (Proceedings of the 1980 Singapore conference) proved so popular that a second printing may be needed.

New Members
New Members applications approved as per the attached list. (Not printed).

Underwater Medicine Courses
Dates published in the October-December 1981 issue of the Journal. Note all applications are to be made directly to the Navy.

General Business
Nil.

Date of Next Meeting
26th June, 1982 at the Madang Resort Hotel.

MEMBERSHIP

Members pay $20.00 yearly and Associate Members $15.00. Associated Membership is available for those neither medically qualified nor engaged in hyperbaric or underwater related research. Membership entitles attendance at meetings and the Annual Scientific Conference and receipt of the Journal/Newsletter.

Anyone interested in Joining SPUMS should write to the Secretary of SPUMS, c/o 80 Wellington Parade, East Melbourne, Victoria, 3002.

QUALIFICATIONS IN UNDERWATER MEDICINE

The Executive Committee has decided to publish the letters below because of the importance of the subject. Comments and opinions from members are invited. Please address letters to Dr John Knight, 80 Wellington Parade, East Melbourne VIC 3002.

Department of Occupational and
Environmental Health,
Commonwealth Institute of Health
in the University of Sydney.

28th January 1982

Dear Dr Knight,

As Chairman of the Education Committee of the proposed Australian College of Occupational Medicine, I write to seek the views of the societies representing aviation medicine and underwater medicine concerning their possible involvement in the new College.

The Australian College of Occupational Medicine is to be established, inter alia, for formulating and maintaining the standard of specialist practice in occupational medicine. It is our belief that not everyone involved in occupational medicine will practice at the specialist level. Thus, a two tier membership is anticipated. An Associate is a physician trained in occupational medicine whilst a Fellow is a physician who opts to practise occupational medicine at the specialist level full-time. At the moment, we are debating the necessity of having a third category of membership, covering those who, though practising occupational medicine full-time at the specialist level, may not have sufficient qualification or experience to justify the use of the title Fellow in Australia. My personal view is that Associateship covers this particular group of people and even if this third category of membership finds its way into the Constitution of the College, it will be for an interim period only.

It is also our belief that aviation medicine and underwater medicine can be considered as special branches of occupational medicine. Thus, the proposed Australian College of Occupational Medicine can accommodate these two areas of medical practice. Being regarded as special branches, training schemes for aviation medicine and underwater medicine have to be modified from that for occupational medicine in general.

Let me first describe briefly the training scheme in occupational medicine. A medical graduate after completing internship is advised to undergo three years of clinical training. Fields such as thoracic medicine, dermatology, haematology, orthopaedic surgery, psychiatry, laboratory medicine etc., are relevant. After that, the doctor should attend a 10-week course in occupational medicine. The Commonwealth Institute of Health will provide such a course in 1982, but other universities can follow suit. Attending a 10-week course will be a requirement for sitting the Associateship Examination of the College. In 1982, the following eight subjects will be examined:

1. Practice of occupational medicine
2. Basic epidemiology and biostatistics
3. Occupational toxicology and disease
4. Occupational hygiene for physicians
5. Work physiology and ergonomics
6. Occupational safety and administration
7. Compensation and rehabilitation medicine
8. Community and environmental health

There is a possibility that some candidates may not be able to get through in the first attempt. Anyway, on passing all the eight subjects, a candidate can apply to be registered as an Associate of the College.

Some Associates, as trained persons in occupational medicine, may opt to practise at that level forever, whilst others may like to undergo a training scheme with a view of becoming a specialist one day. The College will look after this latter group of people as cadet Fellows. A subcommittee of the Education Committee will perform this function, by appointing supervisors to the cadets and co-ordinating the work of the supervisors. Provisionally, this subcommittee may be called the Fellowship Training (Occupational Medicine) Subcommittee.

I see training in aviation medicine and underwater medicine following closely that of occupational medicine until the stage of Associateship. After that, any doctor who intends to specialise in aviation medicine or underwater medicine should attend a further course in that subject. Again, the College will conduct examinations for these two subjects, issuing certificates to successful candidates.

The College can perform such a function by setting up two more subcommittees in its Education Committee: Aviation Medicine (Training and Examination) Subcommittee and Underwater Medicine (Training and Examination) Subcommittee. These Subcommittees have the following functions:

1. Setting the syllabus of the course
2. Approving training organisations
3. Conducting the certificate examinations
4. Looking after the cadet Fellows

Like occupational medicine, not all doctors interested in aviation medicine or underwater medicine will opt to practise at the specialist level. Those not intending to become specialists finish by becoming Associates of the College with Certificate in Aviation Medicine or Underwater Medicine. Once the College becomes established and definite training schemes in Australia guaranteed, then and only then can we sell the idea to the government and the union that all statutory medical examination for workers should be done by Associates or Fellows of the College and all statutory medical examination in aviation medicine or underwater medicine should be done by Associates or Fellows of the College possessing the relevant certificates.

Though not many doctors in Australia will take up full-time specialist practice in either aviation medicine or underwater medicine, the medium is there for them to qualify as Fellows within the College of Occupational Medicine.

I have written this letter in consultation with my colleague, Associate Professor Tom Ng who I understand has worked closely with the RAN School of Underwater Medicine and the South Pacific Underwater Medicine Society in formulating postgraduate training schemes in underwater medicine in Australia in the last two years. A number of difficulties have been encountered and learning from experience, Tom and I believe that the ideas outlined in this letter are feasible and operable.

We should therefore be grateful for your views and comments, and hope to get your support for making the proposed College a SUCCESS.

Yours sincerely,

David Ferguson
Professor of Occupational
and Environmental Health

9th March, 1982

Dear Professor Ferguson

Thank you for your long letter of 28th January 1982 outlining your views on the Australian College of Occupational Medicine. I am writing to ask for further information and to outline the position of SPUMS as I see it. Your letter, and hopefully your reply to mine, will be presented to the Committee at its next meeting.

The following observations are general, as the last report from Dr Beryl Turner, who was representing both the Navy and SPUMS in the discussions, is now over a year old.

I would suggest that consideration be given to changing the title of those who hold the basic qualification from Associate to Member of the College. This would make it more in line with other Colleges. This would also make it sound a better, more worthwhile course.

The course, as I understand it from your letter, is ten weeks, which will give everybody except those interested in Underwater or Aviation Medicine a Diploma as an Associate of the College. It appears that Underwater Medicine and Aviation Medicine would be, in effect “post graduate” parts of the Associateship examination of the College. I think it unlikely that very many people will want to do a ten week course to obtain the Diploma of Associateship and then still have to do a course at least the equivalent of that run by the RAN, which is two weeks introductory course and two weeks advanced course. Almost all the doctors interested in Underwater Medicine are either in the Navy, which is chronically under-doctored and therefore unlikely to send many people to do the ten week course, or in private practice and cannot afford to ten weeks off from the practice to do the course. Some doctors find that they have to do the naval courses over two years because of practice commitments. Is there any mechanism envisaged for allowing candidates to take the course in multiples of two weeks?

There is, as far as I know, only one full-time Underwater Medicine job in Australia, the Officer-in-Charge at the School of Underwater Medicine at HMAS PENGUIN, which could be regarded as a specialist Underwater Medicine appointment by your definition. This job is held for two or so years by any one person. There is at times a second full-time medical officer at the School, who is under training and may succeed to the post of Officer-in-Charge. The Woodside Development in the North West of Western Australia will employ doctors with knowledge of Underwater Medicine, but they will also be employed on other occupational and general medical tasks in the area, so by the definition of your letter, they would not count as specialists in Underwater Medicine. However, some of them may have the knowledge and expertise to be classified as specialists. Also in this group are those recognised as specialists in Underwater Medicine by the RAN, many of whom have left the Navy, and a few other practitioners with special experience. What programme is envisaged to convert an Associate into a Fellow? What will be the attitude of the College to the creation of a Fellow (UWM) every two or three years, who then leaves full time Underwater Medicine?

There is an urgent need to spread throughout the medical profession in Australia knowledge of Underwater Medicine as SCUBA diving for fun is a rapidly growing sport. Unfortunately, not much is mentioned about the problems of Underwater Medicine in the medical courses at Australian universities and most doctors know nothing about Underwater Medicine. It is unfortunate that those who want to learn, find that ability to learn is curtailed by the limited number of places in the RAN courses. These are recognised internationally as being of a high standard. Service medical officers get preference when places are allocated so there are about five places a year available to civilians.

Some years ago, Dr Carl Edmonds, who had been Officer-in-Charge at the School of Underwater Medicine, ran courses which lasted for one week in various diving resorts. These gave doctors an opportunity to learn basic Underwater Medicine. However, I am not aware of Dr Edmonds having run a course for at least two years and I understand this is because there were insufficient applicants to cover costs. Owing to the limited number of places available at the RAN School of Underwater Medicine for civilian doctors to learn about Underwater Medicine, the obvious answer is for the College to organise a course in Underwater Medicine. It will, of course, have to be of equivalent standard to that run by the RAN. The cost would be considerable. Would the costs of such a course be borne by the College or would they be passed on to the candidates?

An integral part of the RAN course is practical experience of firstly, diving, and secondly, recompression chamber management. It might be possible to come to some arrangement with Dr Unsworth of the Hyperbaric Department at Prince Henry Hospital or with the owners of the Underwater Training Centre in Sydney for practice with a chamber. However, where one would be able to provide diving experience with as many different types of diving gear in as suitable and safe conditions as at HMAS PENGUIN I do not how.

SPUMS has been issuing a Diploma in Diving and Hyperbaric Medicine for the last seven years. These have only been issued to people who have demonstrated that they have considerable knowledge of Underwater Medicine. They have completed at least the two courses at the School of Underwater Medicine, and the course in Hyperbaric Medicine run by Dr Unsworth at Prince Henry Hospital and passed an examination. Beyond this, the requirement has been six months full-time employment, or equivalent part-time, in diving or hyperbaric medicine. Almost all the holders of the Diploma have had experience as medical officers at either the School of Underwater Medicine or in diving operations for other Navies. As you can see this involves a much greater commitment than a ten week course. It is of interest to the Society as to what qualification, under what grandfather clause, is going to be offered to the holders of this diploma, most of whom could be described as non-full-time specialists in Underwater Medicine.

Coming on to applying pressure to the Government to have all examinations for Aviation and Diving Medicine performed by Associates of the College, I would point out that the Government does not allow Medical Benefits to be paid for Diving Medicals or for Aviation Medicals, regarding these as either screening tests or a cost of earning one's living. The Government already limits doctors doing aviation medicals to those approved by the Department of Transport. The Professional Divers Association of Australasia recommends to its members only a few doctors in each State as being suitable for carrying out diving medicals on its members. There is no legal requirement for anyone other than a commercial diver to have a medical.

It appears to me that major problems for the College are:-

1. That the RAN is the only current source of expertise in Underwater Medicine.

2. RAN courses have only a few places for civilians each year.

3. The RAN School of Underwater Medicine has the only Underwater Medicine Library in Australia.

4. The RAN courses are free or at most a nominal fee is charged.

I would much appreciate clarification of the difficulties encountered in negotiations with the RAN and SPUMS as we have no reports since October 1980, when to the best of my knowledge things were going smoothly.

I would stress that SPUMS is very much in favour of an academically respectable qualification in Underwater Medicine.

Yours sincerely,

John Knight
President SPUMS

Commonwealth Institute of Health
in the University of Sydney

30th March, 1982

Dear Dr Knight,

Thank you for your detailed letter of 9th March 1982. There are many matters in it that demand response. I copied the letter to the Chairman of the College Steering Committee, Dr David Douglas, because most of the matters concern the future College rather than me as Convenor of its Education Committee.

I shall therefore ask that the issues raised be debated by the meeting of the Steering Committee to be held in Melbourne on 5th April. Either David Douglas or I will respond to your letter.

Yours sincerely,

Professor David Ferguson, MD
ACTING DIRECTOR

Commonwealth Institute of Health
in the University of Sydney

29th April, 1982

Dear Dr Knight,

Further to my letter of 30th March 1982, the issues you raised in your letter of 9th March 1982, were not debated at the meeting of the Steering Committee of the College on 5th April 1982, because the College had not, as expected, been incorporated already. I have resolved, therefore, to answer some points in a personal capacity, with the intention that your letter be debated by the future Board of Censors of the College when it meets. I deal with your points as they arise.

The consensus from the various colleges with whom we have had discussions is that in Australia (as distinct from Britain) the ordinary member is the fellow. This member is a recognised specialist practitioner (in our case, in occupation or underwater or aviation medicine), although there may also be honorary fellows not so qualified. A college which exists for training and recognising specialists does not include lower order members except trainees on their way to becoming specialists. The Faculty of Occupational Medicine in Britain has only Members (specialists) and Associates (trainees), the Fellows being persons of distinction. Some Associates in the Australian College may not progress to Fellow. As forecast in my previous letter, the Steering Committee of the College did opt for a Member category which will be phased out in a few years.

I am sorry that my letter was not clear on the diploma which is to issue from successful completion of our ten week course. The course is to be conducted by the Commonwealth Institute of Health. While the College may approve it for its own purposes, the course remains a course of the Institute, to which non-College aspirants may be admitted. The College may also approve any other course of any other institution which meets its standards. The Institute will award only a certificate of satisfactory completion of its course. The examination in 1982 will be conducted by the Institute because the College is not yet constituted to conduct it, though the College may recognise it subsequently.

In future, the College is likely to conduct its examinations in various capital cities once or twice a year, and various academic institutions, including our own, will almost certainly time courses in relation to the examinations. Almost certainly there will also be part-time courses in some institutions. The Institute, being a national body, necessarily must run full-time courses, though splitting over two or three years may be possible. The examination of the College may well be in units which can be sat for separately or in groups.

The would-be specialist in Underwater or Aviation Medicine will undertake the associateship examination of the College just like any aspirant in occupational medicine. The specialised training in underwater or aviation medicine would be undertaken in the fellowship training phase, the details of which have yet to be made final. If practitioners in underwater or aviation medicine do not wish to proceed to full specialist training, they will of course be accredited separately with having satisfactorily completed the additional courses in their special subjects.

As I have just said, the training program from Associate to Fellow is not yet final. In my opinion, trainees should each have an individual program so that it is possible for people from widely varied backgrounds still to be accommodated, including, for example, specialists in underwater medicine who have left the Navy. This example is a reason for basic general training in occupational medicine.

I agree with you about the need for more opportunities for training in underwater (and aviation) medicine, a problem that the new College will have to address in collaboration with the appropriate specialised societies and government and other bodies.

I cannot predict what qualification the College will offer to holders of the Diploma in Diving and Hyperbaric Medicine. The crux is not purely the diploma, though it would contribute importantly to the decision, but rather the professional background of the person, his or her qualifications and experience in occupational medicine of whatever sort (military, industrial, etc.). It is difficult to accord specialist status to non-full-time practitioners in a special field.

I suggest discussions with David Douglas, President of the Interim College Council, when you are ready.

Yours sincerely,

Professor David Ferguson
ACTING DIRECTOR

SPUMS MEETING AT HMAS PENGUIN, 20 MARCH 1982

This interesting meeting, well organised and run by Dr Peter Sullivan, was attended by an appreciative and responsive audience. It is a great pity that so small a proportion of the NSW membership were able to attend. Cruel commercial realities foiled an attempt to have the attendance of non-SPUMS diving instructors, the meeting clashing with a prime time for diver training.

The opening speaker was Dr Ian Unsworth. He first reported the case of a hookah diver who ascended too rapidly, omitting the required "stops" and suffering PBT. He experienced chest discomfort, a feeling of fullness, at the surface, so attempted self cure by taking a scuba tank and descending to make a 20 minutes stop at 20 feet. On returning to the boat after this he noted pain in the root of his neck, some difficulty with swallowing, and a voice change. His response was to return home for a hot shower before attending hospital. It was noted there that he had some left neck surgical emphysema and subjective (rather than objective) breathing difficulty. Chest X-ray did not show any pneumothorax. He was treated by recompression, in part because of the reported dive profile.

His second case was an unusual clinical problem. It was known by hearsay to many and reporting of the facts was particularly welcome to the audience. The unfortunate victim was a healthy 22 year old, a participant in many sporting activities, who was at a pool training session practicing buddy breathing in about 5 feet deep water. He was seen to stand up and leave the pool prematurely, saying that he "felt peculiar". He later said that he had suffered from a severe pain in the occipital and frontal regions while on the pool floor. About fifteen minutes later he collapsed and the divers present noted signs of a right hemiparesis, which they took to be the result of an air embolism. He was given oxygen by mask and rushed to the nearest hospital. A chest X-ray was NAD and his symptoms and signs had all resolved save for a mild headache when seen at the Casualty Department, but he was kept under observation for a time in the Intensive Care ward. There he was given a bolus of Decadron (100mg) and oxygen by mask. He was allowed to return home late that night, symptom free. He was found early next morning, semiconscious, with a right sided hemiplegia and decerebrate behaviour. A CAT scan was negative, as was a lumbar puncture test. He was treated by Table 6 in the RCC, a course designed to flood the presumed damaged areas of the brain with oxygen rather than representing a diagnosis of air embolism. Response was slight. Angiograms were arranged later and the left vertebral angiogram indicated the existence of a basilar artery thrombosis. Subsequent progress has been slow and significant residual damage affecting speech and the lower limb has resulted. This is thought to be an example of idiopathic thrombosis occurring in a diving situation, the victim's description of events supporting the diagnosis.

Surgeon Lieutenant Colin McDonald gave a talk on some of the medical problems associated with life in the submarine service, which include a merciful reduction of olfactory sensitivity. The space-limited environment has acoustic as well as olfactory pollution problems, and the continued ophthalmic accommodation to the nearness of everything has long term effects in some. Management of the air to remove contaminants is naturally critical, and sudden pressure changes while "snorting" can produce troublesome barotrauma. It is obviously a lifestyle not to everyone's taste.

The paper on asthma and diving, by Dr Douglas Walker, was successful in its purpose of stirring up a vigorous discussion. It was soon apparent that many people were greatly interested in discovering whether every degree and type of asthma should be regarded as an absolute bar to undertaking any type of use of compressed air breathing apparatus for diving. This aspect of the discussion concerning Fitness to Dive guidelines is certainly far from being finally settled in the minds of many.

In-water therapy for DCS was the theme chosen by Dr Peter Sullivan for his paper. He reported a local case where an out-of-air situation necessitated the ascent of a scuba diver without the required decompression stops. At the surface he obtained a fresh tank and then descended to make the stops he had omitted. A few minutes after surfacing from this dive he experienced multiple joint pains. His buddies helped him to "treat" this problem by taking him to 60 feet for 20 minutes, then 10 feet for 10 minutes. The relief he experienced on descent was replaced by increased pain on ascent. Nevertheless he went home to bed, not coming to the RCC for treatment till the next day. Poor results from attempts to undertake in-water air therapy are usual, though success occasionally results. He quoted an example of such an outcome from overseas, a Thai diver who suffered right hemiplegia (a Type II DCS) after a no-stop ascent from 23 minutes at 80 feet. The in water treatment left him with only mild bends pains, a good result in the circumstances. The use of in-water oxygen, particularly as a prophylactic rather than a therapeutic option, is a quite different proposition to the use of air.

Dr John Knight spoke on the use of oxygen and cautioned users on the need for the diver to be seated in a chair rather than the bight of a rope as this was much more comfortable and reduced the chance of obstructing the circulation in the lower limbs. Good communication between diver, buddy and topside was a necessity also, improving both morale and monitoring of the treatment.

The last speaker was Mr John Pennefather. His description of the problems of designing an improved rebreathing set must surely have convinced his audience, had they needed convincing, that there is no place for the homemade set. It is thanks to the painstaking work of such "backroom boys" than modern diving equipment withstands the rough treatment meted out to it by divers. They cannot make it foolproof, but they keep on trying!

The meeting concluded with a discussion of present problems encountered in trying to set up knowledge standards in Diving Medicine. The natural penny-pinching (cent care?) of the Government whereby medical examinations of Fitness to Dive were not allowable on Medical Benefits Schedules was noted. The reasons were appreciated, but ... perhaps someday a way will be found to acquire the standing of a Medicheck, and the same refund status.

Australian Underwater Federation,
Queensland Branch.

February 25, 1982

Dear Dr Knight

SPORTS DIVING MEDICAL EXAMINATIONS

I recently read your letter to the Editor in the July-September issue of the SPUMS Journal. Several aspects present themselves from your article and I would like, through my position as State Director of Coaching, to promulgate information to the Clubs and divers of Queensland.

Firstly, is there a list of doctors with knowledge of underwater medicine who can adequately carry out a diving medical, or should individual instructors in non-metropolitan areas try to discover a "likely"?

Would you please confirm your recommendations that medical examinations are not necessary at less than 3 year intervals if no illnesses, other than the common cold, etc., are contracted?

I am enclosing a Diving Medical Form and would ask you to indicate those sections you consider unnecessary for the examination of a sports diver. I will then submit your recommendations to the AUF with a request for revision of the form so that diving medicals are more appropriate as well as cost/value efficient.

.May I also reproduce your "Advice to Examining Physicians" and have a copy sent out with all medical forms issued by the AUFQ?

As I am also a FAUI instructor I will pass on the information you send me so that fellow instructors are aware. I anticipate that the FAUI Queensland Region would also take up the case of medical examinations being properly conducted by qualified or capable physicians, having regard to the most appropriate time interval and format of examination.

Although it is probably disappointing for you to have done the same thing two years ago, please be assured that I will take action based on your suggestions so that everybody involved in the sport my benefit.

Yours faithfully,

Neil S Dearberg,
STATE DIRECTOR OF COACHING

THE REPLY

Dear Mr Dearberg,

Thank you for your letter of 25.2.82. I will pass a copy on to Dr Chris Lourey, the Secretary of SPUMS, who has the membership list and so can advise you about suitable doctors outside Brisbane.

In my opinion there is no need for a full medical at less than 3 year intervals if no illnesses, other than the common cold, occur. The BS-AC, which is a very regulated organisation, requires medicals on joining the club, and then at 5 year intervals to the age of 30, then 3 yearly till the age of 50 and annually thereafter.

The matter of appropriate medical is to be discussed at the SPUMS Annual Scientific Meeting in Madang in June. It would be best to defer any changes to the Diving Medical Form until after that meeting, when we hope to get a fair measure of agreement among Australian diving doctors.

I will be very happy for you to reproduce my “Advice to Examining Physicians” for handing out with the medical forms issued by AUFQ.

Yours sincerely,

John Knight
PRESIDENT, SPUMS

PROJECT STICKYBEAK

Send incident reports to

DR DG WALKER
PO Box 120
NARRABEEN NSW 2101

US AIR FORCE EXPERIENCE WITH SCREENING FOR CORONARY ARTERY DISEASE IN FLYERS

Peter S Wilkins
Wing Commander RAAF

The US Air Force (USAF) has an extensive collection of aircrew electrocardiograms. The central USAF ECG library at the School of Aerospace Medicine has over a million recordings stored in microfiche and computer software formats. All recordings are assessed by staff cardiologists. During its 20 years of existence, the Central USAF ECG library has been a valuable research resource as well as a diagnostic aid. However, until a few years ago, the library contained only resting cardiograms.

During 1977, two incidents provided dramatic demonstrations of the poor predictive capability of a resting EGG in relation to acute coronary incapacitation. In that year two USAF fighter pilots suffered acute myocardial infarcts in their cockpits, one of them actually expiring during his aircraft’s landing roll. Both pilots had recent ECG’s on file which were interpreted as normal.

The USAF became understandably concerned at the prospect of unpredictable inflight myocardial infarcts causing pilot incapacitations with potentially catastrophic consequences. As new generation, very high performance single-seat aircraft were entering their inventories, Tactical Air Command and USAF in Europe medical services determined to overcome the problem.

In an excess of zeal, Tactical Air Command and USAF in Europe required all their rated aircrews aged 35 or more to undergo annual stress electrocardiograms. All flyers who had abnormal results were grounded and referred to the School of Aerospace Medicine for full evaluation. This program quickly imposed a prodigious strain on medical and operational resources. Large numbers of flyers needed base level processing, the School of Aerospace Medicine received up to ten aircrews per month for assessments and these scarce, mission-ready pilots and navigators each averaged over a hundred days of grounding. In the two years the program operated, only one subject in 20 who underwent exercise testing recorded an abnormal result and only one in 300 who underwent the testing was permanently grounded as a result of abnormalities thereby detected.

Tactical Air Command then collaborated with the School of Aerospace Medicine to develop a rational Stratified Screening Program based on the Framingham Study’s risk equation, modified in accordance with the School of Aerospace Medicine’s own, new data derived from a healthier population. The Stratified Screening Program screens individuals before they begin aircrew training, at ages 30 and 35, then annually. The aims of screening are:

(a) to identify individuals with true coronary artery disease,

(b) to detect individuals apt to develop true coronary artery disease, (ie. already having subclinical coronary artery disease), and

(c) by modification of risk factors, to try to prevent progression of coronary artery disease.

The Stratified Screening Program has much simplified most assessments. Most applicants require only Phase 1 processing, wherein each subject has a baseline assessment of risk factors (age, height, weight, blood pressure, fasting blood sugar level, triglycerides, total cholesterol and high density lipoprotein cholesterol, smoking history and history of coronary artery disease in close family). Additionally, a standard 12 lead ECG is recorded, (in the fasting, rested state, after no smoking for at least 12 hours). The ECG, annotated with the data above specified, is reviewed by the examining flight surgeon as part of the subject's annual flying physical examination, then forwarded to the Central USAF ECG library for central interpretation and filing. If the ECG contains an abnormality or the modified risk equation suggests an unacceptable risk level, the attending flight surgeon or the School of Aerospace Medicine can direct Phase II or III processing.

In Phase II of the Stratified Screening Program, the selected subject undergoes a locally arranged stress ECG. Testing involves maximal exertion on an inclined treadmill following the Bruce Protocol. Post exercise tracings are made for at least six minutes after the test. Very precise testing criteria have been adopted to insure comparability of results, wherever recorded. A local cardiologist/internist interprets the exercise tolerance test and a copy is forwarded to the Central USAF ECG library for definitive interpretation and filing. Significant abnormalities on this exercise tolerance test will prompt a Phase III evaluation for the subject.

The Clinical Sciences Division at the USAF School of Aerospace Medicine conducts detailed cardiology investigations on subjects referred for Phase III evaluations. Maximal treadmill exercise tolerance test, echocardiography, thallium scintigraphy and coronary artery catheterization when necessary, are performed. Anyone who passes such a School of Aerospace Medicine evaluation can be safely assumed to be as cardiologically fit for flying as state-of-the-art medical diagnosis can determine.

CORONARY ARTERY RISK EVALUATION TABLES*

Relative risk of developing heart disease in six years by age group and specified characteristics

35 Year Old Man

	Non-Smoker						Smoker					
Systolic Blood Pressure	105	120	135	150	165	180	105	120	135	150	165	180
Cholesterol												
185	1.0	1.3	1.7	2.0	2.3	2.7	1.7	2.0	2.3	3.0	3.7	4.3
210	1.7	1.7	2.3	2.7	3.3	4.0	2.3	3.0	3.3	4.0	5.0	6.0
235	2.0	2.7	3.0	3.7	4.7	5.3	3.3	4.0	5.0	6.0	7.0	8.3
260	3.0	3.7	4.3	5.3	6.3	7.7	4.7	5.7	7.0	8.3	10.0	11.7
285	4.3	5.3	6.3	7.3	9.0	10.7	6.7	8.0	9.7	11.7	14.0	16.7
310	6.0	7.3	8.7	10.7	12.7	15.0	9.3	11.3	13.7	16.3	19.3	23.0
335	8.7	10.3	12.3	14.7	17.7	21.0	13.3	16.0	19.0	22.7	26.7	31.7

40 Year Old Man

	Non-Smoker						Smoker					
Systolic Blood Pressure	105	120	135	150	165	180	105	120	135	150	165	180
Cholesterol												
185	1.0	1.3	1.6	1.9	1.9	2.7	1.7	2.0	2.4	2.9	3.4	4.1
210	1.4	1.7	2.0	2.4	3.0	3.6	2.1	2.7	3.1	3.9	4.6	5.4
235	1.9	2.3	2.7	3.3	4.0	4.7	3.0	3.6	4.3	5.1	6.1	7.3
260	2.6	3.1	3.7	4.4	5.3	6.3	4.0	4.7	5.7	6.9	8.1	9.7
285	3.4	4.1	5.0	5.9	7.0	8.4	5.3	6.3	7.6	9.0	10.7	12.7
310	4.6	5.4	6.6	7.9	9.3	11.1	7.0	8.4	10.0	11.6	14.1	16.7
335	6.1	7.3	8.7	10.4	12.3	14.6	9.3	11.1	13.1	15.6	18.4	21.6

45 Year Old Man

	Non-Smoker						Smoker					
Systolic Blood Pressure	105	120	135	150	165	180	105	120	135	150	165	180
Cholesterol												
185	1.0	1.2	1.4	1.7	2.1	2.5	1.5	1.8	2.2	2.6	3.1	3.7
210	1.3	1.5	1.8	2.1	2.6	3.1	1.9	2.3	2.8	3.3	3.9	4.7
235	1.6	1.9	2.3	2.7	3.3	3.9	2.5	2.9	3.5	4.2	5.0	5.9
260	2.0	2.4	2.9	3.5	4.1	4.9	3.1	3.7	4.4	5.3	6.3	7.4
285	2.5	3.1	3.7	4.3	5.2	6.1	3.9	4.7	5.5	6.6	7.8	9.1
310	3.3	3.9	4.6	5.5	6.5	7.7	4.9	5.9	6.9	8.2	9.7	11.3
335	4.1	4.9	5.8	6.9	8.1	9.5	6.2	7.3	8.7	10.1	11.9	13.8

* Modified from the Framingham Study

At any stage in the Stratified Screening Program, a significant ECG abnormality (resting or on treadmill) or elevated risk factors can cause a subject's temporary grounding pending definitive assessment of his status.

In the first 12 months' experience of using the Stratified Screening Program in Tactical Air Command, only 23 exercise tolerance tests were adjudged abnormal and only two aviators were permanently grounded. Moreover, temporary suspensions from flying have been shortened to less than six weeks each, on average.

MINIMAL REQUIREMENTS FOR ADEQUATE MAXIMAL EXERCISE TOLERANCE TEST USED FOR SCREENING FOR LATENT CORONARY ARTERY DISEASE

1. Fast for 12 hours prior to test (no meals, coffee, cigarettes, or other tobacco products).
2. If possible, perform test early in the morning shortly after patient wakens.
3. Insure serum potassium is normal.
4. Perform the following baseline studies: fasting 12 lead ECG and supine and standing hyperventilation sample of the leads which will be monitored throughout the exercise.
5. Include at least lead V5 at the end of each stage. Ideally, all 12 leads should be recorded every minute.
6. Accurately record all leads, stages of exercise and blood pressures during each stage of the stress test.
7. Exercise tests should be maximal, limited primarily by symptoms (usually leg fatigue).
8. Include at least six minutes of recovery tracings with the exercise ECG.

The major benefits of the Stratified Screening Program are:

(a) flyers not having increased risk of coronary artery disease are not subject to additional screening procedures, and

(b) reduction in number of "false positive" results requiring flyers to undergo full School of Aerospace Medicine evaluation.

Tactical Air Command believes the present Stratified Screening Program is a valuable predictive tool. It has been adopted now by USAF in Europe, and the USAF's Pacific Air Forces. Further refinements in the program should be possible as experience increases and historical data accumulate. Aircrew acceptance has been excellent, due to publicity given to the need for the program and the high "return rate" of flyers investigated even at Phase II and III levels. The Stratified Screening Program should have considerable future applicability in military aviation medicine practice.

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WILL YOU BE DAMNED IF THEY SUE?

Douglas Walker

Until recently divers in the UK and Australia, particularly those involved in Sport diving, had a secure feeling of somewhat condescending superiority when they discussed their fellow divers in the USA, a tribe seemingly living in constant fear of having a $1 million lawsuit slapped on them at the drop of a weight belt. It did not seem to be necessary to do more than give someone a helping hand before being lumbered with a lawsuit by relatives and lawyers flush with a disposed-of dearly beloved and a thirst for cash. The recently reported case in the UK where two highly trained, respected and more than averagely careful divers ended up defending themselves in the High Court shows that the Days of Innocence are over in the UK, and presumably the "let's sue" habit will soon come here. Do not rely on a ten year or so time lapse for such matters, rather learn and take appropriate care NOW. Remember the advice given to young girls (at least before the days of Supporting Parents Pension) "If you can't be good, be careful".

In these days what degree of care is expected of a dive shop, instructor, or chance buddy? Only time, and a Court of Law can say, but it is unlikely that the hire or loan of compressed air type diving apparatus, whether in good or poor condition, will be thought reasonable unless the recipient is reasonably believed to be competent to use it. Past Incident Reports may be thought to relate to the "hairy" days of diving before the value of adequate instruction and practice became accepted, before the value of using contents gauges and efficient buoyancy vests became the norm rather than the exception. The standard of care expected has risen, and will continue to rise.

Litigation often hits the good guy who makes an honest mistake, but careful attention to presently accepted practices of safe diving is the essential weapon your lawyer will require from you. Getting your customers to sign an indemnity form will hardly be a valid defence if they can be shown not to appreciate the dive's possible dangers, as there would be (arguably) an absence of informed consent and understanding. Or so the tale might go, and who wants to be a test case in our High Court? Leaving aside what may have occurred in Australian waters, we can look at a case reported in the USA as a warning to dive shop operators to keep up their Insurance. In a country where more pupils die yearly under instruction than die from all causes in Australian waters, it is ironic that the case appears to confirm the belief that it is the good guys who get it in the neck.

The victim went to a dive store and booked for a boat dive, at the same time hiring equipment of a type with which he was acquainted. His C-Card was checked before the transaction was finalised and the equipment itself was checked in the store before a witness before being handed over. On the boat all the divers were informed of the boat and dive rules before diving commenced. The boat was licenced for such commercial dive trips. At some time later the victim was seen to surface about 100 feet from the dive boat with mask up on his forehead. He was alone and was seen to wave twice, then submerge. Water conditions were calm. These events were observed and a search was initiated. He was reached within four minutes of his disappearance and on the boat within six minutes. Both the store employees on the boat were trained in CPR, which was immediately begun. The Coast Guard, with two paramedics, arrived sixteen minutes from the commencement of the incident. The victim was noted to have air remaining and to have neither inflated his buoyancy vest nor dropped his weight belt. No details are known about the dive or the buddy's version of what had occurred, but this sounds like a classical air embolism fatality following a panic type ascent, "topside" having done everything reasonable. But the deceased's relatives thought than a lawyer could make their loss bearable and summonses were issued.

The claim was made on a number of grounds, consideration of which could be salutory to everyone in a position of responsibility in a diving situation. The dive shop in this fatality appears to have an excellent defence (and insurance to pay a good lawyer!), but nevertheless the charges were made viz, that they failed to instruct the deceased in the proper procedures for scuba diving, failed to determine whether prior to the incident he was competent to perform the dive in question, failed to properly instruct the deceased AND HIS DIVING BUDDY as to the procedures of the "buddy-system" when one diver is in trouble, and failed to properly instruct the employees on the boat as to the proper supervision of the divers from the boat to determine if they were in trouble. It was charged that there was also failure to rescue the diver when he was in trouble and failure to maintain the equipment of the deceased and of the others. This is known as a blunderbuss charge, fired with the hope that some chink in the defence will thereby be discovered. To add to the entertainment, the buddy was sued also. He was charged with "the duty to use due care in observing the location and condition of his diving partner and breaching the duty when he failed to observe than the deceased was in desperate trouble". The dive store is expecting to present a successful defence, but the buddy is less well placed if such a charge is pursued, the cost in cash and worry being high even if he should be exonerated. Perhaps he should counter claim against the estate of the deceased for being put in personal jeopardy himself and for the mental stress, etc. caused by the litigation. As it is said to be cheaper to kill than injure on the roads of the USA, he just might come out on top. It is mind boggling to try to imagine the dive conducted in accord with total legal safeguards. One would never dive except alone with one's own apparatus made by oneself, as would have been the compressor. Naturally nobody would be fool enough to stick his neck out by training and certifying to your competence. Which is absurd. But LIABILITY is here to stay and the best defence is to always act in a manner your peers would defend against a lawyer armed with hindsight and a Diving Manual. You have been warned!

ADDENDUM

A newspaper report on the inquest held recently in Cairns concerning the death of a day-trip tourist diving with hired equipment indicates the urgent need for the application of stricter safety standards. The victim and his wife were on an advertised trip to an offshore tourist resort. As an added attraction, scuba diving equipment was available to anyone who paid extra. The couple had only once previously used scuba, ten days previously in shallow water. They were provided with equipment and allowed to descend to 50 feet depth at the boat's side before commencing an underwater swim towards the reef area shorewards of them. There was another customer, but he gave up when aware of the dive situation. The "instructor" from the boat swam on ahead of the two others, but swam back hurriedly when he observed that the victim was motionless underwater. It was stated that the buoyancy vest was lacking a CO_2 cylinder and that the regulator was functioning imperfectly. The Coroner recommended that the Queensland Government legislate to prevent such a situation being allowed in the future.

SPUMS SCIENTIFIC CONFERENCE 1981

MEDICAL SUPPORT FOR DIVERS IN NEW ZEALAND

Tony Slark

New Zealand is a small country and we have a very centralised system for controlling commercial diving. This is only inhibited slightly by rivalry between government departments, which seems to be a problem with government departments everywhere. The Department of Labour has the administration of the Construction Act, the legislation which covers work under water. There is in the Construction Act a requirement for the Department of Labour to produce a code of practice for the worker under water. This is under constant revision. It was revised again at the end of 1980. It follows very much the pattern of the past and has only got a few vital changes which some of us were influential in making.

The other Department concerned is the Department of Energy. This is a very important Department in New Zealand and one which likes to retain it autonomy. Often it refuses to co-operate with the Department of Labour in trying to control the legislation and management of people who work under water. Their reasons for this are difficult to understand. I suppose that they feel in view of the relatively few people involved that their present management is as good as possible. In theory, they review every single contract, note the way that the contract is managed, and send people out periodically to see that everything is alright. It works less well in practice because occasionally things happen that should not happen and no-one ever tells them about it, while some supervisors manage things in a way that is quite improper. I have heard some quite horrific stories of divers who were following dive profiles and patterns which were manifestly quite improper. Sometimes great pressure has been put upon individual divers to work in a situation which they individually consider to be quite unsatisfactory. Indeed, I know of one supervisor for a large international company who threatened to sack the whole diving team if they would not go underwater in conditions that were not satisfactory. It was only the strength of character of one of the senior divers, who reckoned that he knew more about diving than the supervisor, that prevented this happening.

This is a difficulty of all the operations that come within the scope of the Department of Energy, which deals with all mining, the petroleum investigations and gas installations. On the other hand the Department of Labour has diving fairly well controlled.

We have a system whereby every qualified doctor can examine people for fitness to remain upon the list of construction divers. We gave some thought to following the British pattern, where the doctors are approved and listed. We thought that, in New Zealand, it would be impossible for every single diver who wished to get a proper medical examination to be in a location that would enable him to be seen by a doctor who was on the list. So we decided that we would, as in the amateur diving form that we use, put on one sheet of the diving form, the specifications of the medical examination that we required and the sort of investigations that we wished to be performed. The completed diving forms are sent to the consultant to the Department of Labour. He vets the forms and then advises the Department of Labour on the suitability of that individual to remain upon the list of construction divers. As with civilians we also say fit to dive under all circumstances or fit to dive under certain specified limitations, or with special supervision. For instance, if when one sees an audiogram with a decrement in the higher ranges, one puts down on the form that the diver should not be exposed to loud noises without hearing protection. Now how the diver, and the Department and the company supervisor get around that is their business and the business of the safety supervisor of the Department of Labour, who knows that the specification has been made.

The medical examination is fairly comprehensive. It is the same pattern as the rest of the world. We require, as well as the full history and examination, a history of the previous year’s pattern of diving, the amount of diving performed and the sort of diving. We require audiometry, spirometry and chest X-ray. Other X-rays are at the discretion of the consultant to the Department of Labour. We have gone away from long bone surveys in every case, because I felt that they were unnecessary, unrewarding and very expensive and possibly in the long term, even a bit dangerous.

The diver is informed of the decision by the Department of Labour. If fit, he is on the list and may perform work in accordance with the Construction Act in the following year. To stay on the list he has to repeat the examination again the following year.

As far as the supervision of the diver on the job is concerned, the diving contractor is required to have a designated practitioner who should come from a list compiled for the Department of Health. This list includes only those doctors who have been approved by the consultant to the Department of Health. The criterion that is used is a fairly general one, in that he requires them to be members of UMS and SPUMS. Sometimes if he knows the doctor concerned is interested in the subject, he may waive the more expensive requirement of UMS membership and accept the membership of SPUMS. The doctor must be known to be interested in diving medicine and to have a continuing interest in it. We are allowed to be fairly self-selective, which I think is a reasonable attitude in a small country which has a relatively small number of doctors, where the special interest can be readily known to the central authority.

A firm conducting diving operations under the Construction Act regulations has to have a designated practitioner. They must also inform the local hospital through that designated practitioner about the procedures they wish to take in the event of a diving emergency. Over and above that there is reference to the Naval Hospital or, in the South Island, to the two interested consultants at the hyperbaric unit in Princess Margaret Hospital, Christchurch. Both are very capable divers and very capable diving physicians.

One group I have not mentioned are the divers of the Department of Fisheries. They follow exactly the same pattern as those in the orbit of the Department of Labour. The Department of Fisheries also has a consultant to the Department, who vets the divers’ examinations as does the consultant to the Department of Labour.

So it is a fairly mixed affair, which only goes wrong when maverick firms come in from overseas, supposedly with overseas advice and consultants, who may or may not be known to us in New Zealand and with absolutely no concern for the local scene. This happens, and divers get injured, extremely badly injured, because of it. One died because of quite inadequate management and hopeless back-up support. When things started to go wrong on this rig, where they were doing unnecessary dives for long periods with unfit divers and a complete absence of training, the only treatment offered to the dying man was 5 mg of Valium orally. The consultant to that diving firm was in Houston (Texas). I think it was an absolute scandal that the firm was allowed to operate in an independent country with such an abysmal lack of concern for the welfare of its employees.

That is our scene, a centralised organisation. It is fairly flexibly conducted, I like to think, even though there is an element of autocracy in it. It is certainly economical in manpower as the consultant to the Department of Labour, the Consultant to the Department of Health and the Director of Naval Medical Services are all the same person, myself.

MEDICAL SUPPORT FOR DIVERS IN AUSTRALIA

John Knight

Medical support for diving in Australia can be considered under the following headings: material, ie. chambers; personnel, the people responsible for treating in chambers; teaching; research; SPUMS as a whole, and individual efforts that people put in. All of these are part of the medical support for diving in Australia.

CHAMBERS

Townsville

We start in the North with a chamber in Townsville, owned by the Australian Institute of Marine Science, which is a multi-place chamber with two compartments and a depth capability of 50 metres. They have treated a number of people since it was installed last year and as far as I know, with complete success. Then we go a long way south, to Sydney. That is a coastline of over 1,800 kilometres without a chamber, with a population of over one million, and many more who live in the cities and towns inland.

Sydney

In Sydney there is the Royal Australian Navy School of Underwater Medicine which has a multi-place chamber. It was brand new in 1942 or 1943 and has been updated regularly since. It has a working depth of 50 metres. It has two compartments. It is used every day for giving divers pot dips, for demonstrations and occasionally at weekends for treatment. Sports divers usually get bent at weekends.

Also in Sydney is the chamber of the Hyperbaric Unit at Prince Henry Hospital. It is a multi-place, three compartment chamber, with a working depth of 18 metres. It was bought by the Lions' Club for a keen surgeon who wanted to do heart surgery under hyperbaric oxygen. But he had got fed up with waiting for the chamber to appear and had moved to another part of the world when the money came through. Nevertheless, they put the chamber in. It is a big chamber suitable for heart surgery and Ian Unsworth was recruited to run it. He knew that the way to get things that you have not got, is to read the regulations. In the mines regulations for New South Wales, it states that if people work under pressure of more than 14.5 PSIG there has to be a chamber capable of at least 165 feet on the site. So he now has a small chamber that goes to 350 feet, attached to the larger complex. It is reputedly six-man, but there is now way you could get six ordinary sized adults in there in comfort. It has a fire fighting system installed, where the water pressure is higher than the pressure in the chamber. That unfortunately means that when they reduce the pressure in the chamber, all four outlets drip on the occupants. However, it is the deepest non-commercial chamber in Australia. It is used a lot for research and has all facilities for anaesthesia in the large, shallow, portion of the complex.

Mallacoota

Then you go another 450 kilometres along the coast to Mallacoota, where they have a number of abalone divers. These men used to get bent very regularly. They used to be flown out along the beach, going around each headland, to stay as close to ground level as possible. The road trip was 150 miles, climbing to over 2,000 feet on the way on a poor road. So they bought a two compartment chamber. They now have a better compressor than they originally had. Ten years ago two men died in that chamber following suicidal dives while poaching abalone. It is only available to those who are members of the Fishermen's Co-op. The doctor who supervises this chamber lives at Bairnsdale, which is 150 miles away.

Melbourne

Then on to Melbourne, where the Metropolitan Board of Works has a chamber for its employees, because they dig in compressed air. The compressed air is necessary, not to keep the water out, but to keep the sand from collapsing in to the tunnel. They have a multi-place chamber which looks rather like retired railway carriage it is so large. It only goes to 40 metres, which is more than the depth the men work at. However it is only immediately available when the MMBW has men working in compressed air. Non-employees have to get permission to be treated in it and provide their own doctor. Furthermore, it is a good way from the nearest large public hospital. It may well have a tunnel worker being treated when a diver would like to be recompressed.

Then there is at Prince Henry's Hospital a standard Vickers mono-place hyperbaric oxygen chamber. It is a bit claustrophobic but it does have great simplicity in operation; one knob and three dials. A number of people have been cured in that chamber. In spite of being a mono-place chamber it does have some advantages. You do get a supremely useful gas gradient as the patient is compressed in oxygen, not bathed in air, so there is no way he can take up extra nitrogen. It is in a hospital, so chest X-rays and investigations can be done before you put him in and afterwards. It only needs one person to run it instead of a team. You can clearly see the patient even if you can not touch him.

Because of the small diameter of the chamber you can not use intravenous therapy in the normal bottle-above-the-customer way. You can always put the bottle under his backside if it is a collapsible bottle and use that sort of pressure. Of course with an unconscious patient, you have got problems.

There is also a multi-place chamber owned by United Divers in Melbourne. It was surplus for a while so they put it on the wharf in Melbourne and offered it to Prince Henry's as another treatment chamber. I do not think anyone has been treated in it. However, people are taken for joy rides in it. They will take them down to 200 feet. I will just tell you a cautionary tale. One doctor who was in the Navy doing his underwater medicine course, was given a ride to 100 feet in that little chamber at Prince Henry Hospital, well inside the no-decompression limits, with stops on the way back. He is a good 15 years younger than I am and has not got so much adipose tissue. But he got an elbow bend. I think that United Divers are sticking their necks out giving all and sundry joy rides, for which they pay, to 200 feet.

Hobart

At Hobart they have got a multi-place, 50 metre, chamber and they treat people.

Adelaide

In Adelaide there is another mono-place chamber at the Royal Adelaide Hospital.

Fremantle

HMAS LEEUWIN has a multi-place chamber, which is limited to less than 100 feet, being a rather tired 1940's chamber. It is due to be overhauled and upgraded.

Commercial Diving Chambers

Each oil rig or diving boat, that is doing diving over 100 feet according to Victorian regulations, must have a two-compartment chamber available on the site of the dive and they have to have a depth capacity greater than the depth of the diving. It is rare for a sports diver to be accepted for treatment as this puts a stop to commercial diving at great expense to the employing company.

PERSONNEL

Doctors who treat diving accidents can be divided into groups. One are those trained in underwater medicine who have a chamber and regularly treat diving accidents. In effect that is the School of Underwater Medicine and Prince Henry Hospital. A city of two and three quarter million has lots of divers who go and do stupid things. If you dive south of the harbour it is much more sensible to go to Prince Henry Hospital. Then there a number of places where the doctors have been through the School of Underwater Medicine courses, have a chamber and occasionally have to treat people. These are Mallacoota and Bass Strait, Prince Henry's Hospital and the MMBW in Melbourne and the Royal Adelaide Hospital. We presume that the North-west Shelf will be staffed by doctors who know something about what they are doing. Then there are other places where there are interested but untrained doctors with chambers. These are the Australian Institute of Marine Sciences, Royal Hobart Hospital and HMAS LEEUWIN (in early 1981). Many other doctors treat minor diving illnesses that do not need recompression chambers. Some know what they are doing and some do not.

TEACHING

Knowledge is available in Australia from the Royal Australian Navy courses at the School of Underwater Medicine, the hyperbaric medicine course at Prince Henry Hospital, the diving centre courses run by Carl Edmonds, and from SPUMS, which does not run courses.

The School of Underwater Medicine runs introductory courses of two weeks, and advanced courses of two weeks and a foreign medical officers course of three months.

The hyperbaric medicine course at Prince Henry Hospital lasts one week. It is run as required, not on a regular basis.

The Diving Medical Centre courses are one week, with lots of diving and a bit of education.

The South Pacific Underwater Medicine Society publishes a Journal, holds meetings and issues a Diploma of Diving and Hyperbaric Medicine. The most important requisite is six months full-time, or equivalent part-time, diving or hyperbaric medicine after having done the two RAN courses and the Prince Henry Hospital course. There are hopes of upgrading it by having it adopted by an academic institution, and including Occupational Medicine.

RESEARCH

There is not all that much research in diving medicine and physiology, but there is some. The School of Underwater Medicine has done quite a lot that has filtered gently around the world. There was work on diver selection and training. The results were largely ignored by the Navy for about seven or eight years and some results were firmly suppressed as being quite unacceptably true. The salt water aspiration syndrome appears to occur in Warrnambool as well as in the swimming pool at HMAS PENGUIN. The high oxygen treatment tables that Carl worked out. He gives the patients the risk of pulmonary oxygen toxicity in order to have the biggest gradient to get a nitrogen out of them. Investigations of inner ear barotrauma and vestibular disturbances, improved closed circuit absorber design, and surveys on the incidence of dysbaric osteonecrosis in divers have all been carried out at the School.

Prince Henry Hospital in Sydney also has done a survey on dysbaric osteonecrosis, which was discontinued when the radiologist left the hospital and went into private practice. They are doing research on hyperbaric physiology and anaesthesia. Those are the only two places where hyperbaric research is going on in Australia on humans or large mammals.

There is some hyperbaric research being done in Melbourne on small animals at the Royal Melbourne Institute of Technology, but I know nothing about it. I think that what

John Miller told us last year about a successful dive to 2,000 feet at Duke University really means that little animals are only a good way of spending your research grant. They do not teach us all that much about what we want to know now that commercial divers are beginning to limit themselves in depth and use machinery instead.

SUMMARY

Medical support in Australia is a few chambers with a few well trained doctors, who work regularly in hyperbaric and diving medicine, and a large number of doctors who see and treat divers for common diving problems, who have no access to chambers, but have lots of contact with divers. Many have gone to one or other of these courses to improve their knowledge.

MEDICAL SUPPORT FOR COMMERCIAL DIVING OPERATIONS

David Elliott

The sort of diving vessel that I am associated with is the new MSV (multi-service vessel), a fire fighting, diving support and repair ship, being built in Finland for Shell in the North Sea. It will work only at our Brent oilfield. It is very large and supported on pontoons the size of a submarine. It has a large diving system with two bells. Divers can go down the supporting columns into the pontoons in the dry, lock into a chamber and then go straight out into the water on an air dive. It is a diving boat and is very expensive. We have to supply medical cover for people on board and for the medical crews. The principles are just the same for that as they are for any other diving operation.

To give you some idea of the Brent field platforms, there will be about 400 to 500 people on board, sleeping, working 12 hour days. The weather is not always very nice. Even with 50 foot waves the platform is 100 feet clear of the sea. That sort of weather means that the platforms have got to be totally self-contained for five days or more, as it may not be flying weather.

The divers in fact dive almost entirely from diving support ships. Rigs are liable to blow out and other accidents, such as fire, may occur. There are life boats which are roofed in and totally fireproof that can be dropped, so enabling the ship's company to get away. But divers under pressure are stuck in the chamber. So diving is done from support vessels which are quite independent of the rig.

PRIORITIES IN MEDICAL SUPPORT

First Aid, communications, trained medical practitioners, medical centres, intensive care under pressure and hyperbaric ambulance are the priorities which I wrote up at a time when Andre Galerne and IUC (International Underwater Contractors) were trying to sell the British Government a white elephant called the hyperbaric ambulance. He was doing a rather good sales job, saying that there were all these divers in the North Sea, and no one really cared about them. He had a portable pressure chamber made of titanium, rated to 600 feet which can be flown around in a helicopter. He suggested that it would be a good idea if we bought it. This list resulted from one of the few disagreements that I have ever had with Jacky Warner, who is the Senior Inspector of Diving with the Department of Energy. He actually fell for the hyperbaric ambulance, so we produced this list of priorities for medical support in diving.

First Aid

The most important medical support is teaching the diver resuscitation and first aid. Diving first aid training goes as far as teaching the diver how to put up drips, put in catheters and if necessary put a needle in the chest. The divers will actually be trained on cadavers in hospitals to do this. The reason is that the diver under pressure can be five or six hours away from anybody else at the surface, if there was anybody else at the surface to get into the chamber. Because of the depth of some of these dives, if you take a person down too fast they are not in good shape when they get to the bottom. So first the divers have to be very well trained. We then say, that in terms of 12 or so divers, there must be one diver who is trained to the standard of the American EMTD, which stands for Emergency Medical Technician (Diver). This requires quite an extensive period of training, which is done to the American syllabus. That ideal has not yet been attained, but we do require that at least one diver in every team has been on a special course of resuscitation and diving first aid training. That is in addition to the statutory training which is laid down in the training manual for divers by the Department of Employment. That has been fairly well taken care of and the only point which is a bit tricky, is the refresher training. First aid is the most important course, because if the guy survives the first ten minutes, or hour, he may survive a bit longer. But if nobody is there to do anything during the first five minutes or so, then the next four of the priorities cease to matter.

Communications

The second priority is communications. By that I mean both what you say and how you say it. If you get a message at 2 o'clock in the morning, you can be confident only that it is incorrect or incomplete. We therefore have a check-list which is about six pages of things which the diving supervisor should check off before he picks up the telephone. The diving system is usually at the bottom of the rig, or the furthest part of the vessel, so if you ask about the blood pressure, he will go sprinting 100 yards to find out, which takes rather a long time, particularly if you are paying for the telephone call. So we like them to get all the relevant information on the check-list and then have clear communications. If communications go by telex, we take a chance on the confidentiality of the General Post Office, although we do know that people overhear, rather than to scramble it and put it in code. This is because I know of one case where the diver, when they decoded the message, was given the wrong treatment. Avoid coding things for confidentiality, it is much better to be in the clear and take the risk that the newspapers will find out.

Trained Medical Practitioners

In the North Sea, the Norwegian and UK sectors in particular, there are doctors who are trained in the medical emergencies of diving.

Medical Centres

Now to define a medical centre. A medical centre is a place to communicate with in a diving medical emergency. It has at least two doctors. You have got to have two doctors on call because if the first doctor has been called out to go to a case then of course another accident may occur somewhere else. In order to have two doctors on call at least three doctors must be available to cover sickness and so forth. A medical centre does not require to have its own chamber, because all divers are required to have chambers offshore anyway. So we have a team of specially trained general practitioners who are available to go to help with a diving emergency. In the North Sea it can take them five or six hours to get there because it is quite a long way, even from Aberdeen, to where the platforms are. Only one doctor need actually be available to travel, the second one needs to be available on the end of the telephone. So he can be several thousand miles away. I have in fact done that duty from overseas. So there is no problem at all in keeping the centre going with only doctor actually on the doorstep. But it should have two doctors at almost immediate availability for telephone consultation.

Intensive Care Under Pressure

If, after a bell blow up, you have two unconscious divers requiring intensive care a team of specialists from hospitals in Aberdeen is available to go out and do their thing under pressure.

Hyperbaric Ambulance

The hyperbaric ambulance, a means of getting the diver back to the shore-side chamber, is a white elephant which we were forced to accept. Using the argument that all treatment on dry land in the UK is a responsibility of the National Health Service we managed to persuade the Scottish Health Department to take over the responsibility of the shore chamber. Little did they realise that the capital cost is nothing compared to the running costs. We only maintain the little titanium chamber that will run to and from the rigs. We have never had to use it in the three or four years we have owned it. It was used once about four weeks ago, but not for medical reasons. The patient had a medical condition, but the indication for transfer was not medical, it was purely convenience, to allow the barge to leave the North Sea for some other part of the world. They had a man on board with a mediastinal emphysema and a pneumothorax, who was having difficulty in breathing during decompression. They took him ashore so they could have a slow decompression. That is the only time that it has ever been used. It is very difficult to think of a condition which would be suitable for transport, because it is quite obvious that the must important thing is to stabilise the patient before you move him. Therefore anybody who has not been stabilised does not require to be evacuated. It is far better to take the doctors to the patient.

Classification of Doctors

The European Diving Technology Committee which is associated with EEC has come up with recommended qualifications and training for medical doctors in relation to diving. You have got to be very careful what comes into national regulations the back way. The United Nations has got a whole stack of bodies like ILO (International Labour Organisation) or LMCO (International Maritime Consultative Organisation), which exist for the sole purpose of dreaming up rules and regulations to tell you why you should not. They will slip in all sorts of rules and regulations when you are not looking and you suddenly find your country has signed the agreement and it is binding. Unfortunately, the country is usually represented by the wrong Government department. If it is something like oil and gas, which interests the Department of Energy, it will be the Department of Shipping that actually goes to the meeting. So as a defensive posture in Europe, we have done this ourselves. The European Diving Technology Committee is a quasi official committee and we have come out with a classification of doctors.

We did not use the term “diving doctor” because we believe this means people such as yourselves, doctors who dive or a doubly qualified as it were. We have therefore avoided that term. We tried to use the term physician, because the abbreviation of diving emergency doctor spells DED and that would not be good news, but unfortunately physician in French is a Physicist not a doctor. So we have this rather clumsy term, Examining Medical Doctor for Divers, who is a doctor trained to conduct medical examinations on divers for fitness to dive. He is on the approved list. He need never enter a pressure chamber, nor need he have been underwater. However, he must have at least 30 hours training on the subject. He is expected to keep up-to-date by attending suitable meetings and refresher courses, so he knows whether a diver coming to him is fit to dive or whether he should be kept off diving. We will not go into the medical standards for diving but the standards are more stringent for commercial than for sports divers and are very much more stringent for those going into training, than for those who are already fully trained.

The next category is the Diving-Emergency Medical Doctor. This doctor is trained to work with divers and in particular to cope with the medical aspects of every kind of medical emergency. By that I do not mean diving illness, I mean every type of diving emergency and you will see what I mean as this unfolds. He must be fit to go under pressure. He must have been trained as an Examining Medical Doctor in the first place, then he must have another 60 hours of training, that is another two weeks. He must have had practical training in pressure chambers and be should also have had underwater experience. Again, be must keep himself up-to-date by attending suitable meetings and refresher courses. We all know experience counts, but there is no way of writing that in, but three weeks of training at least gives us a certain minimum.

Then there is the specialist in Diving Medicine. We tried the term Consultant, but the other European countries objected to this for some reason. The definition is "A doctor generally recognised in the international diving community as being well experienced in aspects of diving medicine". We have three categories. The first is a doctor who is consulted on difficult or unusual cases by the other two categories. The second is a medical doctor with an expert knowledge of diving physiology. The reason for that is because the Norwegians have already gone that far. They have produced in a Norwegian Petroleum Directorate regulation the requirement that the doctor is the person who will determine what the breathing resistance will be in the inspiratory valve of the demand regulator. He will determine what the various peak flow rates will be and what shape the pressure-volume loop will be. It is quite unreasonable to expect a General Practitioner to do this. But that is the new Norwegian regulation and might even filter through into the international Community. The third category is a specialist in some particular field of medicine (other than diving) who has an expert knowledge of the diving aspects of his special subject. In that we can include the ENT people, the pathologists who do autopsies on dead divers, all doctors in various hospital specialties, so that they too count as a specialist in diving medicine. So I think you will agree that is a constructive sort of paper.

PRACTICALITIES OF MEDICAL SUPPORT

That is how the doctors are organised for medical emergencies in diving in the North Sea and how they are trained. At Shell we try to adopt the same standards in all parts of the world. Surprisingly there are no commercially or academically available training courses in diving emergencies for helium work. None of the Navies run them. The Navies only run compressed air diving medical courses, so we have been running our own. We have now run four. What emergencies do we train these doctors for? The emergencies are certainly not limited to the bends. For training one has to use a volunteer diver simulating unconsciousness. Unconsciousness in the water is not easy to deal with. Even with his head hanging forward and small bottles on his back it is not going to be easy to get him through the small hatch into the bell above. There is no easy way of doing that. There are two tricks one can use. One is to half flood the bell so that he will be floated into the bell. The second is to have a ratchet hoist and hook on to the back of a harness and pull him up with the ratchet. This all takes time. A further problem is the amount of hose that the attendant inside the bell has to haul up first, before he can get the diver in. The maximum length of hose allowed is about 30 metres, nearly 100 feet of hose, and there is an unconscious diver on the end of that. Then you have got to resuscitate him. Comex hoist the diver from behind and put on a collar to hold his head back. Oceaneering hoist the unconscious diver from the front so that he has a better airway. There are various heroic efforts taught for cardio-pulmonary resuscitation which can only be good for morale. Unfortunately it has been shown by work on electricity workers on poles in America that there is no way, with any kind of cardiac massage, that you can get circulation into the brain in the erect position. In a bell, even with no hose in it there is just nowhere you could lie the guy down properly and bear in mind that you have had to flood it up to about thigh level to get the man in. So CPR by a diver on another diver is a bit difficult. That is the sort of medical emergency that the doctor will obviously be called to. I do not know what advice he can give. As I said, diving emergencies are not limited to bends.

We also have the problem of the lost bell. Diving bells get dropped on the bottom of the sea. The real problem there is that within an hour or so the interior temperature of the bell gets down to the temperature of the sea, which is cold. If the divers are on helium, they may well die of hypothermia within two or three hours. So one tries to provide adequate thermal protection. Another problem which one has to cope with is how to transfer the diver from the lost bell to somewhere else. The lost bell may be pulled back to the surface, in which case you can transfer the divers from the bell to the main chamber. Or, as has happened recently, the bell is stuck and can not be pulled up, then you have to send another bell down and the divers have to transfer through the water to the other bell to be taken up. A problem with hypothermia is that if you have got to the stage that they are getting bloody cold, as with the divers who were in the bell which was stuck, they will need warming up before they are fit enough to swim across to the other bell. It was a 150 foot swim at a depth of between 300 and 400 feet. Theoretically if they were warmed up too quickly, they might vaso-dilate and collapse on you. In fact a hot water hose was brought across from the rescue bell and hot water was sprayed all around the bell and over the divers. They felt fine very quickly and then did a very successful transfer.

With divers who are brought back to the surface in their bell and locked on to the main chamber, the problem is that, providing of course they are not lying across the hatchway, you have got to get in and assess them. In hypothermia you must never diagnose death in a cold body, it must always be re-warmed first. How are you going to get at them to re-warm them, because you have to shift them down into the main chamber to do it comfortably? How much warming should you do in situ to avoid ventricular fibrillation when you start trying to get them down from the bell into the main chamber? These are unanswerable questions, but you will be asked them if you are the doctor at such an emergency.

Then there is the problem of the abandon ship. It is a Norwegian rather than a UK regulation, but we find we are adhering to it in the UK, to require a hyperbaric lifeboat. It is a lifeboat containing a chamber which will lock on to the main chamber allowing divers to transfer under pressure. Then the whole thing will be dumped over the side of the vessel and float away. The principle problem is of course sea sickness, the secondary problem is cold.

Although diving bells are very small, you can evacuate divers inside that as well. In fact divers have been transferred by bell as far as 150 miles to another rig and successfully locked on.

Talking about chambers and the availability of chambers, there is a rather neat one-man chamber built by Drager, which is readily transportable. It is a boot shaped chamber which will fit inside a Lear Jet. The reason for the special design is that the standard one-man chambers will not fit into a Lear Jet, but this is a very short chamber and it will. It can also go into an Alouette Helicopter. It has to go transversely, but it will fit. In fact there are a dozen or so such chambers in one country. It is absolutely ridiculous that the country with the most organised diving emergency system is Switzerland. The reason for this is that the Swiss Army and the Swiss Police do a lot of diving in the mountain lakes. That is diving at altitude. They need to check the hydroelectric schemes and practice anti-mine warfare. They have portable chambers that can go by vehicle or by air. The army now tends to send their chamber by lorry to the site of the diving and treat the diver on site. The system is available for civilian divers and I would like to draw your attention to it. I had great joy in drawing the attention of the National Health Service to it in the hope that they may be able to do something similar in the UK, because we have a slightly longer coastline than Switzerland. Believe it or not, this scheme costs anyone who wishes to subscribe $10.00 per year plus the cost of the actual emergency if you ever have one. One can insure for that cost also. The Swiss Air Rescue Service was built up to collect injured people from skiing accidents and motor accidents, particularly road traffic accidents, in remote parts of Switzerland. It is a very well organised service. If you are a member, you will be picked up by Lear Jet from any other country in Europe and flown back to Switzerland for treatment. That service includes under pressure. They have done it from Spain and other Mediterranean countries under pressure to Switzerland for treatment. The only cost is the cost of the flight itself, and that cost comes out of a medical insurance policy. So it is a good scheme. It is a great pity we cannot have it in the UK. Perhaps you can manage it in Australia.

The White Elephant titanium chamber is quite easily portable. It goes inside a Sikorski S61 helicopter. It consists of a white two man chamber and a red single man chamber which can be manhandled down to the diving chambers at least a deck or two below the helicopter pad. The attendant is brought up first, if there is not an attendant already under pressure in the two man chamber. Then the patient is transferred under pressure. It is a fairly expensive chamber system and is good to 600 feet. At the end of the helicopter ride the two man chamber is locked onto a fairly standard saturation diving system for medical treatment as required. It is a bit of a white elephant, because you are not going to save the diver who got unconscious in the water.

DISCUSSION

Question: Dr Bill Hurst

When unconscious divers are hauled into the bell is there life line already attached, or does the tender have to swim out and attach one?

Dr David Elliott

All divers in commercial diving are on a hose which is gas and hot water and communications. The standby diver may be able to haul the diver in by his hose or he may actually have to swim out and fetch him. On our diving emergency doctor courses we actually train the doctors to do this. We put the bell down to about 30 feet, put one doctor out, tell him to flake out and then send the other doctor out to try and pull him in. It is quite a bundle of fun.

Question:

What about CPR head down rather than head up?

Dr David Elliott

It would be feasible theoretically. It would not be easy to do however. First you would have to get a hitch around their feet. Secondly, their heads would be under water until you blew down the water that was in the bell. Quite honestly, I think it would be easier to get them in head first.

Question:

Would that not involve re-designing the bells?

Dr David Elliott

There is no way you could re-design any existing bell.

Question:

Do all commercial divers wear the harness all the time?

Dr David Elliott

They all have the harness on. It is part of the gear.

Question: Dr Tony Slark

I was rather surprised at your enthusiasm for the Swiss chambers, compared with your helicopter chamber, which admittedly appears to have very little practical usage so far and hopefully never will have. But how is it that you are so enthusiastic about the Swiss monoplace chambers which can flash around Europe with sports divers?

Dr David Elliott

The around Europe bit is very rare. In Switzerland they have got three hospitals which have got treatment centres. To get patients into these hospitals they would otherwise have to go over high mountain passes. So the only way to get a patient safely from a diving accident to a treatment centre is to take him under pressure.

Question: Dr Janene Mannerheim

What sort of gas banks or compressors accompany the small ambulance chambers?

Two or three cylinders. Enough to last an hour or two.

Question:

You mentioned the first aid resuscitation. Have you come to grips with the problem of updating CPR? It seems to be fairly well known that at least yearly practice is required by not only first aiders, but also medical practitioners, if they are going to safely and adequately use cardio-pulmonary resuscitation. Surely the updating is as important as the initial training. How do you cope with this problem?

Dr David Elliott

I think that is equally true of all the other techniques that divers are being taught. At Dundee and Aberdeen they are being taught intravenous drips and pleurocentesis and that sort of thing, which I think is very important. The trouble is that having had that training they are then sent out somewhere remote like Angola and they will not be back for three years. It is a problem, but at least initial training is better than nothing.

Question: Dr Tony Slark

I was most impressed with that photograph of the Brent field rig and the swell around it, a most dramatic photograph. The thought of launching a hyperbaric lifeboat from that fills me with absolute horror. Is it envisaged that this would ever be the case?

Dr David Elliott

In one word, yes. If the system were to blow up, if there was a gas blowout and it caught on fire, the hyperbaric lifeboat would be better than burning to death. There are divers who say that they would only get into a hyperbaric lifeboat if the diving supervisor was to use a grizzly bear to chase them out of the main chamber.

Question: Dr Tony Slark

You said that the local hospital has a team of specialists, all available to fly out to manage the accident that occurs on the rig. I wonder whether this situation exists in Newfoundland?

Dr David Elliott

Not at all. It is unique to Aberdeen in Scotland and it really consists of an anaesthetist and a surgeon who know enough about the peculiarities of pressure to be able to give regional blocks and do whatever is necessary and if intensive care is required, to do that. That is about all it is.

Question: Dr David Davies

In Adelaide, the plan for decompression sickness was to take the patient to HMAS PENGUIN in a Hercules. The Vickers monoplace oxygen chamber at the Royal Adelaide Hospital is only used for gas gangrene. It seems to me that Australia, a country of vast distances, is ideal for the use of the Drager chambers.

Dr John Knight

Yes, transport under pressure could be the thing in Australia. The trouble is that is costs money. It is another story of competing departments. Some ten years ago the Department of the Navy decided that they could afford thirteen two-men portable chambers, which could be locked onto new two-compartment chambers in Sydney and Fremantle. The order had to go through the Department of Supply, whose engineers got in on the act. They said that the specifications were not adequate. They were not happy to use off-the-shelf proven valves used in commercial diving for controlling gas supply. They wanted specially designed valves made. Designing these kept engineers busy for about a year. When they had finished the cost of each of the thirteen small chambers was going to be more than the off-the-shelf cost of a Babcock and Wilcox ten person two compartment chamber. By this time the thirteen aluminium shells were ready to be fitted out. At that point there was one of the recurring financial crises, and anything that could be scrapped was scrapped. So the chambers were put on the “no further progress” shelf. That was some seven years ago. I assume they have now been sold for scrap aluminium.

There was an effort by the officer in charge of the School of Underwater Medicine about three years ago to purchase commercially available Babcock and Wilcox two person portable chambers, which would have cost somewhere around $20,000 each. The trouble was that portable to Babcock and Wilcox is not portable to anybody else. It took eight men to lift it empty. Trying to put it into a boat, using a hand operated derrick, with sandbags inside representing the weight of two men, had to be called off when it looked very likely that the thing would go through the bottom of the work-boat. So that was rejected as unsuitable. It could be transported on the back of an army lorry. The army was very keen to buy them but they were talked out of it because it could not lock onto the RAN two-compartment chambers. If you are going to use portable chambers, they have got to lock on so that the patient can be transferred for treatment in the larger chamber.

Question: Dr David Davies

Surely there are enough divers in Australia to rake up $20,000 and get a portable chamber?

Dr Tony Slark

I think they did a magnificent job in Christchurch. It was largely due to the guidance that came from two very capable physicians that it was a success. In general, I am adamantly opposed to this whole business of small portable chambers. I think it is not a very good system for the ordinary sort of scuba diving accident. In the working diving accident you are bound to have proper chambers on top of the diver who is sick. In a scuba diving accident this does not happen. There is no way that your portable chamber is going to be anywhere near the sick diver when he first shows his illness. He has got to be evacuated first. So you are evacuating him as quickly as you can to a small chamber with no hospital facilities and with no proper medical management. You are interposing just one of the aspects in the treatment of the sick diver, pressure, at an intermediate stage in his management. In most cases you would do better to carry out your evacuation completely to the site where he can be treated fully.

In Tauranga, about 150 miles south of Auckland, there was a movement such as you have suggested, when the local divers got together after the death of the man that I spoke about. They got a lot of money and bought a one-compartment chamber. You can put a sick diver and an attendant in it. They have run out of money and nobody else wants it. It is a white elephant in just the same way as the more complex hyperbaric ambulances. It sits on the back of a truck and is never used. It would have been a far better memorial to this poor chap who died if they had had a fast lifeboat in that area, instead of this chunk of metal which, so far as I can see, is never going to be useful.

Question: Dr David Davies

You are talking of 150 miles. In Australia we are talking about getting them from Adelaide to Sydney, after they have come 200 miles up the Eyre Peninsula by road. One has got to evacuate over very long distances. The Hercules has to fly from Richmond in NSW to Edinburgh in SA to collect the patient and back again with him. It is many hours of flying.

Dr John Knight

You can always charter a helicopter and fly low.

The great joy for most of Australia is that decompression sickness is rare. I do not know how many cases there have been in South Australia in the last 5 years, but I expect very few. In Melbourne, there would have been less than ten. But in Sydney there are about twenty a year. They do have an aerial ambulance. The Surf Rescue people have a chopper and they can get people to HMAS PENGUIN quite easily. But few divers ever contact that organisation. They nearly always turn up in their own car, usually driving themselves.

Getting back to where people feed into the system, it is the person himself who makes the decision to go to a chamber. A doctor from Sydney found himself Safety Officer of his club. He was an ophthalmologist, so you do not expect him to be an expert on resuscitation. The safety equipment included an Oxy-viva. He asked around the club to see if it had ever been used. The answer was no. He went on a dive when the captain of the club got himself bent. All the way home he refused oxygen. He refused any treatment at all, except getting into his motor car and going to Prince Henry Hospital. It is no good setting up a wonderful evacuation system unless the divers are giving themselves first aid. I agree with David's point that the first thing is to make the diver capable of helping his colleagues.

Dr David Elliott

There are two other examples which are worth considering. In Israel many of the diving resorts have portable one man chambers. A lot of them are portable two-man chambers, where the attendant can sit at the head of the casualty, the L-shaped chambers made by Drager. After pressurisation, the chamber is flown to Haifa, where the patient is then transferred under pressure to the main facility. TUP (Transfer Under Pressure) only works when you are transferring under pressure to a main facility. It must be organised so that the portable chambers are available at the diving site so there is no delay in getting the guy under pressure and away. Israel is a very good example of how TUP can be done.

In the USA they now have DAN, the Diving Advisory Network. It is a code 800 number, a toll-free call. From anywhere in the United States you can telephone this one number and be connected to the co-ordinating centre for all diving accidents. This has been evolved partly because the US Navy does not want to load themselves with too many civilian diving accidents. NOAA (National Oceanic and Atmospheric Administration) has given a grant to Duke University to set this up. Besides the national centre there are five or six regional centres. Jeff Davis in San Antonio for the South-west, Duke itself for the mid-east, somewhere in Florida for the Florida region, somewhere up in the Great Lakes region and one or two on the west coast. All these places have chambers and doctors who are on 24 hour call specifically for compressed air diving accidents. It has just been set up but it is very expensive. It is a trial for two years to see how it goes.

Question: Dr Ray Leach

For Australia, it seems that the pattern is to treat the patient with 100% oxygen as close in time as possible to the accident and then transport him by Hercules to Sydney. But using a large plane like a Hercules does seem somewhat unnecessary. I understand that even commercial aircraft can be pressurised to atmospheric pressure, but at some expense to the airline. Should we not have some sort of simpler aerial ambulance for divers, smaller Jets, which could be pressurised to atmospheric pressure, during which time the diver could receive 100% oxygen during transport, rather than bothering the Air Force for these expensive Hercules?

Dr John Knight

If the diver can afford to charter a Lear Jet he can be flown at ground level. But how many of the divers you know can afford to have his own private jet? That is one of the problems. Another problem is that civilians are only treated at the School of Underwater Medicine because they are emergencies that turn up there.

Because the demand is small outside New South Wales it is very difficult to set up a comprehensive system that will be cost effective. If we are going to have an Australia wide system it is going to have to be Government funded and with present financial attitudes the Commonwealth Government is not going to pay for it.

DYSBARIC OSTEONECROSIS

David Elliott

Dysbaric osteonecrosis, although we are not absolutely certain of its cause, is an association of bone necrosis with exposure to pressure changes. The first cases were reported about 70 years ago. Pain was the problem and they were found on X-ray to have damaged joints.

The British Medical Research Council decided that they would do surveys first on compressed air workers and then on divers. They really got going in the 1950's and 1960's and came up with quite a few useful reports in the Journals. One must appreciate that the radiological classification of bone necrosis scooped in a whole lot of people who were totally asymptomatic. Bone necrosis occurs in two places, in the shaft of a bone and in the juxta-articular region. It is only collapse of the joint surface that will give rise to pain. The shaft lesion is for practical purposes totally benign. The shaft lesions are histologically exactly the same as osteonecrosis due to other aetiologies. It has the same prognosis - a one in approximately 10,000 chance of osteosarcomatous change. Two cases of osteosarcoma occurring in compressed air workers with bone necrosis have been written up.

So far as we are concerned it is a juxta-articular lesion that is important, because it can be a crippling disease. In the 1950s and 1960s there was a ten year survey of divers in the Kiel Canal in North Germany. Of about 40 divers, 7 became totally unable to work.

A group of 79 Japanese divers had about 20% definite lesions, of which about 15 were juxta-articular. John Harrison and myself reviewed Royal Navy divers about the same time. Out of 350 divers we found only 4% with lesions, of which less that 2% were juxta-articular. Ohta and Matsinuka from Japan had 50% of divers with lesions. About 15% or 16% were juxta-articular. There is a significant difference between the British and the Japanese figures. If you look at Ohta's original report, which was in Japanese (I had it translated) you find that the divers aged 18 only had about 2% incidence, the divers in their twenties had a 5%-10% incidence, divers in their thirties about 50% incidence and the divers in their forties had about an 80% incidence of bone necrosis. There were 60 or so divers aged 18 down to 2 divers aged 40. The dive profile for these guys was given. Two divers went down to 120 feet or so for four hours in the morning. Being of peasant stock they knew nothing about decompression tables, so they came up for their lunch and in the afternoon they went down and did the same thing all over again. Which, as was said in the paper, is why the flag of the factory ship was always at half-mast. So there could be some clue there as to the aetiology of bone necrosis.

The shaft lesions are benign and appear to be basically ossified fat. So to the pathology of the juxta-articular lesions. The first change is a creeping substitution. New trabeculae grow over dead trabeculae. The radio-opaque area is a failure of new growth coming into that part. But if you examine the area histologically you would find evidence of new trabeculae replacing trabeculae over as much as two thirds of the head of the humerus. The lesion is very much more widespread than can be seen on X-ray. There is a latent period. It takes three to four months before the first X-ray evidence can be spotted. This makes it very difficult to give a diver the OK at any particular time, if he is going along to a new employer.

What is the possible pathogenesis? As with spinal cord decompression sickness, there are a whole stack of hypotheses and you can take your pick. They are probably all true. There is an embolic hypothesis which suggests that lipid emboli, which are formed from bubble activity, enter the end vessels of the bones. Autochthonous bubbles, bubbles which are generated per se, formed in the bone, may expand and cause occlusion of the blood supply. Then there clever hypotheses like the isobaric counter diffusion of gases inside the bone, gaseous osmosis, change of intermedullary pressure and all those things. What it really means is that we have not got a clue.

After all sorts of clever papers have been written on the pathogenesis of this lesion, what do we actually find? In the original programme that John Harrison and I did the surprising thing was that we got nothing in the hip joints. The hip and shoulder are two juxta-articular regions that are affected. You can get shaft lesions in both upper humerus and upper femur, but they are much more common in the lower femur. Among other causes of bone necrosis are severe and chronic alcoholism, in which they tend to get a lot of lesions in the femur, both juxta-articular and in the femoral head. Of course some wag said that maybe the cause of the Naval osteonecrosis was alcohol. So, very carefully, we did a controlled survey of an age and rank matched sample in the Navy of over 100 men and found a zero incidence of bone necrosis. This has since been repeated by the US Navy with the same result. So I think that it really is a diving related condition. I am very careful to say that early on because often when I start showing slides of early lesions to orthopaedic surgeons say "Oh, I often see things like that. These things are of no significance".

The Medical Research Council, specifically Dennis Walder, Ian MacCallum and a few others, has established an international classification of this condition.

Our Naval survey showed that dysbaric osteonecrosis is related to age. People under 24 have 0.2%, and remember that this is dealing with both the benign shaft lesions and the juxta-articular lesions, so the figure is a bit misleading. Over the age of 24, the incidence goes up so there is an age association. As to length of experience, there is some relationship, because the older you get the more experience you get. There is a very significant rise in the more experienced divers. They are more likely to have a lesion.

Our Naval survey showed a relationship of bone necrosis to bends. Of those recompressed for decompression sickness, we had 9 out of the total population of 42 with bone necrosis. Whereas in those who had never suffered from decompression sickness we had only 4 cases out of nearly 100 divers. So there seems to be some association with recompression for decompression sickness. There was an association with symptoms of decompression sickness and also an association with experimental diving. So we had a whole lot of things with which there was a statistical association, and all you can say at the end of all that is the more diving you do and the more horrendous the diving, the more likely you are to get bone trouble.

We did get cases of people who dived only on compressed air. The original Kiel Canal work was only on compressed air. You can get it in sports divers, but what we do not know is what those divers have really done with their decompression stops and whether they stayed within the correct Navy tables. We did have one Navy diver who had only done air diving, but again we just have not got the faintest idea what he might or might not have done in his spare time. I do not think you can say that the Navy tables were responsible for that case.

The primary presenting complaint is pain. When the joint spaces are intact the individual is asymptomatic. But when the joint surface is damaged, pain is felt. One diver had a very sudden onset of pain. He was a civilian diver doing a standard dive repairing some lock gates. He put his hand above his head to push up on something and his joint just gave way. So that sharp onset of pain underwater was totally coincidental, he could have done it equally well on the surface. A sudden onset of pain is unusual, but it has happened.

Although the usual latency is about 3 months, it may take up to 5 years to show the lesion. Submarine escape can also cause dysbaric osteonecrosis. In 1931 HMAS POSEIDON, a submarine, sank in about 100 feet of water. Six men escaped from the forward compartment. They all got back to the surface. After twelve years three of them were X-rayed and all three of them had articular lesions. So that demonstrates that one exposure can cause it.

The prognosis is very difficult, on the whole people tend to get worse rather than better. Shaft lesions may regress, but it is unusual. Whether or not one can predict the future of an individual, I think one must assume the worst. If anyone has a juxta-articular lesion you want to get them to give up diving, and give up any work that might stress that particular joint. Perhaps the best treatment is to send them along to an orthopod who can then take the responsibility, for by then it is too late for a diving doctor to do anything for him.

The diagnosis is fairly easy. The only point of the shaft lesion so far as I am concerned is that there is confirming evidence. I have suggested to Denis Walder that he should cut out the knee X-rays, but he likes to see shaft lesions there if there is a doubtful juxta-articular lesion somewhere else, because it helps to support the diagnosis. It is the way in which the X-rays are read that is important. Each set of X-rays is sent to a consultant radiologist, who is experienced in the diagnosis of bone necrosis, and he will classify the lesions, if any, that he sees. The zeros of course can get put on the heap, but the rest will be sent to another consultant of equal experience and are re-read. If there is any difference between them, the films are sent to yet another radiologist, who will try and resolve the difference between the first two. Considering there are eight films per diver, there is quite a lot of hard work establishing the diagnosis at this research level.

Dr Elliott showed slides of typical lesions. For examples please refer to "Dysbarism Related Osteonecrosis" (the proceedings of a symposium held in February 1972) published in 1974 by the US Department of Health, Education and Welfare. Sold by the Superintendent of Documents, US Government Printing Office, Washington DC.

Reading these X-rays is not easy but it has been done in a very scientific manner and therefore may be considered valid.

When it is necessary to do these particular bone X-rays (and anyone who does them should look up the original papers) each X-ray has to be taken in a particular way and external rotation of the shoulder joint is important. Occasionally lesions are only seen on one of the two views.

So here then is the classification as set out in Table 1. The A lesions are the juxta-articular and the B lesions are of the shaft, which of course can occur in the head itself.

TABLE I

CLASSIFICATION OF DYSBARIC OSTEONECROSIS

A LESIONS	JUXTA-ARTICULAR	
A1	Dense areas with intact articular cortex.	
A2	Spherical segmental opacities	
A3	Linear opacities	
A4	Structural failures	
	a.	Translucent subcortical band.
	b.	Collapse of cortex
	c.	Sequestration of cortex
A5	Secondary degenerative arthritis (osteoarthritis)	
B LESIONS	HEAD, NECK AND SHAFT	
B1	Dense areas (*not* Bone Islands)	
B2	Irregular calcified areas	
B3	Translucent areas and cysts	
B4	Cortical thickening	

Not everything that shows on an X-ray is bone necrosis. A standard cyst of the neck of the femur has been sufficient to stop a diver being employed, which of course is quite unfair. The medico-legal implications of bone necrosis are so great that a lot of diving companies, especially in the USA, are not prepared to take divers on if they have got anything wrong with their bones at all.

What about the distribution? Of over 300 lesions in over 200 men the majority were in the B category. So one can almost dump that lot and forget all about them. Only nine people altogether had structural failure. Those figures come from a survey by the Medical Research Council, which is continuing. The figures which we now have from the Registry were 60 divers with intact juxta-articular lesions and 9 with fractures. An incidence of only 1.4%, because the survey now has over 4,000 divers, a very big collection of X-rays.

The condition is fairly well understood in that we think it is caused by inadequate decompression. We now know enough about it so that we will advise the diver with a shaft-lesion that it does not matter a damn and he can carry on diving. Which is advice that a year or two ago we were not prepared to give. We now advise anybody who has got a juxta-articular lesion that he should give up diving and should see an orthopaedic surgeon.

We have been looking also at other survey techniques. One or two of them are still purely in the research stage, but bone scanning has been really quite interesting. The trouble with bone scanning is that it is too sensitive and if done soon after a dive, you get lesions in a very high proportion of divers, but more than two thirds of them revert back to normal over a year. So scans, which are quite a lot of trouble to do, are not really very helpful. They will merely tell you that if you have got nothing there, the odds are that you are going to get nothing in due course. If you have got a lesion it does not prove anything, but unfortunately about one third of those do go on to produce a radiological lesion sometime later.

DISCUSSION

Dr John Knight

Some of the cases of osteonecrosis that were studied by Ian Unsworth in New South Wales were divers who had a history of trauma from football and suchlike. Their lesions could be detected on X-rays which had been taken for other reasons before their diving.

Dr David Elliott

Fair enough. The official list of the differential diagnosis is given in Table 2. If anyone has got one of those diseases, they should not be diving.

TABLE 2

CAUSES OF OSTEONECROSIS NOT ASSOCIATED WITH DIVING

Steroid Therapy
Excessive Alcohol Consumption
Hepatic Disease
Gout or Hyperuricaemia
Thrombocytopenia
Thrombocythaemia
Hypercholesteraemia
Hyperlipidaemia
Discoid Lupus Erythematosis
Systemic Lupus Erythematosis
Fabry's Disease
Raymaud's Disease
Gaucher's Disease

If you are unfortunate enough to have a juxta-articular lesion, go to your favourite orthopaedic surgeon and have a series of new hips for the rest of your life. Juxta-articular lesions do not necessarily progress from A1 to A5. The trouble is that you do not know which will. Some will remain asymptomatic.

Question:

At what stage do symptoms develop? Do joints have to be involved?

Dr David Elliott

A lot of people with juxta-articular lesions are symptomless. But all people with symptoms have got a juxta-articular lesion with a structural fault of the joint.

Question:

Is there a recommended period of time after a long bone fracture that a person can resume diving?

Dr David Elliott

On the whole people just carry on diving as soon as they are fit to do so. Until we know better, there is no reason to stop them.

Question:

Do you have any evidence that dysbaric osteonecrosis is related more to prolonged exposure under pressure rather than exposure to high pressure?

Dr David Elliott

There are three factors actually: decompression, exposure to high pressure, and the duration of the exposure under pressure. I am on the side of the decompression aspect, which is my particular drum. However the MRC figures tend to show that saturation divers are more prone than bounce divers. I do not know what interpretation to put on that. It is not depth related. But it certainly is duration related for saturation diving. You could say that the saturation diver, so far as bones are concerned, could have a pretty lousy decompression. There is hardly ever a saturation decompression that is bends free. Bends are normal in saturation diving. Limb bends are not regarded as any sort of emergency in commercial diving. It is just part of the daily scene. You know that the pain will go away under recompression. I think that it is probably more related to that, than either the depth or the duration of the saturation.

Question:

I wonder how the companies cope with the problem of the long latent period. If you take a diver from another company and he develops a lesion after twelve months of working for you, who will be responsible?

Dr David Elliott

You are dealing with a complex situation with law suits and juries and all that. Shell only employ contractors. The diving contractor is the person who is responsible. When a diver gets bone necrosis he will sue everybody. That is a bit of good legal strategy. The fact that he had a clean X-ray when he joined the company will usually be judged by a jury as evidence that he was in good nick when he was first employed, and therefore the company is responsible. You will get a lot of people arguing of course, about that sort of point. The latency is well established in the literature. Therefore I believe that a court which has been properly advised by Counsel should not give judgement to one party or the other.

Dr John Knight

In Singapore, where the fishermen divers have much the same sort of incidence as the Japanese, they tend, for reasons of kindness to the patient, to hang the osteo-arthritic hip on the last attack of decompression sickness that gave him pain in the joint, so they can get him some compensation from his current employer. They consider it too difficult to decide who is responsible.

Dr David Elliott

In diving, there are two kinds of insurance, personal liability and personal accident. In the USA divers have had up to $50,000 for a totally benign lesion. But in the UK, there has never yet been a court case about a diver's osteonecrosis. I know of only one case that was settled out of court. It was brought on the accident insurance which was of no great consequence. As it was settled out of court, it does not create a precedent. There are only two big insurance companies in this business. They are saying that they are going to settle out of court until they find a case to act as a precedent. But for that they have to have all the records correct. This is difficult because what happens is that when you go to a diving company to get diver's logs, they can not find them. The diver says "Look here, I got bent, and they did not do the right decompression and it is all their fault". So far the diving company has been unable to disprove that he was bent through negligence. But at the same time it has not been proven either. Once negligence is established in one field, then of course it can be applied all the way through. So it is a complex legal approach, but so far no case has been successful under employer's liability legislation in the UK.

Question:

How often should the screening be?

Dr David Elliott

It is pretty complex. It used to be annual for everybody. But now that it has been recognised that compressed air divers and young divers do not get it so often, that has been changed. I objected to the wording of the new rules and regulations, but my objections were ignored. On the whole the British regulations are quite good. They read as follows:

"X-rays of long bones and joints, in accordance with the recommendations of the MRC decompression sickness panel techniques, should be carried out on all divers at the initial examination, with the exception of divers who indicate that they will not be diving on compressed .natural air to depths greater than 30 metres and whose total exposure to pressure will not exceed four hours in any single occasion. Such examination should then be carried out annually as appropriate considering the diver's experience over the previous three years with the following exceptions. Annual X-rays are not required for divers using only compressed natural air, who have not been exposed to pressure more than the equivalent of 30 metres, and whose exposure at any one time has not exceeded four hours."

Do you want me to go on? You can get the gist. On the whole it is annual, but for young guys and people who dive at less than 30 metres, and do not stay under for more than four hours, they will be about every three years.

COMMERCIAL HELIUM-OXYGEN DIVING

David Elliott

Diving is a subject in which you are all obviously interested, so having given you some fairly serious papers, I thought that it was time to give you one which is really of interest value only. But, nevertheless, as doctors involved in diving, it is worth your while knowing what is going on in the commercial diving field, if only to appreciate the fact that diving is a very important part of occupational medicine and applied physiology.

Pressure affects every ceil of the body. In fact there is hardly a system that is not affected by pressure. I would remind you that many bio-chemical reactions in the body are not iso-volumetric, which means that they will either be inhibited or accelerated by pressure. This means that literally every cell of the body is affected. There are various rather subtle enzyme changes that can go on in man when he is at very great depth. Pressure is used as a research tool, as an additional variable to basic physiology. There are a number of physiologists who are interested in the effects of pressure, who study various uni-cell preparations and other systems in order to test how pressure affects physiology. I think that it is worthwhile appreciating that there is a lot more to diving applied physiology than the somewhat easy version which we teach in the courses for divers and so forth. I feel very strongly that diving should be part of applied physiology training, because it is a very useful academic subject in the area of altered physiology. I also believe that more occupational medicine should be taught in medical schools. I think as diving doctors and as hospital consultants this is something that you can influence in the future.

Having finished my little sermon, let me now get on to the diving which I am working in myself. Diving is indeed a limiting factor for the future of the offshore gas and oil industry. This talk will not be diving medicine, it will be about practical diving and diving physiology.

The diver is regarded as nothing more than a versatile, effective and relatively cheap underwater tool. If the job could be done by some mechanical device the engineers would prefer it. So far as they are concerned the diver is just a damned nuisance, because he is a biological specimen. Things can go wrong and when they do everything else on the platform can come to a stop. Divers are cheap, and they are versatile, but they are not very popular. But with good diving procedures and well maintained equipment accidents are quite rare. Our problem is that as divers go to deeper and deeper depths, as the world needs oil from deeper water, so the margins of safety for divers associated with the oil industry are getting less and less. Also the cost of supporting a diving system at great depth increases enormously.

This has stimulated a number of developments such as JIM, which is a one-atmosphere suit. I imagine that most people in Australia are familiar with this because it has been used extensively, both in Bass Strait and on the North-west Shelf. The thing about JIM and the other one-atmosphere systems is that the man is totally protected from the high pressure environment. Therefore there are no physiological problems of any significance. The difficulty is that JIM, although pressure rated now to 2,000 feet, is cumbersome. For instance, if he gets his foot caught in something he can not reach down below his knees so another JIM would have to have to be used to rescue him. It is so big that if you design an underwater manifold system for the pipeline you have to design it three to four times as large as you would have to do if you had a diver to do the same job. That costs a lot more money than employing a diver in the first place. Sometimes it is cheaper to employ a diver to do the job because it is so cumbersome. JIM and remote controlled unmanned robots were supposed to virtually replace divers from the off-shore scene. Like most predictions this one was considerably premature. In fact the only place where JIM really works is on the exploration side. Here the drill ship is just testing a well in some remote part of the sea and occasionally may need to send JIM down to do something at the sea bed. For the construction phase of the oil field and later for the life of that oilfield, when there has to be maintenance inspection and occasional repair, there are a lost of tasks for which JIM is quite unsuitable.

Welding underwater is often required. One uses a thing called a pipe alignment frame. The pipe alignment frame links up the bits of an underwater pipeline that have to be joined. The frame is quite a big piece of engineering. The bell will come down and the divers will either get out of the bell and do some sort of job in the water, or they will blow down the little inverted habitat inside the frame and work in a dry environment to weld the two ends of the pipe together.

Divers are essential to the kind of work which the gas industry and the oil industry will need in the future. Therefore the priorities are to try to determine how deep man can go in the open sea to work both effectively and safely, because that is the limit for what we can get back out of the sea in the way of oil and gas. That is my primary job for a particular oil company. Rather surprisingly, there is no other oil company that does this sort of thing. I think they are hoping that we will do it for them. But in the meanwhile we have got a head start on them and are far better able to bid on offshore contracts, because we know as much about commercial diving as any diving concern.

What I would like to do next, is to give you a synoptic history of helium diving. Although I am tempted to go back to the year 1906, when there was a record air dive to 310 feet, I think I had better begin in the early 1960's, which is when it all began to take off. At that time the world record was held by the Royal Navy. It was 600 feet with a bottom time of about 6 minutes. Commercial deep diving at that time was limited to bounce dives to about 450 feet with about 30 minutes bottom time, sometimes stretching to 60 minutes. The divers were normally ex-USN divers using ex-USN hard hat equipment and US tables. I can well remember the way that they treated their bends. They did entirely in-water stops and they would shout over the intercom "Hey, Bill, let out a bit of slack". That is the way they treated any bends on the way up. It was a pretty dodgy game and that is as recently as 1960.

At the same time and at very much shallower depths, only about 30 feet to 100 feet, the USN Sealab 1, with George Bond and the Con-Shelf One with Cousteau were beginning to gain some public attention. They were pioneering the idea that divers might like to live in an underwater city. I have yet to meet a commercial diver who agreed with that particular idea. So it was a bit of a red herring, although some of the research has indeed been relevant.

Against this dominantly naval background, the Royal Navy doing bounce diving and the US Navy doing saturation diving in a habitat, we began to get stories of some crazy Swiss mathematician doing impossible dives and coming up in a time that should surely kill him. This chap, Hans Keller, and his medical advisor, Professor Buhlmamn from Zurich University, were thought to be using secret gas mixtures in order to do decompressions which were just so rapid as to be potentially lethal from our point of view. Nevertheless, they managed to do a 1,000 foot dive under the eyes of the French Navy, in their chamber in Toulon. Next they got US Navy support and did a dive, using a Shell platform, off California, to 1,000 feet. There is some doubt as to just how much Hans Keller managed to do in the water at 1,000 feet, but he certainly got out of the bell, because it was his fin that stopped the lower door from closing after that. But he was very short of gas because there had been a leak overnight and they were using the last bottles to do their dive. So it was not done in a particularly efficient, good diving manner. The result was that his buddy died on the way up from decompression sickness. The standby diver sent down from the surface to try and close the bottom door was swept away and never seen again. So you can understand that the Americans who witnessed that, both the Navy and Shell, really thought that there was no future in deep diving. The USN then continued their saturation diving in shallow depths while Shell proceeded to develop a thing called the Lockheed system.

The Lockheed system is a one-atmosphere system. One has a typical open sea workboat with an A-frame containing what looks like a diving bell. That is a one-atmosphere bell and it is an absolute dream to go in for a diver because it is so comfortable. This bell is lowered onto a sea bed habitat which is also one-atmosphere. Engineers can go down and do any maintenance and then shut the door and come back to the surface. That sounds like a jolly good system because you do not have to use divers. But there are a number of problems which we need not bother to go into. One is the vast expense of maintaining the surface support. Another is that Lockheed rather oversold it by saying that it was a "shirt-sleeve" environment. For an engineer who has never left the surface before it could be quite terrifying. But for anyone who has been diving in a bell it is an absolute breeze. So the Lockheed system was born. That was the basis of most American commercial developments in the next few years, with one notable exception, which I shall come to later.

Shell formed a diving company and commissioned Professor Buhlmann and Hans Keller to do research. We only got rid of that company two years ago. He had been working for us for 18 years and had done a lot of good work in that time.

So in Europe we began to feel that Keller had done, in spite of those fatalities, a lot of good work. It was a tremendous breakthrough. Immediately, the Royal Navy resumed its bounce diving. This is where I came in. A 600 foot, one hour bottom time dive done in the 1964-65 season, off the south coast of France.

What we are talking about, whether it is a saturation system or a bounce dive system is a deck decompression chamber and a diving bell. The bell goes down and gets to the bottom. It equalises with ambient pressure so that the divers can get out. They return to the bell and shut the bottom door. The bell is hoisted to the surface kept at the pressure of the bottom. It is then locked on to the deck chamber at the same pressure. After they have transferred the divers can do their decompression, if it is a bounce dive, comfortably in the chamber. If it is a saturation dive they can stay there and live at that depth, going down later as required.

The most significant commercial development at that time, 1965, was the first commercial saturation dive, for the hydroelectric scheme on the Swiss Mountain Dam.

What has been happening since then? We have just been trying to make the divers go deeper, longer, and do it more safely.

Saturation Diving

A bounce dive with 15 minutes bottom time at 450 feet requires approximately 5 1/2 hours of decompression. So if you get an hour's working time, of which a lot will be taken up in getting out of the bell and all that sort of thing, you have got to have more than a 24 hour availability of men. Gas uptake reaches equilibrium after about 6-12 hours, the precise time is neither agreed nor known. If you stay longer than that and become equilibrated, then there is no further uptake. Since there is no further uptake the decompression penalty will not increase any further. So after you have been down at the bottom for nearly 24 hours the decompression profile will be identical even if you were to stay there a month. That is exactly what is done.

The concept of saturation diving is, you go down, you stay there, achieve equilibrium and then it does not matter when you come up. You may just as well get the job finished and then come up slowly. The only difference now is that we tend to saturate at a depth somewhat shallower than the working depth, and then make little bounce dives each day to the working level. That means that if one has to use a hyperbaric lifeboat the divers may be 150 feet nearer to safety than they would otherwise be. It is also something of a bother because we think that may be what is causing bone necrosis. But we really do not know.

I would like to show you a pressure chamber which was actually built, welded together, stressed, in the basement of a hospital. There is a ward immediately above it. So the engineering, the airconditioning system, the great heat stress, was quite a challenge. It is a 1,000 metre system, and it was designed by the same man who designed that little one man chamber that was in the Swiss helicopter. One can go down at a rate of 500 metres in 50 minutes, maintaining ambient temperature at 32°, which is what the diver requires, and also maintaining the noise level at less than 20 decibels. It is beautifully designed.

You were shown a film of JANUS IV in Singapore. It was a combined dive by the French Navy and the Comex diving organisation, off the south coast of France. My slide picture was taken at 450 metres in the open sea. They actually did 10 minutes at 510 metres, which is the deepest that man has been in the open sea. But unfortunately a piece of Comex breathing apparatus packed up, so it was not really a working dive. Nevertheless, it shows that man can get in the water and do beautiful work at those depths.

Perhaps the world's best deep-diving unit is in Panama City in Florida. Unfortunately, I have absolutely no say in its management because it belongs to the USN. It has got a saturation living system at the top and underneath there is a floodable chamber that can take a 32 feet submersible. The whole thing will go down to 2,000 feet. They employ four doctors, twelve medics, and sixty divers. Their research effort is as great as the rest of the world put together.

We are not very interested to find the maximum depth that man can work. Really what we are interested in is, how well can man work in cold water and in breathing apparatus. One needs a decent breathing apparatus with good communication to the surface and heating of the inspiratory gas. The other thing which bothers us a little bit is whether there are any long term consequences to the health of the diver. The answer, at the moment, is that although we have found various changes and enzyme changes at depth, it all appears to be transient. But by transient I mean that they go within a few months of surfacing.

Last year you had John Miller on the Duke University dive in 1980. Shell put $50,000 into Duke University's dive in January this year (1981).

One needs a little bit more gas for a deep chamber dive than one does for sports diving. The oxygen content of the gas has to be monitored very closely. It is 0.72% at maximum depth, so that has to be kept within about O.05%. They were doing pulmonary physiology, including breath by breath 0_2 and CO_2. So the standard of gas calibration had to be absolutely superb. They had two technicians working for one year just to calibrate all the gases they needed for that dive. They went doom to 2,165 feet in the first instance, which is the depth that they just achieved last year. John Miller was once again responsible for the medical aspects of the dive. I was just a visitor. They performed all the normal sorts of cyclometric tests. There were three professional divers inside and each one did an arterial puncture on one of the other divers and had no trouble in doing it. I consider that is a major measure of their mental and physical ability at depth.

At that depth one diver did 240 watts for 5 minutes. I think that effort on the exercise bicycle is best compared to running a 5 minute mile in mud with Wellington boots on. He was a little bit knackered afterwards, but his $PaCO_2$ remained pretty good. It did not go up very much. So that shows that man can work very hard at very great depths. It shows too that we can hope that man will perhaps one day get to those depths in the sea. Then they went deeper and did 24 hours at 2,250 feet. They had more than eleven days deeper than 2,000 feet. That is the deepest that man has ever been to in high pressure chambers.

The deepest and longest that man has ever worked in the sea commercially is half that depth. That is the bottom bit of the Cognac Platform, at a depth of 1,025 feet. To place it, two derrick barges were used with a saturation system on each. This was for Shell, and I was quite heavily involved.

The saturation system on one of those barges has an entry lock to the deck chamber and a mating diving bell, which is hoisted by an A-frame. There is the saturation shack where they monitor the gases and pressures and generally look after the men who are living in the chamber. There is the dive control shack where they look after the bell. There is also the most important thing in diving monitoring, the little mobile eyeball known to the divers as "Harvey". If he did not come and watch them they used to beckon him over and pat him on the head. It is very useful because they position the work basket and the bell right next to the job, which has been pre-planned. The diver would not come out until all was ready, and topside were able to see everything the diver was doing. That diving was over a period of two years. The divers worked more than 14,000 man hours at more than 900 feet. There is a great gulf at present between what can be done commercially and what can be done in a University laboratory.

So the next emphasis is how we are going to bring them together, because commercially we do not have the equipment of the USN Experimental Diving Unit. I mentioned when I was dealing with contingency planning both the Lost Bell and Polar Bear project, which is what was done at the Norwegian Underwater Institute in Bergen. The chamber only started work in February 1980. It is rated to 650 metres and has two living chambers, a transfer lock, and a wet lock, rather like the one at Panama City, but a quarter of the size. They have got a bell which theoretically can take divers from the living chambers and lock them onto the wet part. But they do not do that, because they only have a second-hand bell. The Polar Bear Project, which Shell sponsored and ran, had help from the by Department of Energy and the Norwegian Training Directorate. When we were running the Shell doctor's course in Bergen last year I was pleased that the Norwegian Shell Company came along and said that they would sponsor this complex, as Shell's contribution to Norwegian Research, because oil companies have to make a contribution in Norway if they want to have any hope of getting a contract for development.

Last November we did a 300 metre dive in this chamber. The purpose of that really was to weld the two together, I think they made every mistake in the book, but they came out of it very well indeed. They are now so confident that we are going to do a 500 metre dive in that chamber. You can actually have a dry compartment and then a wet compartment in a horizontal chamber. We are going to send one team of men down to 500 metres on oxy-helium rather like the USN has done and Zurich University has done, and Professor Lambertson has done. In the other chamber we will take the divers down on the Duke University profile with added 10% nitrogen. We will then compare the two groups of divers when they hit maximum depth. The emphasis is not on the academic as much as on the practical. Our real objective is to simulate open sea conditions in cold water and test breathing apparatus, heating systems and communications systems.

DISCUSSION

Question:

Is there any move to try hydrogen in deep diving or can we expect to go from Trimix to yet a more complicated mixture?

Dr David Elliott

Hydrogen is a very good diving gas. It is less narcotic and lighter than helium. It does have a tendency to explode on contact with air, but if the oxygen content is less than 4% it is non-combustible. The Swedish Navy, many years ago did some very successful dives on hydrogen, but unfortunately a diver died due to a simple procedural error. He was pulled to the surface, when they should have given him a few stops, which was rather tragic. But that death killed the Swedish Navy's interest in deep diving. But it was not the fault of the hydrogen.

The USN has commissioned research on hydrogen. There have been some rather horrendous explosions during this research. It is a very good diving gas and the difficulty is how to use it safely. In about 1967 Comex did a hydrogen dive. They went to about 200 feet on helium. The hydrogen was stored outside the diving bell and there was a little air lock outside the diving bell. They went into that little lock and switched gases when outside in the water. That is safe and I think that is the only safe way it can be done. Otherwise the hydrogen must at some time get back to the surface and be an explosion risk. Peter Bennett would far rather use hydrogen instead of nitrogen and helium as his diving gas but, needless to say, the hospital will not allow him to do so. Although it is safe to use at great depth, it is not safe to have it near the surface, so far, commercially.

Question:

What are the oxygen partial pressures used in deep diving?

Dr David Elliott

I will talk in fractions of an atmosphere. You have not much margin to play with as far as gas mixing is concerned. You have got to keep the oxygen partial pressure between 0.21 and 0.6. Above 0.6 you are liable to get pulmonary toxicity. Keeping it about 0.4 or 0.5 is about halfway between the two. In fact it has been shown that man is slightly physically more effective on 40% oxygen than he is on 20%.

Question:

In experimental diving do you have to continually monitor and adjust oxygen levels?

Dr David Elliott

Yes. This is a problem with very deep diving. You virtually need a complete university department to do a dive like Peter Bennett's. How are you going to translate that into commerce for practical diving? That is my problem.

Question:

How can you have wet and dry compartments in a horizontal chamber?

Dr David Elliott

One has two transparent vertical partitions, one from the roof (A) and one from the floor (B). They overlap by a couple of feet. (Figure 1). Water is put in the chamber on the side of the floor partition (B) that has the roof partition (A) coming down. Once the water reaches between the two partitions the pressure on the water surface at (C) will stop water getting into the rest of the chamber. Then more water is added while gas is vented from the water filled section. Then one has a water filled section, in a horizontal chamber, for divers to work in.

FIGURE 1

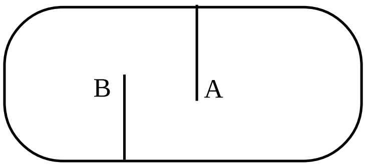
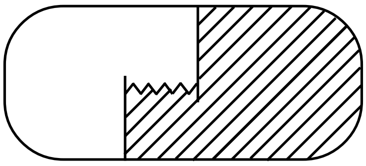


FIGURE 2



Question:

Is it very difficult to measure oxygen partial pressures accurately. Do they just work it out by the amount they are adding to the chamber?

Dr David Elliott

No, it is all calibrated. The people who are doing it are university physiologists. They are talking about measuring 0.001% accurately. I see no way at the moment that we can ever translate that to the offshore scene. However I think there are a lot of university things that we can convert for practical purposes. You can convert achievements into commercial diving operations. Helium is indeed very expensive, and this is the reason why we are now having these so-called push/pull systems, where the helium is returned either to the bell or to the surface, for re-processing.

There is no doubt that in man some of the respiratory limitations which were thought to be mechanical, are in fact a consequence of High Pressure Neurological Syndrome. But basically, if I can give you a grossly over-simplified hypothesis, here is an explanation. You can imagine that the fatty tissues and the watery tissues of the body compress at different rates. Then at very great depths the myelin sheath, on which conduction is dependant, is actually thinner, relative to the axon, than usual. As a result, and I repeat that this is grossly simplified, you get a whole stack of things due to High Pressure Neurological Syndrome. In order to restore that neurilemmal layer to its relatively correct thickness so that conduction can be carried on as it was, you have to add an anaesthetic agent, This acts by being fat soluble and expanding the neurilemmal sheath. The anaesthetic agent which you add is in fact nitrogen, because nitrogen is an inert gas. The mechanism of inert gas narcosis is the same as alcohol and anaesthesia. So we try to find a balance between the effects of helium and pressure which cause the neurilemmal sheath to go thin and adding nitrogen as an anaesthetic agent to re-expand it to its normal value. It is amazing that it works as well as it does. There are a few bits of the syndrome which it does not manage to deal with. We are not sure what causes the ultimate problem, that of convulsions.

If you produce alcohol at great depth the effect of pressure would, as it were, reverse the anaesthetic effects of the alcohol so that the yeast would be more productive. Although it does not work with drinking alcohol, it does work with some commercial alcohols. So fermentation at pressure, and the pressure reversal of anaesthesia, was one of the things that prompted Peter Bennett to write the paper in Undersea Biomedical Research in which he predicted that of the percentages 5, 10, 15, 10% would be the right theoretical percentage of nitrogen, which would exactly balance out the effects of pressure at any depth. The depth is independent of the absolute pressure, it is the percentage that counts.

Question:

You may have observed some rather sleepy people around at various times and I have heard the expression a long time ago describing an individual as being a “bubble-head”, which was the diving equivalent of a punch drunk. Have you any experience of this sort of person, other than those you may have met locally and recently?

Dr David Elliott

Actually, your question is very important and it will lead me off on a rather long tangent if I am not careful. What you are really implying is, are there long term effects on the central nervous system from diving? This was a scare which was created by a Hungarian worker, who was looking at compressed air workers. It was written up in Ian McCallum’s book “Compressed Air Work”. It has been quite impossible ever to confirm in any other autopsy material. He claimed to have found cysts in the brains of compressed air workers and said it was all due to their diving. But the very careful autopsy examinations of compressed air workers in Britain and the United States, completely failed to support that. There have been papers written by a group from Galveston, Texas, in which they claim to have done various psychometric tests and found that a few divers were deficient. We had John Hallenbeck come to a meeting in Luxembourg to give a review from the point of view of neurologists with diving experience, as to the likelihood of brain damage following diving. Without going into the arguments his conclusion was that one would not expect permanent damage to be done to any diver unless it was due to untreated decompression sickness. That one does have to accept, but certainly not all these other problems.

MAMMALIAN BREATHOLD DIVING

John Knight

I am going to talk about air breathing mammals, of which one has two legs, two arms, a head and is called man or woman and compare that mammal with the other mammals that go underwater.

DIVING RESPONSES IN ALL MAMMALS

All mammals when they dive develop a bradycardia. There is vaso-constriction to all areas except the heart and brain. As a result they develop a lactic acidosis and more than usual anaerobic metabolism. That applies to all mammals, but some have these responses more developed than others.

There are certain advantages from these diving responses. They shut down the circulation to the unnecessary parts of the body. As an anaesthetist, I reckon that the heart and the brain are necessary for survival. By shutting down the peripheral circulation, these responses reduce the oxygen need. Again, by shutting down the peripheral circulation, there is increased oxygen extraction from the blood, because the blood-tissue partial pressure differential is higher. The production of energy without oxygen is increased. By shutting down the circulation to the periphery the core temperature is maintained. Anyone who gets into the water in Victoria shuts down the peripheral circulation very smartly. In a wet-suit I can last for about three-quarters of an hour before my core temperature has dropped to the point where I start to shiver.

There are certain disadvantages. There is an increased oxygen debt because of the anaerobic metabolism. The oxygen has to be supplied later. There is tissue anoxia from the shut-down. No matter how efficient the peripheral vasoconstriction is, one still loses heat and gets cold.

IMMERSION RESPONSES IN MAN

The effect of getting into water in the vertical position is that hydrostatic pressure compresses the legs and abdomen and forces blood from the periphery up into the chest. This results in a number of physiological reflexes. There are receptors which monitor the size of the great veins in the chest. If they get stretched, the brain reckons that there is too much blood and takes steps to get rid of fluid. As a result there is a diuresis. That is why about half an hour after one gets into the water there is an overpowering urge to dampen your wet suit even more. It is a very comfortable dampness because it is warmer than the water.

Lung Changes

Vertical immersion puts blood into the chest and even with the diuresis it leaves more blood in the chest than before. As blood is transferred to the thorax, lung mechanics change. If there is more blood in the lungs, the lungs become stiffer. This results in an increase in airway resistance of the order of 58%. This results in an increase of 60% in the work of breathing. This is with immersion to the neck. Underwater the work of breathing is further increased by the inefficiencies of the diver's breathing apparatus.

The increase in pulmonary blood volume increases the size of the closing volume. With expiration an equal pressure point develops at which the small airways collapse and trap the air beyond it. During immersion the pressure is higher and the trapped volume, the closing volume, larger. As a result of the increased pulmonary blood volume areas which are normally poorly perfused, are better perfused but they are not better ventilated. So there are changes in ventilation-perfusion ratios. These changes occur because normally the apices of the lungs are perfused less than the bases. Also the apices are better ventilated than the bases. But when we get in the water the blood flow is redistributed and the whole lung is more or less uniformly perfused, but ventilation continues to be preferential.

Lung compliance decreases. Our lungs become stiffer so it is more difficult to take a breath. The vital capacity goes down, depending on whose work you quote by 3% to 10%. The residual volume decreases by 4% to 17%. The expiratory reserve volume decreases by 50% to 74%. That is the part of your lung contents you could breathe out if you tried to but is not used in normal breathing. The maximum voluntary ventilation, (MVV) decreases by 15%. This is because the lungs are stiffer and cannot accommodate to rapid change. When underwater one breathes denser gas than at the surface, so the MVV goes down further due to the increased density.

There are two theories why the vital capacity goes down. Recently it has been claimed that the increased thoracic blood volume would completely explain the decrease. Earlier workers attributed 60% of the decrease to extra intrathoracic blood and 40% to the changes in chest mechanics, ie. the upward elevation of the diaphragm and the resistance of the surrounding water to chest expansion. I am not sure that either side convince me that they are right. I think that the earlier workers are probably right. When one has water around the chest one has to push the water out of the way to expand the chest, which must be a drawback to taking a full breath of air.

This displacement of blood into the thorax allows humans to breathhold dive to depths at which their total lung capacity has been reduced to less than their residual volume. Humans can go as deep as 100 metres, if you happen to be Jacques Mayol. I can not do it, but if you have got the right physique and the right amount of blood shunted into your lungs, you can do it.

Gastro-oesophageal Pressure Changes

Another consequence of immersion is gastro-oesophageal pressure changes. If you weigh divers during a dive as the

Swedes have done, you find that they get lighter towards the end of a dive. In other words, they are displacing more water. The reason that they are displacing more water, is that every time they equalize, they swallow a little bit of air. It goes down into the stomach much more easily than in air because the pressure differentials are much reduced in water.

We normally have a quite reasonable pressure gradient between gastric pressure and oesophageal pressure. If we stay upright underwater that increases, but if we invert ourselves, as most of us do at some stage in a dive, that pressure difference decreases tremendously. Upside down in the water the pressure to keep gas out of the stomach is not there. People who come out of the water feeling slightly bloated have every reason to feel that way, if they have been swimming upside down.

Cardiovascular Changes

The cardiovascular changes apply to humans, dogs, beavers, hippopotamuses, or any other mammals that you like to put in water. There is a heart size increase. In humans it is 150 ml, 50% increase compared with out of the water. The stroke volume increases by 35%. In thermoneutral water the peripheral resistance is decreased by 30%. As a result of the decrease in the peripheral resistance, peripheral circulation increases. This has been shown by radioactive xenon elimination from muscles which increases by 130%. Also by measuring the rate at which nitrogen came out of the immersed body compared with the out-of-water body. In 35°C water, nitrogen excretion rate was increased by 40% in the first 30 minutes and by 27% over 7 hours. There was a greater increase in excretive rate in 37°C water.

In cold water there is an increase in peripheral resistance due to the effects of cold on the skin and heat loss.

So perhaps one could say that the sensible thing for the diver to do while decompressing is to sit in a bath of warm water. This is based on the idea that you get rid of the inert gases better if you are warm and immersed to the neck. What happens when you warm a cooled body during decompression is a gamble. I am not volunteering to be the first experimental subject.

There is not all that much work that tells one about what happens when someone gets into the water feet first and then swims horizontally or head down. As far as I can make out, many of the changes of vertical immersion are reversed. But I have not read any evidence to show that the changes that occur on immersion are completely reversed. One must always remember that any diver who has been in the water for any length of time is going to dehydrate just from the physiological results of pushing blood from his periphery into his chest, stimulating the great vessel reflexes and excreting more urine.

RESPONSES ACQUIRED WITH DIVING PRACTICE

Any mammal which is subjected to diving improves his or her diving ability with practice. There is evidence that groups of humans that breathhold dive for their living, had higher haemoglobins, bigger lungs and a better efficiency of ventilation; that is they exchange more gas per breath, than those who do not. Incidentally, Robin Cox told me some eight years ago that the only positive research finding that he had got out of all the diving medicals that had been done in Yarmouth, was that the eighteen year olds had developed a bigger vital capacity by the time they were twenty. People who breathhold dive for a living can hold their breath for longer so can tolerate a larger oxygen debt. They can tolerate a raised $PaC0_2$. Also they can tolerate cold better. They start to shiver after a longer than usual heat loss. If they have got enough food, they increase their insulation.

These responses have certain advantages. If one has a bigger vital capacity, one can go deeper before getting a thoracic squeeze. With a higher haemoglobin there is an increase in body oxygen stores. increased tolerance to a raised PCO_2 allows the person to hold his or her breath longer. The two together allow a longer dive. Tolerance to cold can be acquired. Whether all humans can develop this tolerance is a subject that can be debated for many days. It is accepted that many ethnic groups are tolerant to cold. I believe that western Europeans can be made tolerant to cold otherwise they could not have done the exploratory voyages that they did in unheated sailing ships.

AQUATIC MAMMALS

The specialised aquatic mammals are better at diving than we are. They are especially adapted to life in the water. A human has problems when he gets underwater. If he wants to dive for more than a couple of minutes he has to have an air supply. He has to have a tank on his back, a regulator in his mouth, a compensator on his chest, and so is not a streamlined shape. The specialised aquatic mammals, whether they be beavers, or sea otters, or seals or whales, have a nice rounded body contour for efficient swimming. They also have various anatomical changes that help. Their chest walls are easily compressed. They have lungs that collapse and expand again easily. They have adaptations in their blood vessels which allow blood to be shunted, not to the lungs, but into the blood vessels in the thorax, so that the lung does not get stiffer. When they dive, they shut down the renal circulation and become anuric.

They also have certain modifications in their anatomy for avoiding barotrauma. The lining of the middle ear is distensible, unlike that of humans. As they go down blood is shunted into that lining. It is like a great big velvet rug, which swells out and surrounds the ossicles and completely displaces any air in the middle ear. They also have an adaptation to avoid decompression sickness and nitrogen narcosis. As they go down their lungs collapse and gas is pushed into the non-respiratory airways. Here it has no exchange with the blood so the PN_2 does not rise. So they do not get nitrogen narcosis. Neither do they take up any extra gas. They also have high haemoglobin and so carry a lot more oxygen. They can use the venous oxygen stores.

The circulatory shutdown shunts the blood to the heart and brain. Because they are streamlined they have increased swimming power. Because they shut down the peripheral circulation they are tolerant to cold. A whale is not impervious to cold. It survives in the Antarctic because it has about a foot and a half of blubber all around. He has got heat producing organs inside and the insulation keeps the heat in.

TABLE I

BREATHHOLD DIVING TIMES (IN MINUTES)

Man	3.5
Dog	4
Beaver	15
Porpoise	6
Killer Whale	12
Manatee	30
Grey Seal	20
Harbour Seal	23
Weddell Seal	43
Blue Whale	50
Sperm Whale	75
Bottlenose	120

Now to compare the times that mammals can hold their breath. Dogs can do it better than humans. The beaver can last longer than with dog or man. The porpoise, a very specialised aquatic mammal, can breathhold only twice as long as a human. A porpoise is about the same size or perhaps a bit bigger than a human. It is really quite interesting that his breathhold is so much less than that of the sperm whale, which is vast compared to the porpoise. Yet the sperm whale has a breathhold of over an hour.

If we compare the actual dive times with those predicted on the basis of oxygen carried in the blood, even man exceeds the predictions. The various diving reflexes increase the dive time beyond the theoretical limit.

TABLE II

PREDICTED AND ATTAINED DIVE TIMES (IN MINUTES)

SPECIES	PREDICTED	OBSERVED
Man	2.5	3.5
Porpoise	2.5	6
Seal	6	18
Fin Whale	17	30
Bottlenose	36	120

Man is a poor performer in the depth stakes. The 100 m record was attained after a long work up with special equipment to get Jacques Mayol down quickly. He reached it in a very spectacular series of dives. It was a lot further than anyone had been before and a lot further than the physiologists predicted was possible a mere five years before he did it. We know that sperm whales dive to 1,000 metres because some have died at that depth entangled in submarine cables and been found when the cable was lifted for repair.

TABLE III

DEPTH OF DIVES (IN METRES)

Man	100
Grey Seal	134
Harbour Seal	250
Porpoise	305
Weddell Seal	550
Bottlenose Whale	825
Sperm Whale	1000

One of the major modifications in aquatic mammals is their remarkably slow respiratory rate at rest. A human sitting on the beach sunning himself breathes fifteen times a minute. A Californian sea lion sitting on the beach sunning himself breathes six times a minute. The dolphin needs to take three or four breaths a minute. The killer whale breathes 0.8 times a minute when he gets to the surface. This is probably the most spectacular change in aquatic mammals - their incredible efficiency at inflating their lungs.

Besides the slow respiratory rate the diving mammals have, relative to man, a very much reduced ventilation. This is not surprising as their relative lung capacity is also reduced. We are pretty inefficient. We require to change 12 litres of air per minute per 100 kg. Porpoises only need 6 litres per minute, per 100 kg. The bottle nosed whale, which can dive for two hours, only needs 3 litres per minute per 100 kg.

We have a tidal volume of about 500 ml or so which works out at approximately 0.8 of a litre per 100 kg. While the porpoise has a very much higher tidal volume than we do, he does not fit into the scheme of things properly. The bottle nosed whale has a tidal volume which is three times ours per 100 kg.

Comparing vital capacity with weight, porpoises are not as good as we are. Seals are about the same as we are. But the really deep divers, the ones who can really last, are very much better equipped with what one might call a power to weight ratio. They have got relatively smaller lungs for their bodies than we have, yet they use a greater percentage of the inhaled oxygen than we do.

Humans have got about 900 ml of oxygen available in their lungs or 7 ml per kg. We use 4 ml/kg/min. So two and a quarter minutes is quite a reasonable estimate of when one should start to breathe again. The fin whale has a whopping great oxygen storage. But when you translate it into mgm per kg, it is really quite small and his usage is quite high,

TABLE IV

RELATIVE VENTILATION

	BREATHS PER MINUTE	RELATIVE VENTILATION (1/min/100 kg)	RELATIVE LUNG CAPACITY (1/100 kg)	RELATIVE TIDAL VOLUME (1/100 kg)	OXYGEN UTILIZATION (%)	DIVE TIME (min)
Man	15	12	5.0	0.8	4.5	3.5
Porpoise	1	6	6.6	5.9	8 to 10	6
Seal	3.4	14	5.0	1.8	5.7	18
Fin Whale	1.2	3	2.9	2.5	8 to 10	30
Bottlenose	1.2	3	2.5	2.2	8 to 10	120

which explains why he is not at the bottom of the list. The bottle nosed whale, which has a much smaller storage, and uses slightly less in ml/kg, uses so much less that he is able to take those very long breathhold dives.

TABLE V

PULMONARY OXYGEN STORES

	OXYGEN AVAILABLE (ml)	LUNG VOLUME (ml/kg)	RESTING OXYGEN USAGE (ml/min)
Man	900	7.0	400
Porpoise	1,000	6.9	450
Seal	1,520	5.0	250
Fin Whale	3,350,000	2.9	200,000
Bottle	109,000	2.5	3,500

The bottlenose whale uses a lot more oxygen than we do per kg, nearly three times as much. Yet he can dive an awful lot longer. He can do this because of the various anatomical and physiological adaptations. His high haemoglobin level allows him to take up a lot of oxygen. He has a lung which collapses when he dives, and so prevents him developing nitrogen narcosis, decompression sickness, or barotrauma, and still provides enough oxygen for him to do long, long dives.

When an animal puts its face into water it develops bradycardia. The vital spot is the snout area, the beak. If you push a duck's beak into water its pulse rate goes down. If you push a human's nose into water, his pulse rate goes down. If he has a tachycardia, in a large proportion of people, the tachycardia stops. If a human puts his face into water his pulse rate drops to 40 or 50. The porpoise, when his face is out of water, has a pulse rate of 60. He puts his face under water and it drops to 30. The hippopotamus divides his pulse rate by nearly 10 when he puts his face under water. The beaver by approximately 10. The seal divides his by 10. The whale very nearly divides it by 10. The penguin goes from 200 to 20 with immersion. If the heart rate goes down like that the oxygen should last longer, because it is not going to be pumped around the body so quickly.

TABLE VI

BRADYCARDIA WITH IMMERSION

	RESTING PULSE RATE	IMMERSED PULSE RATE
Man	75	40 to 50
Porpoise	60	30
Penguin	200	20
Sea Lion	95	20
Whale	100	12 to 24
Hippopotamus	100	10 to 20
Beaver	75 to 90	10
Seal	70 to I40	7 to 14

The scuba diver with a mask on does not develop as slow a bradycardia as he would with his mask off. Covering the beak area does not cancel the reflex. The bradycardia is greater in cold water than in warm water. Humans do not really rate as bradycardic mammals, which probably explains some of the problems that Chris Lourey was talking about in Singapore. *(This paper was published in the 1981 Supplement to the Journal).*

CONCLUSIONS

So humans are not really suited to be breathholding diving mammals.

Neither are they suited to being scuba diving mammals unless they have adequate insulation to prevent them getting cold. They are not suited to being scuba diving mammals unless they stay within the limits of experimentally determined safe diving habits, ie. the diving tables. We are all sticking our necks out to get into the water and go down to look at beautiful things underwater. There is an awful lot not known about humans' reaction to being in the water. But we do knew that what is known to be relatively safe exposure has been determined by trial and error over many, many years. We would be stupid to go outside those trial and error guidelines, especially those of us who are older. Even Navy divers, who are usually 19 to 30, should keep inside the limits set down for Navy divers, which have been proved on Navy divers. We should keep in practice, so keeping our diving adaptation. We need to be confident in the water, so that we may enjoy our holidays, enjoy our diving, pick up large scallops and keep our heads down when a motor boat goes overhead.

DRAFT EDTC MEDICAL SUBCOMMITTEE REPORT 1/81
QUALIFICATION AND TRAINING OF MEDICAL DOCTORS FOR DUTIES RELATED TO DIVING

The categories of medical doctors who have responsibilities for the medical aspects of professional diving are listed below, together with the recommendations for their training.

It is to be noted that the term "diving doctor" is not used since this commonly refers to a medical doctor who is merely interested in sports diving. Also, the UK term "physician" is avoided because it is a word used in French for a non-medical scientist, physicist.

1. DIVING MEDICAL DOCTOR FOR DIVERS

   A doctor trained to conduct medical examinations on divers for fitness to dive
   He need not enter a pressure chamber as part of his duties. An Examining Medical Doctor for Divers must have had at least 30 hours of appropriate training in the subject. It is expected that he will then keep himself up-to-date by attending suitable meetings and refresher courses.

2. DIVING-EMERGENCY MEDICAL DOCTOR

   A doctor trained to work with divers and, in particular to cope with the medical aspects of every kind of diving emergency. He must be fit to go under pressure.
   A Diving-Emergency Medical Doctor must have been trained as an Examining Medical Doctor for Divers. In addition he must have had at least 60 hours of theoretical training in the medical aspects of diving and diving emergencies. He must also have had practical training in pressure chambers. If possible he should also have underwater experience. It is expected that he will keep himself up-to-date by attending suitable meetings and refresher courses.

3. SPECIALIST IN DIVING MEDICINE

   A doctor generally recognised in the international diving community as being well experienced in aspects of diving medicine, such as:
   1. a medical doctor who is consulted on difficult or unusual cases by Examining Medical Doctors for Divers and by Diving Emergency Medical Doctors;
   2. a medical doctor with an expert knowledge of diving physiology;
   3. a specialist in some particular field of medicine (other than diving) who has an expert knowledge of the diving aspects of his special subject.

There is no training course which is appropriate to this category. A Specialist in Diving Medicine has extensive experience in his subject.

The above is the full text of the classification of doctors associated with diving referred to by Dr David Elliott on page 17 of this issue.

DIVING SAFETY MEMORANDA

COMMANDER SA WARNER
Chief Inspector of Diving
Department of Energy
Petroleum Engineering Division
Thames House South
Millbank London SW1P 4QJ

DIVING SAFETY MEMORANDUM NO 6/1982
APPOINTMENT OF DIVING SUPERVISOR

The Diving Operations at Work Regulations require that every diving contractor shall appoint, in writing, diving supervisors.

Having discussed the legal interpretation of the requirement for the diving supervisors to have a written certificate of appointment it is agreed that a written certificate appointing the supervisor for each individual operation is acceptable, but where a supervisor may be moving from one operation to another within the same company a type of "blanket" certificate may be used. A certificate along the following lines is suggested:-

Certificate of appointment of a diving supervisor (issued under Regulation 5(1)(a) of Diving Operations at Work Regulations 1981 in respect of diving in Great Britain, territorial waters and designated areas).

We: XYZ Diving Company Limited

of: Registered address being a diving contractor as defined in Regulation 5(4) of the Diving Operations at Work Regulations and being satisfied that the under-mentioned is a competent person with adequate knowledge and experience of the diving techniques to be used in diving operations of the type carried out by the company I hereby appoint Name - Joe Bloggs of (address of diving supervisor) as an air diving supervisor/bell diving supervisor.

carried out by this company and may be cancelled at any time.

Full name of competent person completing this certificate on behalf of the organisation named above.

Signature
Position.

DIVING SAFETY MEMORANDUM NO 7/1982

MAINTENANCE, EXAMINATION AND TESTING OF PLANT AND EQUIPMENT

Regulation 13 of the Diving Operations at Work Regulations 1981 requires that all diving equipment is maintained in a condition which will ensure so far as it is reasonably practicable that it is safe whilst being used. It requires the keeping of a register for keeping certificates and recording details of maintenance.

In some cases the general standard of equipment and maintenance offshore leaves much to be desired. Diving supervisors and divers are permitted to carry out their own pet modifications and this can lead to a loss of quality control.

Every diving installation should have its own planned maintenance system. All maintenance carried out in accordance with the planned system should be signed for by the competent person carrying out the maintenance.

Any modifications to diving equipment should be carried out by a competent person and so tested to prove that it has not been detrimental to the safety of the original design. All modifications should be shown on the "as fitted drawing" up to date copies of which are available for each installation.

DIVING SAFETY MEMORANDUM NO 8/1987 EMERGENCY ISOLATION OF GAS CIRCUITS IN THE EVENT OF A RUPTURED BELL UMBILICAL

A study of accidents involving rupture of a diving bell main wire and/or surface to bell umbilicals has emphasised the following points:

(a) Occupants in the bell can be thrown about and injured or momentarily shocked.
(b) There is almost always an ingress of water if the external door is not closed.
(c) Surprisingly often, people fail to shut off valves on some circuits.

Points (a) and (b) can be remedied by the introduction of safety belts and by keeping the outer bottom door systematically closed during ascents or descents.

Point (c) can be explained by the fact that divers in such a situation can be emotionally upset, that not all valves are prominently displayed or can be clearly seen as being in an open or closed position, and often some are hidden behind equipment (umbilicals, survival bags, etc.)

In order to improve the diver safety when surface umbilicals are ruptured the following actions should be taken:-

Wherever reasonably practicable all gas and hot water circuits to diving bells should be fitted with a type of non-return valve (non-return valve, flow fuse, deadman handle, etc.) in addition to hull integrity valves.

Hull valves should be of a type that clearly indicates if they are in the open or shut position. ("Quarter turn" or "ball" type valves should have positive means of clipping them into an open or shut position to avoid accidental operation of the valve).

All valves should be clearly labelled by name as well as by number. A waterproof check list of all the valves that must be shut to ensure the pressure integrity inside the bell is to be carried in the bell with a duplicate check list kept on the surface.

DIVING SAFETY MEMORANDUM NO 9/1982 GUIDANCE ON MAXIMUM PLANNED DURATION OF BELL RUNS AND SATURATION EXPOSURES

Following discussion with the Association of Offshore Diving Contractors the following guidance is provided:-

Under normal circumstances bell should be planned not to exceed 8 hours duration. (The term "bell run" should not be confused with "bottom time". A bell run is the total time from the bell being separated from the deck compression chamber at the beginning of a dive to the time that the bell is reconnected to the deck compression chamber. "Bottom time" is used in conjunction with decompression schedules and is total time from "left surface to left bottom").

The planned duration of a normal saturation exposure for any individual should not exceed 28 days and it is recommended that a minimum of 28 days between saturation dives be applied.

HELICOPTERS AND DECOMPRESSION SICKNESS

Ken Wishaw

There is no doubt as to the usefulness of the helicopter in marine search and rescue. Many people owe their lives to its unique abilities in this role. However, its role as a medical transport vehicle is not, as yet, universally accepted. In particular, among diving medical authorities, two distinct opinions exist as to its value in transporting divers with decompression sickness.

In spite of its potential value in this area, there is a dearth of information in popular publications on its value in this situation. Reddick (1) reported six cases of *Aviation* decompression sickness. No complications occurred during flight if the helicopter stayed within 200 feet above ground level of the take-off point. Just how relevant this is to diver decompression sickness is difficult to estimate. Most other authors mention only in passing, that it is a possible transport mode.

ADVANTAGES

1. Most importantly the helicopter offers the ability to transport sophisticated medical assistance to the diver. Even without transport of the diver by air, it is of benefit to make a correct and detailed assessment as soon as possible after the incident. Early implementation of medical treatment (rehydration, high percentage oxygen, maintenance of ventilation if unconscious, etc.) vastly improves the final outcome.

2. Transport to a recompression facility is far more rapid by air than by road. This becomes even more apparent as dive site to chamber distance increases. Most helicopters have a cruising speed of about 110-140 miles per hour.

DISADVANTAGES

There are four arguments against helicopter transport.

Altitude

Obviously, this must be at a minimum, yet people often equate air transport with high altitudes. Most helicopter flights are done below 1,000 feet and extended flights are commonly flown below 100 feet without undue risk and are approved by the Department of Transport.

Looking specifically at the Sydney region, the highest altitude required for the patient will often be the front door of the chamber! In contrast, road transport from areas outside Sydney Region will necessitate considerable time at the 900-1100 feet altitude.

Vibration

Just when bubbles come out of solution when shaking a champagne bottle, so bubbles may come out of solution when a diver is shaken. Difficult as this is to prove, it is quite a logical argument. Just what frequencies are most harmful is not known.

A comparative study (unpublished) on mechanical vibration and noise was performed on helicopters, fixed-wing aircraft and road vehicles by RG Bosshard and J Yeo of the Spinal Unit at Royal North Shore Hospital, in conjunction with the Sydney Wales Helicopter Rescue Service and Dr C Ambrose of the Health Commission of NSW. Various helicopters, fixed-wing aircraft and commonly used road ambulances were employed. Mechanical vibration was measured using small accelerometers strapped to both patients and vehicle chassis, measuring in three axes.

Their conclusion was that the magnitude of the frequency was small (<0.14 g). Helicopters were free of two particular problems namely, increased vibration due to take off and landing by fixed-wing aircraft and adverse road and traffic conditions encountered by road ambulances. Weather conditions did not significantly alter the findings.

They concluded that vibration was not a factor against the use of the helicopter for patient transportation, in spite of hearsay evidence to the contrary. These findings are also supported by the conclusions of the authors (2.3).

Cabin Space

The ideal helicopter should have a large cabin space and weigh next to nothing to minimise the downdraught required to stay airborne. Unfortunately, medium to large helicopters require a downdraught which is often incompatible with marine or coastal rescue and landing.

The commonly used light medical transport helicopter in Australia is the Bell 206B Jet Ranger, which will accommodate three crew in addition to one or two internal stretcher patients. Although not as roomy as a standard road ambulance, most functions - IV infusion, O_2 therapy, etc., can be undertaken. With correct preparation by staff experienced in helicopter medivac, patient welfare can be maintained during flight. If major procedures become necessary, landing sites are always close by and if necessary, diversion to the closest hospital is more rapid by air than by road, from any given location. By use of this rapid transport system, the time the patient is out of the controlled environment of a hospital is drastically reduced.

Weather

Bad weather restricts helicopter flying only ten days per year in Sydney. It is a more stable flying platform than fixed-wing aircraft during windy conditions. As previously stated, adverse weather conditions do not effect vibrations. Within the next two years, all-weather helicopters will become far more common in this country.

INVESTIGATIONS

With all these factors in mind, the author investigated the subject with Surgeon Lieutenant Peter Sullivan from the School of Underwater Medicine, HMAS PENGUIN.

In the last ten years there have been seven well documented cases of divers with decompression sickness being transported by helicopter in NSW. No serious complication or deterioration occurred during these transports and three improved symptomatically. At present we are seeking details of other cases to attempt a statistical analysis.

We attempted to form an in-vitro model of vibration factors, using air compressed gelatin plates, transported by different modes and compared for bubble production. However, due to considerable variability in bubble formation from plate to plate in the control group, the experiment was abandoned.

CONCLUSION

The use of helicopters in rescue retrieval and transport of patients with decompression sickness offers many advantages, The apparent disadvantages when studied from a factual, rather than emotive and hearsay point of view, are minimal. It therefore warrants further usage in this role where time can often be significant in patient welfare.

REFERENCES

1. Reddick EJ. Movement by Helicopter of Patients with Decompression Sickness. *Aviation Space and Environmental Medicine* Oct 1978; 49(10): 1229-30.

2. Dupuis H. Human Exposure to Mechanical Vibration at Lying Posture in the Ambulance Helicopter UH-LD. *Operation Helicopter Aviation Medicine AGARD Conference Proceedings No. 255*. 1978: 12.1

3. Findeis H and Gebhardt G. Zur Lastizkeit Mechaniser Schwingungen. *Zeitschrift fur dei Gasamte Hygiene und Ihre Grenzgjebiete* (Berlin), Feb 1979; 25(2): 163-165

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UNNECESSARY DEATHS

"The Old Master"

Three Naval Officers, who were not formally trained Navy divers, recently drowned while diving in an underwater cave. Though diving in underwater caves is not Navy diving mission-related, some of the conditions the victims encountered and some of the errors they committed are familiar. Therefore, an analysis of their mistakes and a knowledge of how they might be avoided can increase Navy diving safety. This story is recounted here as a case study in diving safety only, and does not constitute an official statement and/or analysis of findings.

The fatalities occurred while the divers were exploring a well-known, frequently dived underwater cavern in north central Florida. Two of them were experienced open-water sport divers. The third diver had recently completed sport diver training. Each wore a single 80-cubic-foot aluminium tank, had a single hose regulator with a pressure gauge, life vest, knife, wet suit, mask and fins and carried two underwater lights. Conditions in the cave appeared favourable: a maximum depth of 70 feet, visibility over 100 feet, a water temperature of 72°F, little or no current, but a floor covered with fine silt. Before the fatal dive, the three had swum from one entrance through the cave approximately 400 feet to a second entrance.

On the second dive, planned as an underwater photography venture, the divers entered a third entrance - still using the same air supply from the first dive, now partially depleted. Several hours later their bodies were recovered, their air supply completely exhausted, at a distance of between 50 and 150 feet from the cave's entrance and at a depth of 60 feet.

Apparently, they had ventured into the cave and passed the silt-free entrance into a heavily silted area. During the photography session, their finning motions had stirred up the bottom, completely shutting out their visibility. Although the divers were found apparently headed out of the cave, they obviously had had insufficient air to find the entrance in the disorientation caused by the silting.

Regardless of one's previous experience, when diving in a new and strange underwater environment, it is imperative to learn the specific dangers that might be encountered. Had these unfortunate divers received training in cave diving, their lives might not have been lost. Diving in this same underwater cave, experienced cave divers have made over 300 dives - charting over 21,000 feet of underwater passage, some of which is 3,000 feet from the nearest known entrance - without a single accident. However, in this same cave over 30 untrained cave divers have perished. The primary difference between the two groups: the trained divers understood the dangers involved and developed and practiced safety procedures to avoid accidents.

Had our ill-fated divers more knowledge of cave diving, they would have realised that, in all cave diving fatalities, at least one of the following cardinal rules is violated: First, *always* maintain a continuous guideline back to the surface. Second, reserve sufficient air for your exit in case of emergency. Third, *do not* dive deeper than 130 feet.

How do these conditions relate to Navy diving, and how can a Navy diver deal with them? Navy divers frequently find themselves working in similar conditions. While inspecting ship's hulls, divers frequently experience disorienting poor visibility, and their access to the surface is often blocked or restricted. When using surface supplied diving gear, a diver has a continuous guideline to the surface. Should the compressor air supply fail, does the diver always have sufficient air to make a safe ascent to the surface?

Perhaps you have encountered similar situations. Have you made a dive using SCUBA in an area where you could not directly ascend to the surface and did not have a guideline? When diving under a ledge, have you always made sure that you had reserve air for a safe exit? If not, you were probably fortunate not to have ended up like our three cave divers - a terrible and senseless waste of our valuable manpower resources,

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RECOMMENDATIONS FOR FLYING AFTER DIVING THE DIVING MEDICAL ADVISORY COMMITTEE

28/30 Little Russell Street
London WC1A 2HN

March 1982

In response to a request from helicopter operators and subsequently the AODC, DMAC was asked to consider what restrictive conditions should be applied to flying after diving. A Workshop with international representation from the aviation and diving medical communities was convened at the Institution of Mechanical Engineers on 18th and 19th January, 1982, to establish the basic scientific principles and to use them to build up a rational and acceptable set of guidelines.

The full proceedings will contain a review of the evidence which lead to these recommendations and will be published in due course, but the following report summarises the conclusions and recommendations which were reached.

For the purposes of this review, it was considered that diving could be divided into two categories, viz:-

1. Air and nitrox diving

2. Mixed gas diving

In addition, the Workshop considered the special problems of air transport after dysbaric illness.

Two maxima of cabin altitude were considered, viz:

a) 2000 feet

b) 8000 feet

1. Air Diving

	Time before flying at cabin altitude 2000 ft	8000 ft
No-stop dives	2 hours	4 hours
(Total time under pressure less than 60 minutes within the previous 12 hours).		
All other air diving	12 hours	12 hours
(less than four hours under pressure)		
Air or Nitrox Saturation	24 hours	48 hours*
(More than four hours under pressure)		

**Experience in this range is extremely limited, and this recommendation should be interpreted with caution.*

2. Mixed Gas Diving
(Diver on air at sea level)

No flying at all for AT LEAST 12 hours following return to atmospheric pressure following heliox and trimix bounce and saturation diving.

3. Following Therapy for Dysbaric Illness

	Time from Completion of therapy 2000 ft	8000 ft
Successfully treated	24 hours	48 hours

Cases with residual symptoms must be decided on an individual basis by a diving medical specialist.

4. Decompression Illness in Flight

In addition, the Workshop considered the problem of decompression illness occurring during a scheduled flight. They recommend the following procedures:-

4.1 Where the diver's symptoms consist only of pain in a limb, he should be treated with analgesics, oxygen if available, and the plane can continue to its destination without diversion or adjustment in altitude.

4.2 When the diver has any other symptoms, immediate advice should be sought from a diving medical specialist. It may be necessary to reduce the cabin altitude or divert to the nearest airport. In the meantime, the patient should be given oxygen if available.

A CHARMED LIFE

Life can be unjust. The success story of the proverbial green bay tree being known to all by repute. Just listen to this. After a great white shark killed a surfer off Monterey in December 1981 a gold prospector with some scuba diving experience decided that he would catch it. Ignoring the local custom of wearing a wet suit to protect one from the chilly waters of the bay, he wore only shorts. His attempt was soon concluded, leg cramps from hypothermia necessitating his rescue. Local opinion was not complimentary to him. He refused to go to hospital and declared that he would make a further attempt. This time the battery of his 6m skiff's engine failed. He had no oars. Some work hard, but fail to make the death column, others reach it despite their strongest efforts to do otherwise.

STOP PRESS

A paper published in 1981 on the subject of Wing Commander Peter Wilkins' paper (page 9) may be of interest.

REFERENCE

Everett WD. Risk of coronary heart disease - Risk analysis in the clinical practice of aerospace medicine using a programmable calculator. *Aviat Space Environ Med*. 1981; (52)9: 561-563.

NOTES TO CORRESPONDENTS AND AUTHORS

Please type all correspondence, in double spacing and only on one side of the paper, and be certain to give your name and address even though they may not be for publication.

Authors are requested to be considerate of the limited facilities for the redrawing of tables, graphs or illustrations and should provide these in a presentation suitable for photo-reduction direct. Books, journals, notices or symposia etc., will be given consideration for notice in this journal.

REPRINTING OF ARTICLES

SPUMS ANNUAL SCIENTIFIC MEETING 1982

Saturday June 26th — Arrive Madang.

Committee Meeting

Sunday June 27th — 1630

ANNUAL GENERAL MEETING

Session Chairman: Dr Chris Lourey

Exercise Physiology	Dr A Bove
Sharks	Dr W Douglas

Monday June 28th — 1630

Session Chairman: Dr John Knight

The Basis for Drug Therapy in Decompression Sickness	Dr A Bove
USN Air Decompression Tables: Theoretical Bases and Analyses of their Safety	Dr B Bassett
A Diagnostic Puzzle	Dr C Finlay-Jones

Tuesday June 29th — 1630

Session Chairman: Dr John McKee

Strategies for the Treatment of Decompression Sickness when no Chamber is available	Dr A Bove
The Edmonds Underwater Oxygen Treatment Apparatus	Dr J Knight
Decompression Sickness, Rabaul, 197a	Dr W Douglas
Air Embolism and Decompression Sickness Case Reports	Dr I Unsworth

Wednesday June 30th — 1630

Session Chairman: Dr Victor Brand

SPORT DIVER Tables. A Proposed Design	Dr B Bassett
Decompression Sickness Case Reports	Dr J McKee
Fitness for Diving	Dr A Bove

Thursday July 1st — 1630

Session Chairman: Dr Ian Unsworth

Cardiovascular Disorders and Diving	Dr A Bove
Two Cases of Necrotising Fasciitis	Dr P McCartney & Dr P McCartney
How Common is Dysbaric Osteonecrosis ?	Dr J Knight
Migraine, Headaches and Divers	Dr R Lloyd-William

Friday July 2nd — 1630

Session Chairman: Dr Graeme Batty

Pulmonary Disorders and Diving	Dr A Bove
Flying after Diving/Diving at Altitude: Report of a Tri-Service Validation Test Programme	Dr B Bassett
An Unusual Case of Gas Gangrene	Dr M Martyn

Saturday July 3rd — 1630

Session Chairman: Dr Ray Leitch

Other Medical Problems and Diving	Dr A Bove
Dive Club First Aid Kits, What Should They Contain?	Dr R Lloyd-William
What Should We Ask For In A Sports Diver Medical?	Dr J Knight

Sunday July 4th

Available for Discussions

Monday July 5th — Depart Madang